

Current Trends in Quality Science – consumer behavior, logistic, product management



EDITOR: Hanna Śmigielska



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**Institute of Quality Science
Poznań University of Economics & Business**

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Introduction

The monograph: Current Trends in Quality Science – consumer behavior, logistic, product management, contains descriptions of recent research in management science and quality. The papers collected in this issue cover all aspects of product quality from a multidisciplinary perspective. The subject matter contained in 34 articles by individual authors allows us to distinguish several directions of research that relate to the quality of products and services. All the papers are in line with the issue of sustainable development. To achieve sustainable development, coherence is needed between three key elements: economic growth, social inclusion and environmental protection. They are interrelated and all are essential to the well-being of individuals and whole societies.

In this monograph, the first group of issues concerns studies related to consumers' market behaviour, especially their market behaviour during the difficult period of the Covid-19 virus pandemic. Among the topics of the publications there are also studies directly related to the pandemic, i.e. sustainable consumption of Covid-19 filter masks. Other studies describe analyses of consumers' attitudes towards food and non-food products. Another group of studies deals with consumer behaviour and innovative packaging solutions, as well as perception and research on the use of techniques for assessing environmental aspects related to the product over its life cycle (LCA studies). The last group of papers concerns the subject of waste management, food safety and protection management and quality research on innovative products and services. All publications contain the theme of quality research in the conditions of sustainable development and economy, quality oriented to individual customer satisfaction and benefiting the economy, society and environment.

Hanna Śmigielska

Part 1

CONSUMER BEHAVIOR

THE ROLE OF INTERNAL ASSESSMENT IN HIGHER EDUCATION QUALITY IMPROVEMENT

Andrzej Chochół¹, Olga Hnatyszak¹

Abstract

The aim of the article is to present an internal assessment of education quality in higher education institutions as one of the key elements in the process of improving education quality. The paper discusses issues related to the concept of the quality of higher education, its evaluation, as well as the process of internal assessment of education quality within a university. It has been presented that despite the unusual importance of the internal assessment of education quality, there are no specific recommendations or regulations in this area. The analysis of documentation of internal education quality assurance systems for selected Polish universities has shown that very often these systems are developed as a minimum required in relation to the guidelines of the Polish Accreditation Commission.

Internal evaluation of the quality of education is an inseparable element of the process of improving the quality of education in a higher education institution and should constitute one of the key elements of a formalized internal education quality management system. The Authors also present proposals for actions aimed at conducting internal assessment of education quality in a higher education institution. This assessment should be carried out on the basis of indicators related to the expectations of different groups of stakeholders of a given university as well as it should take into account its specific operating environment. For successful implementation it is important the presented vision to be consistent with the mission and strategy of the university.

Keywords: higher education, higher education quality, internal quality assessment, quality improvement.

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Introduction

Integration of Polish universities with the European Higher Education Area (EOSW) has introduced them to a new single market for educational services, which involved the need to develop a new strategy for competing on the international arena. An outstanding scientist in the field of marketing, Manfred Bruhn, describes organizations realizing the strategy of fighting through quality as “European Winners” who achieve success on the EU single market thanks to the inclusion of new technologies, improving the quality of work and implementing quality methods of management as well as the use of new raw materials and the implementation of new improved processes (Bruhn, 1989). By transferring the above vision to the field of higher education, it can be concluded that universities operating under market conditions should focus special attention on quality in all areas of their functioning. Among other things, the quality of education that a given university is able to provide plays a very important role in the competitive struggle for the best students, research staff and financial resources. The quality of education in recent years has been evoked not only in Poland, but all over the world, as it is an important issue not only for universities, students and academia, but also for potential employers and the entire economy. The quality of education is related to the state’s intellectual capital, and therefore also to its innovativeness and speed of development. Through efficient implementation of innovative solutions while maintaining rich academic traditions, the university is able to meet the requirements of the current market and support the state’s economic development shaping a pro-innovation attitude as well as students (creating human capital of the state) (Hnatyszak, 2016).

The issue of improving the quality of education is present not only in the various internal documents of higher education institutions (such as development strategies, missions, quality policies or documents of University Quality Management Systems), but also in many legal acts at both the EU and the state level. In the newly implemented in Poland “Law on Higher Education and Science”, the mission of the higher education system was defined as “conducting the highest quality of education and scientific activity, shaping civic attitudes as well as participation in social development and creating an economy based on innovation”, and the role of higher education in life, development and achievement of the state’s well-being was emphasized (Journal of Laws No. 164, 2018). The need to ensure the quality of education also results from such documents as:

- Bologna Declaration and creation of a European Higher Education Area,
- the Act of July 27, 2005 – Law on Higher Education (Journal of Laws No. 164, item 136, as amended) and executive acts to the Act,
- Program for the development of higher education and science in Poland for the years 2015–2030,

- requirements of the Polish PKA Accreditation Commission,
- recommendations of the European Union and EU organizations dealing with the quality of education, e.g. (ENQA).

Based on the guidelines and recommendations contained in the report entitled by the European Association for Quality Assurance in Higher Education. “Standards and guidelines for ensuring the quality of education in the European Higher Education Area”, internal and external systems for ensuring the quality of education in the European Union countries are created. It should be noted that in a given document there is no specific wording what the quality of education is for institutions of the higher education system. The definitions of a given concept are not specified in their studies by either the legislative authorities or the Polish Accreditation Committee. Few attempts to explain the definition of the quality of education can be found in some studies published by the specialized UN Organization for Education, Science and Culture UNESCO (Campbell & Rozsnyai, 2002; Vlăsceanu, *et al.* 2007), British Agency for Quality Assurance in Higher Education (QAA, 2012) as well as in the literature on the subject. It should be noted, however, that it is difficult here for a consensus among authors, and the proposed explanations are different and often too general. Despite the lack of a clear definition of what is the quality of higher education, it is its provision that is one of the main objectives of the Bologna process. The report of the European Network for Quality Assurance in Higher Education “Standards and guidelines for ensuring...” puts a great emphasis not so much on the quality of education as on its improvement, stressing that higher education institutions should develop and implement appropriate strategies for continuous improvement of quality education (ENQA, 2015). It should be noted that the improvement is a change in the status of something for the better, therefore, to conclude that there is improvement in the quality of education, universities should constantly monitor the quality of education as a function of time, so as to obtain reliable data for further analysis. In other words, an element of internal quality assessment of the educational process is necessary. Referring to the Deming cycle (Deming, 1986) presenting the principle of continuous improvement (Plan – Do – Check – Correct), it is impossible to take effective improvement measures bypassing the stage of checking or assessing the quality of education.

Such an assessment should be an important element of the university system of education quality assurance and be carried out on the basis of specific indicators, enabling not only comparison of results in time, but also assessment of the effectiveness of implemented actions improving.

This article is a continuation of research conducted on the internal evaluation of the quality of education in universities, which was presented at the 21st IGWT Symposium in Rome.

Methods

Undoubtedly, there is an agreement in the environment that the quality of education is important and universities should make every effort to ensure its high level. An internal evaluation of the quality of education should be an integral part of the process of improving the quality of education. In connection with the above, one of the goals of today's study was to check whether there are regulations or recommendations regarding internal evaluation of the quality of education, which could be used to support higher education institutions during the creation of quality management systems. The main research method was the analysis of documents and materials, which was applied in relation to the most important legal acts, guidelines, standards, recommendations regarding the quality assurance of education in higher education in Poland. In addition, it was decided to conduct an analysis of internal quality management systems of Polish universities in terms of the presence of an element of internal quality assessment of the education process (self-assessment) as well as guidelines and indicators against which it is carried out. Ten Polish higher education institutions have been selected for the analysis, which over the last five years have been in the leading positions in the prestigious national ranking of university colleges. This choice was motivated by the fact that these universities, in the course of years, in the top positions in the rankings, present the highest level of the quality of education in the country.

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Results and Discussion

According to the ministers' statement in the Berlin Communiqué (2003), "in accordance with the principle of institutional autonomy, the primary responsibility for quality assurance in higher education rests with each institution", which leaves universities free to introduce new innovative solutions for internal evaluation and improvement of education quality. Nevertheless, internal quality assurance systems built on the recommendations of the European Association for Quality Assurance in Higher Education rarely go beyond seven areas, which are detailed in the "Standards and Guidelines for ensuring...", which include:

- policy for quality assurance,
- design and approval of programmes,
- student-centred learning, teaching and assessment,
- student admission, progression, recognition and certification,
- teaching staff,
- learning resources and student support,
- information management,
- public information,
- on-going monitoring and periodic review of programmes,
- cyclical external quality assurance (ENQA, 2015).

The element of based on measurable indicators internal evaluation of the quality of the education process was not included in the given recommendations ("Standards and guidelines...") Only in §1.1 The policy and quality assurance procedures mentioned that higher education institutions should have the opportunity to develop and monitor their effectiveness within the given scope of procedures. An internal quality assurance system, which could indirectly lead higher education institutions to self-assessment as part of the quality of the education process. In turn, European standards and guidelines for external quality assurance of higher education emphasize that external evaluation procedures should take into account the effectiveness of internal quality assurance processes and take into account the self-assessment element (or peer-to-peer process) of the quality assurance process entity, while the scope or criteria of the given self-assessment as well as the It has no provisions that would explicitly refer to self-assessment in terms of the quality of the educational process being implemented, and not an assessment of the effectiveness of the internal quality assurance system, as it is at the moment.

In the newly implemented law on higher education and science, the quality of education has been given more attention, then in previous one (The Act of July 27, 2005, Journal of Laws No. 164, 2005), which does not contain provisions referring directly to internal monitoring of the quality level implemented by universities in the education process. But even these provisions mostly concern the external evaluation of the quality of education, which is carried out by the Polish

Accreditation Committee. It is the PKA requirements that require the development and implementation by universities of an internal education quality assurance system. The annexes to the Statute of the Polish Accreditation Commission contain provisions stating that the system implemented by universities should enable "... systematic monitoring, evaluation and improvement of the educational process implementation in the evaluated field of study, including in particular the assessment of the implementation of the assumed learning outcomes and periodic review study programs aimed at their improvement..." (PKA, 2015). It is also recommended to include factors related to the conditions of the learning process during the assessment, but the main focus here is on the didactic side of the education process, i.e. study programs, learning outcomes and research and teaching staff. The Polish Accreditation Committee also requires monitoring of the functioning of the internal education quality assurance system as well as a systematic assessment of its effectiveness. While analyzing the requirements of PKA, it should be noted that in principle they do not go beyond the scope of the guidelines contained in the aforementioned "Standards and guidelines for ensuring..." (ENQA, 2015).

In the course of accomplishment of the goal set at work, an analysis was made of the documentation of education quality management systems of selected Polish universities. The first stage of the research was to check the fact that higher quality internal education quality management systems function in the given higher education schools. The analysis showed that in nine out of ten universities this system is formalized, that is, it operates under the proper regulation of the rector of a given university, and one of the universities of such a system did not have any. In six cases, the higher education institutions made an internal assessment of the quality of education, while in five of these cases the assessment did not go beyond the areas mentioned in the previously mentioned "Standards and guidelines...". It should be emphasized that these assessments were in most cases carried out in a descriptive form, i.e. a verbal answer to pre-determined questions or in the form of an opinion expressed by a person appointed to conduct such an assessment. Undoubtedly, such an assessment method makes it difficult to monitor the improvement of the quality of education over time as well as the effectiveness of improvement activities implemented in this area. Only one of the analyzed universities has developed measurable indicators designed to monitor the quality of the educational process, which are presented in Table 2. During the analysis, the authors did not take into account the numerical indicators developed by the universities resulting from the evaluation of didactic classes, employees as well as surveys of graduates as they are related to the guidelines of the Polish Accreditation Committee, and are not sufficient to conduct a comprehensive assessment of the educational process. Collective results of the analysis of quality management systems carried out among selected academic schools are presented in Table 1.

Table 1. Internal evaluation of the education quality at selected universities

University	Formalized internal quality management system*	Element of internal evaluation of the quality of education**	Developed indicators of the quality of education***
A	yes	yes	no
B	yes	yes	no
C	no	no	no
D	yes	yes	no
E	yes	yes	yes
F	yes	no	no
G	no	no	no
H	yes	yes	no
I	yes	yes	no
J	yes	no	no
<p>* – a university system for ensuring the quality of education ** – without taking into account the self-assessment of the functioning of the university system for ensuring the quality of education *** – without considering the evaluation of didactic classes, employees, the fate of graduates</p>			

Additionally, as a result of the analysis of the documentation of the HEIs, it can be concluded that the activities in the field of improving the quality of education are implemented in randomly selected areas of the education process and are often reparative in relation to the nonconformities or adapt the education process to new formal requirements in a given area. In connection with the above, it can be assumed that in given higher education institutions it is very difficult, if not even impossible, to realistically assess the effectiveness and accuracy of the implemented solutions.

In the authors' opinion, undertaking any actions in the field of improving the quality of the education process should start for each higher school by defining what is the quality of education and what are its determinants. Take into account the specific environment of each university's operation, its mission and long-term strategy.

The next step is to define guidelines and indicators for which the internal quality assessment procedure of the educational process should be carried out. Universities should develop a method of evaluation that will enable monitoring and comparison of the results obtained over time, so that these data can serve as a reliable source of information for taking appropriate actions in the field of improving the quality of education.

Table 2. Evaluation criteria for the quality assurance system in one of the analyzed Polish universities

GROUPS OF CRITERIA		INDICATORS
1. Employees	1.1. Academic degrees and titles awarded to research and teaching staff 1.2. Number of academic teachers participating in postgraduate studies, trainings and courses 1.3. Distinctions and teaching awards received by unit staff 1.4. Participation of academic teachers in international programs and didactic exchange realized with foreign academic units	
	2.1. Activity of students within scientific circles 2.2. Activity of students in research programs 2.3. Rector's scholarships for the best students awarded in the unit 2.4. External scholarships obtained by students 2.5. Other distinctions connected with the education process obtained by students 2.6. Participation of students in education-related international programmes and exchanges with foreign centers 2.7. Participation of students in education-related programmes and exchanges with domestic centers 2.8. Indicators supporting assessment of selected aspects of the educational process	
2. Students		
3. Didactic infrastructure and didactic materials	3.1. Newly commissioned or newly equipped teaching facilities 3.2. New scripts and textbooks published by faculty members	
	4.1. Full-time and part-time studies provided within the unit 4.2. Specialties offered for full-time and part-time studies 4.3. Subjects conducted in foreign languages 4.4. Classes conducted by visiting professors 4.5. Offer of post-graduate studies and specialist courses 4.6. Classes conducted using e-learning methods 4.7. Changes in curricula of existing majors/specialties 4.8. Newly launched and changed subjects (course modules) 4.9. Conducted promotional campaigns and meetings with school youth	
4. Educational offer and its promotion		

5. Evaluation of education process	5.1. Questionnaires on teachers' evaluation 5.2. Statistics of student questionnaires on subject evaluation 5.3. Statistics of postgraduate students' surveys 5.4. Alumni surveys, if conducted by unit 5.5. Employer surveys, if conducted by unit + descriptive evaluation	
6. Development of internal system of education quality assurance	Descriptive evaluation	
7. Doctoral studies	Descriptive evaluation	
8. Students self-government	Descriptive evaluation	

Additionally, when developing the internal assessment criteria, the expectations of stakeholders, which concern different areas of the education process at a particular university, should be taken into account. Due to the type and nature of their activities, universities cooperate with a large group of stakeholders, so making their complete list seems impossible. Nevertheless, it is possible to identify the most important stakeholders for the university and divide them into two basic groups: internal stakeholders (eg students, doctoral students, lecturers, student organizations, university and faculty authorities, etc.) and external stakeholders (e.g. employers, university and university candidates) graduates, local and central authorities, local community, etc.). Each of these groups will have different expectations as to the educational process, which will determine the perception of its quality to varying degrees.

Conclusions

Despite the unusual importance of the issue of the quality of education in higher education as well as its improvement, one can observe a lack of a defined approach to the concept of the quality of the educational process, as well as the lack of specific provisions related to the internal assessment of the quality of education by universities, that is, guidelines defining how to monitor and evaluate is there actually an improvement in this quality.

The analysis of documentation of internal education quality assurance systems for selected Polish universities has shown that often these systems are developed as a minimum required in relation to the guidelines of the Polish Accreditation Commission. The fact, that only one of analyzed universities has developed measurable indicators designed to monitor the quality of the educational process may be an indicator of the organisation's low awareness of educational quality management, lack of a defined vision and goals related to educational quality as well as unwillingness to go beyond the minimum required in this area. Analyzing the related literature, it can be seen that the situation is also similar outside Poland. When analysing the literature on the subject, it should be mentioned that there are very few studies on specific methods of educational quality assessment (as a complex process), more researchers focus their attention on the determinants of educational quality (Chochół & Hnatyszak, 2021). However, most researchers are interested in methods, which are based on an approach to education as a service, so they associate the assessment of the quality of education mainly with student satisfaction (e.g. SERVQUAL, SERVPERV, HEdPERF, EduQUAL, SQM-HEI, EDUSERVE methods) (Mohd, 2012). Such an approach to the issue of higher education and its quality is not exhaustive and does not take into account the entire process of education at the university.

Internal evaluation of the quality of education is an inseparable element of the process of improving the quality of education in a higher education institution and should constitute one of the key elements of a formalized internal education quality management system. Internal education quality assurance systems should be created for the university's own needs and aim at continuous improvement of the education process carried out by a given unit. The assessment within such system should be carried out on the basis of indicators related to the expectations of different groups of stakeholders of a given university, taking into account its specific operating environment. To this end, each institution of the higher education system should clearly define what is the quality of education for it and what factors determine it. This vision should be consistent with the mission and strategy of the university. Only such an approach is able to enable a higher education institution to provide high quality education as well as its continuous improvement, and thus effective competition on such a dynamically changing European market for educational services.

References

- Bologna Process Committee (1999). *Joint declaration of the European Ministers of Education convened in Bologna on 19 June 1999* (The Bologna Declaration).
- Bruhn, M. (1989). Marketing in Europa ohne Grenzen. *Harvard Manager*, 1, 67.
- Campbell, C., Rozsnyai, C. (2002). *Quality assurance and the development of course programmes*. Bucharest: UNESCO-CEPES.
- Chochół, A., Hnatyszak, O. (2021). *Model of internal evaluation of higher education quality at the university*. Warszawa: PWE, 52–54.
- Deming, W.E. (1986). *Out of the Crisis*. MIT Center for Advanced Engineering Study, Cambridge.
- Hnatyszak, O. (2016). Impact of innovation on the higher education quality and its evaluation. In: M. Kuczera, K. Piech (ed.), *Issues currently discussed by young scientists*, 2. Kraków: Creativetime.
- Journal of Laws 2005, July 27, Act of 164 nr 1365 (in Polish, Prawo o szkolnictwie wyższym), Dz.U. 2005 nr 164, poz. 1365.
- Journal of Laws 2018, July 20, Act nr 1668 (in Polish, Prawo o szkolnictwie wyższym i nauce), Dz.U. 2005 nr 164, poz. 1365.
- Mohd Zuhdi Ibrahim, et al. (2012). Assessing Students Perceptions of Service Quality in Technical Educational and Vocational Training (TEVT) Institution in Malaysia. *Procedia Social and Behavioral Sciences*, 56, 272–283.
- Programme for the development of higher education and science 2015–2030, (2015). Ministry of Science and Higher Education (MNiSW). Warszawa, Poland.

Realising the European Higher Education Area. Communiqué of the Conference of Ministers responsible for Higher Education (2003), Berlin.

Standards and Guidelines for Quality Assurance in the European Higher Education Area, (2015). Brussels, Belgium.

Statutes of the Polish Accreditation Committee (2015). Warszawa: PKA.

The UK quality code for higher education: A brief guide (2012). London: Quality Assurance Agency for Higher Education.

Vlăsceanu, L., Grünberg, L., Pârlea, D. (2007). *Quality assurance and accreditation: A glossary of basic terms and definitions*. Bucharest: UNESCO.

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ART IN MANAGEMENT

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Abstract

The conditions of uncertainty and the dynamic environment they are becoming nowadays norm for entrepreneurial activity, generate the need to improve management processes by using non- standard elements from other fields.

The aim of the article is to establish the legitimacy and possible benefits of incorporating art into management processes at the individual, team and organizational level. The role of selected elements from the area of art in the functioning of the organization was identified and defined, with particular emphasis on emotions and creativity arising from the area of art. The essence of the meaning of art and the role of the artist in the contemporary world were presented. The key role of art in new management concepts was shown.

The adopted research method will be a critical review of the literature.

Keywords:

art in management, creative competences, meta- abilities, emotions, new trends in management

Introduction

The complex reality surrounding the contemporary organization can be illustrated with the acronym VUCA – volatility, uncertainty, complexity and ambiguity. Rational, analytical methods more and more often turn out to be insufficient in relation to unpredictable processes and events characteristic for the organization's environment. Existing governance principles need to be integrated with new governance principles that would enable organizations to

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become adaptive and resilient, and human-centered, to encourage continuous evolution and innovation. The management of the first decades of the 21st century requires the development of organizational skills that combine rational organizational and emotional dimensions (Schiuma, 2011). This means that new forms of knowledge will gain in importance, especially those that distinguish a human being, such as emotions, energy, intuition, and creativity. The question arises whether incorporating art into organizational processes can positively affect the contemporary organization? What is the meaning and role of art in creating organizational value?

Art in the modern world

Art critic Maria Anna Potocka, when asked “What is art for?”, She replies that firstly to serve as a private cognitive-critical tool. Secondly, to enrich the social point of view with comments that averaged thinking is not capable of. She compares contemporary art to a private existential tool that allows you to get to know yourself, to see from a distance the problems you depend on, to control your own existence, at the same time transforming them into something deeper and more your own (Potocka, 2011).

Thus, art helps to explain “the world”, both at the individual and organizational level. At the same time, it creates an opportunity for this relationship with the environment to be unconventional, visionary and unpredictable. The personality of the artist, his originality, individualism and uncompromising nature play a huge role in this process (Potocka, 2011). With regard to members of the organization, such an understanding suggests individual, subjective perception of the creative potential of individual individuals, assuming, after Beuys, that “every man is an artist”.

Reflecting on the role of the artist today, it is worth quoting the words of Anda Rottenberg, a Polish historian and art critic, which she gave during the European Forum for New Ideas devoted to visions and forecasts for the world after the pandemic: The artist is the only witness to history that can be trusted. Reactions to what they say are late or absent. Artists do not work in a vacuum, they work against reality. And suddenly it turns out that this reality is unimaginable. In understanding, taming and imagining the “unimaginable”, it is worth using what we can learn from the world of art (Palacz-Brzezińska, 2021).

Assuming that the artist perceives the world in a non-schematic way, a question arises about the accompanying creative process. From the point of view of neuroscience, the brain it functions as an integrated whole, with separate neural networks interacting with each other. As a result, artistic creation requires a combination of many different cognitive processes (attention, planning, executive

functions, cognitive flexibility, memory recall, latent knowledge, etc.), which are implemented by various interactive neural circuits (Perdreau & Cavanagh, 2013).

Currently, apart from the once significant ideological, artistic and moral barriers, art has also overcome the geographical barrier, becoming a global language of interpersonal understanding (Tendera, 2010). This language, characteristic of a given type of artistic expression, is pictorial, sensual, emotional and also refers to the recipient's special, aesthetic sensitivity (Jasiński, 2012), but always remains universal. Contemporary art answers the most general and, at the same time, the most basic questions about the world in general and man's place in it, thus building a general picture of the world (Jasiński, 2012). In the post-pandemic reality of the first decades of the 21st century, the questions posed by the post-impressionist painter Paul Gauguin in the title of his painting, are relevant nowadays: "Where do we come from? Who we are? Where are we heading?". By touching on fundamental values, art helps to find meaning and balance in an unpredictable environment. This happens both at the individual level and at the organizational level.

Art offers tools based on meta-facilities that help in better, deeper understanding and establishing relations with the contemporary world. Currently, the role of art in the development of theory, practice and education of management is growing; and artists' competences such as creativity, ingenuity, appreciation of aesthetics and design orientation are increasingly essential to individual and organizational success in a competitive global world (Gallos, 2021). Art is a way to understand the increasing complexity faced by managers and leaders (Nissey, 2010). Harvard Business professor Rob Austin said: Economics the future will be about creating value and appropriate forms, and no one knows more about the processes of doing it than artists do (Adler, 2006).

Management in the twenty-first century – new trends

The treatment of organizations as human systems is characteristic of the new concepts of management (Adler, 2010). The current complicated reality generates the need for changes in the existing management rules. The question is what should characterize the organization of tomorrow? In Hamel's opinion, what companies once considered merely a moral imperative – creating organizations that are truly human – is now an inevitable business imperative (Hamel, 2009). The management model proposed by Hamel assumes, i.a.: developing and using diversity (also as a condition for the survival and long-term profitability of the company), reorganizing the existing hierarchy, creating an environment conducive to innovation, experimenting and developing a shared passion of employees. The organization of tomorrow, according to Hamel, should be innovative, flexible and

inspiring. However, the priority in managing the future, according to the researcher, is a deeply humanitarian organization that develops human imagination, triggers creativity, and respects people. In an organization functioning in accordance with Hamel's vision, noticing and applying elements from the field of art seems completely natural. Hamel advocates the humanization of language and business practices. According to his theory, future management systems must support and develop human ideals, such as beauty, justice and community (Hamel, 2009). In an organization operating in accordance with Hamel's vision, the perception and use of elements from the field of art seems completely natural.

Also close to art is the concept of humanistic management, in which the priority is man, his well-being, emancipation and development. The concept is embedded in the broadly understood humanities, expanding cultural capital, inspiring and developing creative attitudes and actions. It is management "from the human level" and focused on the human, seeking understanding and explanation of attitudes, motivations and human problems, without judging and without being beyond the humanity of both the respondents and the researcher, manager and manager (Kostera, 2015).

Recognizing the key role of man in business activities means managing aesthetic and emotional dimensions as a factor leading to the success and improvement of the organization (Taylor & Hansen, 2005). The new key issue of the postmodern management paradigm is how to set up organizational systems that recognize the relevance of human nature and utilize people's emotions and energies as key value drivers to steer the capacity of organizational value (Schiuma, 2011).

Art in organization

Organizations of tomorrow must be flexible, innovative, inspiring and socially responsible, as well as operationally perfect (Hamel, 2009). Over the past three decades, entrepreneurs and business leaders have discovered the potential of artistic thinking to improve management skills at an individual, group and organizational level. Some organizations combine art and business to initiate art-based management (Nissley, 2010).

Art in organization is treated as a resource, mainly in aesthetic terms (Strati, 2000). Elements from the area of art in management are perceived within the framework of aesthetic technologies. Aesthetic technology is defined as an art form and/or artistic process that is instrumentally used to address or solve a business/organizational problem. Artistic practices are used in the practice of managing the aesthetic dimensions of an organization, supporting business processes related to dealing with emotional, energetic, ethical and empirical characteristics of an organization and in integrating these dimensions with the organization's operating

mechanisms. The power of artistic thinking in organizations is precisely based on “interp-spaces” (i.e. spaces of possibility), where “participants experience new ways of seeing, thinking and doing things that add value to them [personally and collectively]” (Antal & Strauß, 2013). Dimensions such as passion, emotions, hope, morality, imagination, aspirations and creativity are now being established as new strategic factors of organizational value (Schiuma, 2009).

Art in organization – individual and team level

In this approach, art stimulates and activates aesthetic experiences, which in turn trigger people’s emotions and energy. In the context of organization, art inspires creative activities, developing non-standard thinking, enriching the perception and cognitive abilities of employees (Carlucci & Schiuma, 2018). Art positively influences the development of competences in the field of psychology, such as mindfulness, emotional intelligence, cognitive flexibility, develops the individual and team potential of the members of the organization, appreciates their individuality, strengthens mutual relations, develops commitment, professional passion, initiating and adapting changes. Influences the development of imagination and intuition.

It is important to distinguish between the creative attitudes and initiatives of the members of the organization on an individual and team level. New “humanistic” concepts of management emphasize the growing role of the individual, but also the initiation of “bottom-up”, emergent team processes in the organization (Hamel, 2009; Kostera, 2015; Nowak, *et al.* 2015). This approach corresponds to the subjective treatment of an individual, characteristic of art and the artist. Therefore, collective creative organizational processes using elements of art and psychology can be defined as communal, while respecting and preserving the individuality of the individual.

Research confirms that artistic interventions have a significant impact on organizational life. As a result of studies of various types of European organizations, eight categories of positive impact of artistic interventions have been identified: strategic and operational influences, organizational development, relationships, personal development, collaborative ways of working, inventive ways of working, seeing more and different, activation. The development of these factors constitutes the organisation’s innovation potential. Artistic interventions also contribute to strategic and operational factors such as productivity, performance, recruiting and reputation (Antal & Strauß, 2013). Treating art as a resource and source of human experience, researchers distinguished two main interpretative perspectives on the role of art in management. The first perspective treats art as a learning platform, a body of knowledge from which managers can draw inspiration to identify new

organizational and business models that appreciate the aesthetic, emotional, and energetic dynamics of life and organizational activities (Nissley, 2010). Thus, contacts with a work of art and the creative process can intensify organizational elements, traits and relationships based on aesthetic experiences, which can be used as analogous models for imitation and/or from which to learn and stimulate creative thinking (Schiuma, 2011). Art teaches a holistic approach that integrates rationality, emotions, intuition and technology (Carlucci & Schiuma, 2018). Management needs to enter into an alliance with art intuition (Kostera, 2013).

The second interpretative perspective treats art as a carrier of aesthetic experiences, developing aesthetic sensitivity. Art in this approach plays the role of a carrier of aesthetic properties in tangible and non-material organizational infrastructure and products, so that they are able to stimulate people's aesthetic sensitivity affecting emotions and energetic dynamics" (Schiuma, 2011). In this approach, art is also incorporated, as an aesthetic value, into the products and/or processes of the organization, it functions in the workplace to improve organizational identity, develop brand reputation, and create organizational symbols capable of building and representing the identity and image of the organization.

The role of art in organization can also be considered in a dynamic and static context. The dynamic perspective concerns the factors influencing the flow of value in the organization. It focuses on the issue of "how do organizations create value? The static approach concerns the assessment of factors defining the organization's value resources at a given time. The question related to the static point of view is "What is the organizational value generated?" (Carlucci & Schiuma, 2018).

Art in organization – the organizational level

At the organizational level, art can be used to create network relationships with external stakeholders, consequently positively affecting the reputation of the organization and brand reputation (Carlucci & Schiuma, 2018).

Art, enriching cognitive processes, is also connected with the ability to perceive non-standard opportunities in the environment where others do not notice them. In turn, cognitive flexibility, emotional intelligence, imagination and intuition make it easier for the organization to respond to changes in the environment and to evolve.

A creative approach to resources and their reorganization leads to the creation of dynamic abilities. Creativity, as a dynamic ability, is extended to the entire organization, therefore it should be considered as a normal part of the life of the organization and its strategy (Dyduch, 2013). Art can play the role of strategic

management, supporting the mechanisms of creating value in an organization (Carlucci & Schiuma, 2018).

Competences in the area of art, such as the creative process or cognitive flexibility, can be helpful in building the strategy of a contemporary organization. Thinking in terms of creativity at the strategic level is needed (...) at every stage of the company's operation (Dyduch, 2013). Factors from the area of art, such as creative discovery, improvisation, experimenting, creating visions through interaction, fusing contradictions in multidimensional processes of innovation, play a significant role in the concept of a creative strategy (Dyduch, 2013). Assuming that in a turbulent environment, prediction is difficult, and models based on biological diversity are often more useful than analytical methods, according to Hamel, the goal in the future will not be to develop a strategy, but to work on creating conditions in which new strategies could emerge and evolve (Hamel, 2009).

Art can also play a significant role in the challenges related to the sustainable development of the organization, as the challenges related to sustainable development are not only scientific and technical; but they are also cultural. The collaboration of organizations with artists in the field of sustainable development seems to result in better communication skills, better articulation of problems, more creative problem-solving, and questioning of personal and disciplinary mental models (Cardenas & Rodegher, 2020). Empathy and mindfulness, a humanistic approach characteristic of art, favor sustainable development in terms of relations within the organization and in its contacts with the environment in which it is part of the ecosystem.

There are opinions of researchers that the (commonly used) ways of using art-based methods in management may limit their potential. At the same time, they note that one of the most important benefits of using art-based methods is the ability to manage at the meta level, develop perceptual abilities and use the creative process (Springborg, 2011). Concerns also concern the use of methods based on art in management, only for the sake of economic benefits, disregarding the subjectivity of the participants in the organization. There are also voices among researchers that it is impossible to authentically transplant artistic ideas into the sphere of business (Ancelin-Bourguignon, *et al.* 2020).

Art enriches the language of management with words from the area of spirituality, psychology, positive emotions and, above all, fundamental values. However, there is a certain incompatibility between the two "languages" – art and management. Truth, Good and Beauty, which are somehow the goal of art, mindfulness, positive psychology, as a result of their application in management, are to lead to "capture", "competition", "exploitation". This is reminiscent of the language of warfare in the Age of Aquarius. Perhaps the change in the management paradigm will be associated with a gradual change in the linguistic sphere.

Conclusions

Art as an important resource of contemporary organization contributes to the creation of material and non-material values. It is considered to be the basic element of the concepts recognizing the central role of man, which are the foundation of the new management paradigm.

Special creative competences and meta-abilities brought by art to management lead to unconventional, innovative solutions and the creation of unique business models. Including elements of art in management processes positively influences the holistic (combining rational and emotional approach) development of cognitive processes. Art, the change of which is an immanent feature, makes it easier for the organization to adapt to the dynamics of the environment, develops cognitive flexibility, and positively influences the perception and creation of entrepreneurial opportunities. It also positively influences the rapid, unconventional reorganization of resources, and thus the creation of dynamic abilities.

Art is connected with a humanistic approach and subjective treatment of the participants of the organization, as well as empathetic relations with the environment of the organization, thus contributing to sustainable development.

The development of education in the field of art in management seems beneficial already at the stage of educating future leaders and managers. Art can be used to control and strengthen internal and external organizational relationships.

Appreciating the role of art and incorporating its elements into business processes, especially in today's complex reality, can bring many benefits to management, both ethically and economically.

References

- Adler, N.J. (2006). The arts & leadership: Now that we can do anything, what will we do?. *Academy of Management Learning & Education*, 5(4), 486–499, <https://doi.org/10.5465/amle.2006.23473209>.
- Antal, B.A., Strauß, A. (2013). *Artistic interventions in organisations: Finding evidence of values- added*. Creative Clash Report. Berlin: WZB.
- Bourguignon, A., Dorsett, C., Azambuja, R. (2020). Lost in translation? Transferring creativity insights from arts into management. *Organization*, 27(5), 717–741. doi:10.1177/1350508419855716.
- Cardenas, E., Rodegher, S.L. (2020). Art-Science Collaborative Competencies: A Mixed-Methods Pilot Study for Improving Problem Solving for Sustainability Challenges. *Sustainability*, 12(20), 8634, <https://doi.org/10.3390/su12208634>.

Carlucci, D., Schiuma, G. (2018). The power of the arts in business. *Journal of Business Research*, 85, 342–347.

Dyduch, W. (2013). *Twórcza strategia organizacji*. Katowice: Wydawnictwo Uniwersytetu Ekonomicznego w Katowicach.

Gallos, J. (2021). *The Arts and the Art and Science of Management Teaching*. Oxford Research Encyclopedia of Business and Management, <https://oxfordre.com/business/view/10.1093/acrefore/9780190224851.001.0001/actfore-9780190224851-e-186>.

Hamel, G. (2009). Moon shots for management. *Harvard Business Review*, 87, 91–98.

Jasiński, B. (2012). Sztuka zamiast filozofii. *Sztuka i Dokumentacja*, 6, 97–107.

Kostera, M. (2013). Helikon SA, czyli o sztuce, zarządzaniu i inspiracji. *Zarządzanie Kulturą*, 6(2), 46–53.

Kostera, M. (2015). Refleksje o zarządzaniu humanistycznym. In: B. Nieremberg, R. Batko, Ł. Sułkowski (ed.), *Zarządzanie humanistyczne*, 53–61. Kraków: Wydawnictwo UJ.

Nissey, N. (2010). Arts-based learning at work: Economic downturns, innovation upturns, and the eminent practicality of arts in business. *Journal of Business Strategy*, 31(4), 8–20.

Nowak, A., Zabłocka-Bursa, A., Ziembowicz K. & Bartkowski, W. (2015). Wpływ społeczny z perspektywy obiektu wpływu teoria i modele symulacyjne. *Psychologia Społeczna*, 34, 296–309.

Palacz-Brzezińska, A. (2021). An Artistic Roadmap “Art of emotions. Emotions in art”. Hestia Artistic Journey Foundation, <https://uncommonground.pl/en/an-artistic-roadmap-art-of-emotions-emotions-in-art/>.

Perdreau, F., Cavanagh, P. (2013). Is artists’ perception more veridical?. *Frontiers in Neuroscience*, 7(6), 1–11, doi:10.3389/fnins.2013.00006.

Potocka, M.A. (2011). Po co jest sztuka?, *MOCAK Forum*, <https://www.mocak.pl/maria-anna-potocka-po-co-jest-sztuka>.

Tendera, P. (2010). Sztuka globalna. *Estetyka i Krytyka*, 19(2), 197–202.

Taylor, S.S., Hansen, H. (2005). Finding form: Looking at the field of organizational aesthetics. *Journal of Management Studies*, 42(6), 1211–1231.

Schiuma, G. (2011). *The value of arts for business*. Cambridge: Cambridge University Press.

Springborg, C. (2011). *Arts-Based Methods for Facilitating Meta-Level Learning in Management Education: Making and Expressing Refined Perceptual Distinctions*. Cranfield, <http://dspace.lib.cranfield.ac.uk/handle/1826/6972>.

Strati, A. (2000). Aesthetic theory. In: S. Linstead, H. Hopfl (ed.), *The aesthetics of organisation*. Sage Publications.

PROBIOTIC FOOD IN RATIONAL NUTRITION IN CONSUMERS' OPINION

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Abstract

Rational nutrition is nowadays one of the most important factors of modern pro-healthy lifestyle of a human being. Universality of this concept is connected with the fact that it concerns the entire human population, and that a significant part of the modern society pays more and more attention to the health quality of food products it chooses. New types of food are part of trends related to the composition of a rational diet for each generation. Functional foods are an element of modern nutrition and new foods that differ from those commonly consumed, not only in health-promoting nutritional properties and functional qualities, but also in technology and the way of obtaining raw materials. Probiotic foods, as an example of this, undoubtedly have such qualities.

The aim of the study was to collect information about the awareness of consumers on the nature and use of probiotic food in a rational diet and its impact on health. The study shows that consumers quite often consume such food during antibiotic therapy, but they also support themselves with probiotic preparations purchased at the pharmacy. However, a relatively small number of respondents consume such products prophylactically.

Keywords: probiotic food, rational nutrition, consumer

Introduction

Food and nutrition issues have been of great interest for societies for a long time, especially in our modern times. It is worth noticing that one of the important trends

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in the concept of social life development in the so-called third wave according to A. Toffler is the orientation towards a healthy lifestyle, which is connected with pro-ecological behaviors, proper nutrition or practicing sports and physical recreation (Toffler, 1997). Therefore, let us recall that proper human nutrition consists in the complete satisfaction of the body's demand for energy and for all nutrients necessary for the development of life and the maintenance of health (Borycka, 2015). Comprehensive scientific research, which has been conducted for more than half a century, has further proven that the way of nutrition, is not only important in maintaining good human condition but can also prevent the onset of many diseases (Grajeta, 2004; Borycka, 2015). Specialized studies have also shown a direct correlation between proper human nutrition and good health food quality, and have confirmed the relationship of these attributes with human health, including the incidence of certain diseases of civilization (Jew, AbuMweis & Jones, 2009; Szponar, 1994).

Civilization changes, health reasons, consumers' increasing knowledge on the influence of a balanced diet on human health resulting from common access to knowledge on the functioning of the organism, components and nutritional values of food, as well as scientific and technological progress contributed to the development of a new generation of food, including the segment of functional food, meeting the needs of the market at the turn of the century. Undoubtedly, a sign of the times was also an increase in demand for foods with specially designed composition, showing beneficial, documented health effects. In addition, there has been an increase in consumer interest in maintaining "well-being", manifested in good health, maintaining a nice figure and stopping aging processes (Borycka, 2015).

Such consumer expectations are met by functional food, which is treated by specialists as a method of prevention of civilization diseases, a recipe for improving health and well-being. Such foods are becoming more and more popular and widely consumed, and in highly developed countries the area of functional foods is developing much more rapidly than the rest of the food market (Kasprzak, Nizinski & Widelska, 2018). Probiotic products, included in the functional food segment, although known for a long time, are currently becoming very popular due to increased nutritional and health awareness of the public (Karpińska-Tymoszczyk, *et al.* 2016).

Hence, the aim of the research described in this paper was to assessment awareness and consumer behavior in the market of functional foods from the group of probiotic products.

New generation food

The turn of the XXth and XXIst centuries poses a huge challenge for designers and producers of food, connected not only with meeting the customers' needs in terms of its quality and safety, but also with innovations in designing new types of food products of pro-health character. This is inspired not only by the above-mentioned technological progress and modification of consumer needs related to nutrition and obtaining food, but also by omnipresent environmental threats to food and civilization transformations of contemporary societies. At present, the human organism is exposed to an increasing number of toxins, which makes the group of civilization diseases steadily growing. Moreover, people are accompanied by chronic stress, a diet poor in vitamins, micro- and microelements, and frequent eating in a hurry. All these elements lead to malnutrition, lowered immunity and reduced well-being.

Increasing demands and significant changes in the life and environment of today's society have revealed a huge gap in the approach to nutrition for scientists and food producers. In response to the aforementioned threats and market demand, and using the possibilities of science and technology, a whole group of products called modern/new food including functional food was created, which in addition to nutritional functions will also perform other, primarily healthy tasks (Figure 1) (Pucek, 2017).

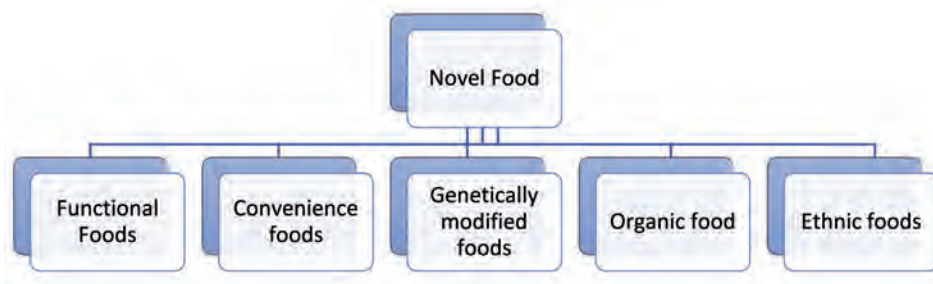


Figure 1. Breakdown of next-generation foods

Source: based on: (Pucek, 2017).

Thus, in the 1990s, the concept of functional food was born and products were developed. The concept was first formulated in 1991 in Japan in the Foods For Specified Health Uses program – FOSHU – as “foods which, based on documented knowledge concerning evidence of relationship between a food or its constituents and health, may have a beneficial effect on health. Drawing on the Japanese experience, soon in 1998, the European Commission “Functional Food Science in Europe” (FUFOSE), coordinated by the Washington-based International Life Science Institute (ILSI), developed a detailed characterization of functional foods (Karwowska

& Bogacz, 2007; Świdorski, 2006). According to FUFOSSE recommendations, such products should be intended both for healthy people, who want to maintain good health and well-being, prolong life, reduce the risk of disease, and for people particularly at risk of so-called diet-related diseases and those exposed to stress. Moreover, such foods should undergo the same physiological processes in the human body related to sensory perception, absorption and utilization in metabolic processes as traditional foods. Functional foods should show preventive effect against some diseases especially civilization diseases, including cardiovascular, gastrointestinal and immune system diseases (Borycka, 2009; Borycka, 2015; Świdorski, 2006). Such foods, thanks to their physiological active ingredients, make it possible to provide health benefits regardless of their function, i.e. proper nutrition (Karwowska & Bogacz, 2007, Świdorski, 2006). Bioactive food components with recognized beneficial health properties are used in its production: dietary fibre, oligosaccharides, polyols, amino acids, peptides, proteins, polyunsaturated fatty acids, vitamins, minerals, choline and lecithin, lactic fermentation bacteria, phytochemicals (Kołożyn-Krajewska, 2001).

The essence and market of probiotic food

The turn of the 20th and 21st centuries poses a huge challenge for food producers, which is not only connected with meeting the customers' needs related to the quality and safety of food, but also with innovations in designing new types of food products of pro-health character. One of the types of modern food is probiotic food containing in its composition live bacteria cultures that can be classified as probiotic (mainly lactic fermentation bacteria). The term probiotic is reserved for preparations or products that contain live microbial cells, improve human and animal health, have beneficial effect in the oral cavity or gastrointestinal tract (administered as food additives or pharmaceutical preparations), in the upper respiratory tract (applied as aerosols) or in the urogenital tract (topical preparations) (Kołożyn-Krajewska & Libudzisz, 1999). According to the definition adopted by the FAO/WHO, these are live microorganisms which, when administered have beneficial health effects when administered in sufficient quantity (Nowak, Śliżewska & Libudzisz, 2010). Probiotics must have a beneficial effect on the body and contain strains of microorganisms with documented health-promoting effects based on clinical studies. FAO/WHO experts further defined the term prebiotic as non-viable nutrients that benefit the health of the host by modulating the gut microbial complex. The term describes non-digestible ingredients that stimulate the growth or activity of beneficial bacteria present in the large intestine (Śliżewska, *et al.* 2013). Probiotic food fits strongly into the concept of novel foods and finds its place and application in improving the quality of life. The literature data show that it has beneficial effects on health and the

human body, it can also be counted as food that reduces the risk of diseases of civilization (Kołożyn-Krajewska, *et al.* 2016; Pucek, 2017; Świderski, 1999). Probiotic food, helps in lowering blood cholesterol levels, stimulates the immune system, helps in the synthesis of certain vitamins or protects the body from sterilization of intestinal microflora during antibiotic therapy (Świderski, 1999). The results of research carried out within the European scientific project PROBDEMO, started in 1996, have shown that probiotics have measurable benefits for humans and their health and that probiotic food has a positive effect in the daily diet of people suffering from various diseases, but also in healthy people (Table 1) (Kołożyn-Krajewska, 2001).

Table 1. Factors influencing the increased nutritional value of probiotic foods

Determinants of the increase in nutritional value of probiotic foods
<ul style="list-style-type: none"> ▪ increase in nutrient density ▪ the appearance or growth of new substances, formed by fermentation, that have nutritional significance ▪ enrichment of foods with prebiotic compounds ▪ elimination of health disadvantageous components, e.g.: cholesterol, toxic or allergenic substances ▪ improving the balance of nutrients ▪ increase in bioavailability of selected ingredients ▪ increase in sensory quality of the product, e.g. by breaking down compounds with unfavorable odors

Source: based on: (Kołożyn-Krajewska, 2001).

Analyzing the contemporary food market one may risk a thesis that socio-economic changes, scientific and technological progress and increased needs of health-educated consumers have led to its transformation towards functional food. Modern society is trying to choose food products more rationally, and the awareness of a healthy lifestyle resulting from a combination of physical activity and proper nutrition is constantly growing. Therefore, probiotic products such as yogurts and yogurt desserts, among others, whose undoubted advantage is the fact that they not only provide adequate nutritional value but also positively affect human health, including helping in the prevention of diseases and sometimes even their treatment, are more and more willingly purchased by Polish consumers (Błaszczak & Grześkiewicz, 2014). People suffering from gastrointestinal diseases, according to doctors and nutritionists, should introduce probiotic foods into their diet. It is recommended that they consume fermented dairy products because they are easily digestible, which is important in many gastrointestinal diseases. This is an alternative for people who are lactose intolerant, as they can completely replace its consumption without leading to deficiencies, such as calcium. Thanks to the content of specific bacterial strains, consumed fermented dairy foods improve

the assimilation of nutrients, e.g. proteins. Proteins from fermented milk are more easily assimilated than from conventional milk. Pro-biotic functional foods, however, are not reserved only for people who are struggling with diseases, such as intestinal, stomach or other diseases. Beneficial microorganisms contained in this type of food have been found to support the body after antibiotic therapy by inhibiting the growth of pathogenic microorganisms. Consumption of products with probiotics can also minimize the risk of traveler's diarrhea or diarrhea caused by stale food, because the bacteria supplied to the body with probiotic food effectively fight toxic substances and regulate intestinal motility (Biernat, 2001; Świdorski, 1999).

Consumers towards probiotic food in the light of research results

Methodology

The study described in this article was conducted in the form of a survey. It was carried out in March 2019 using the direct research method, in which the research tool was a self-made survey questionnaire. It was attended by 52 adults from the Radom region, diversified in terms of gender, age, education and financial situation. The selection of the participants was purposive; the respondents (42 people) were in the group of people buying and consuming probiotic food. The aim of the study was to collect information about the awareness of consumers on the nature and use of probiotic food in a rational diet and its impact on health.

The results of the study

A similar number of females and males participated in the study, although females (55.8%) were a relatively slightly larger group of respondents. The study population was fairly evenly matched in terms of age; the largest group of respondents was represented by people in the age range of 20–25 years (44.2%) and 26–42 years (26.9%). The largest group of respondents lived in cities with population over 200 thousand, while the second largest group of respondents lived in rural areas (28.8%). The dominant part of the research sample (63.5%) were employed people. Most of the respondents declared having higher (65.4%) and secondary education (32.7%).

When asked about their health status (Figure 2), most of the respondents declared it to be very good (34.6%) or good (42.3%).

Most of the respondents had no knowledge about the nature of pro- and prebiotics. Although only 11.5% of the respondents admitted that the terms pro- and prebiotic are completely unknown to them, only 42.3% of the respondents

declared that these terms are not alien to them. Unfortunately, none of the people surveyed had heard of a prebiotic (Figure 3).

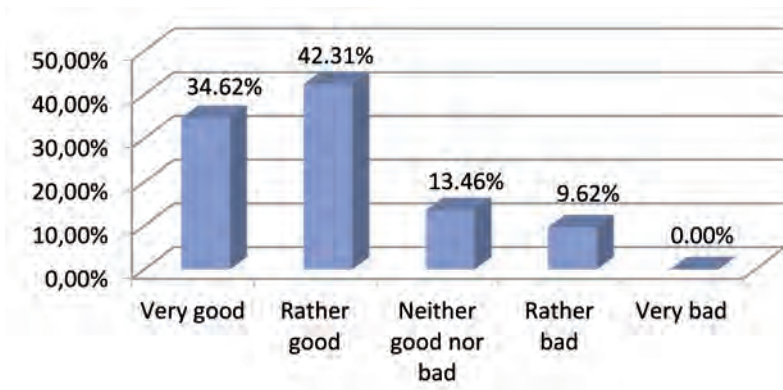


Figure 2. Declared health status

Source: own study.

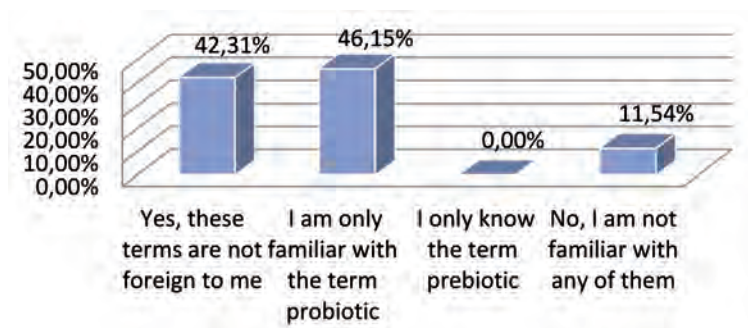


Figure 3. Knowledge of the terms pro- and prebiotic

Source: own study.

In addition, the results of the study showed (Figure 4). that the difference between pro- and prebiotic was known to only 19.2% of the respondents, while as many as 73.1% of them, were aware that there was some difference, but could not indicate what.

From the results of the above survey, it could be concluded that it might be a purposeful but not easy task for the respondents to indicate the correct definition of a probiotic (Figure 5).

The results showed that the definition of probiotic was problematic for the respondents. Less than half of them (23 people i.e. 44.2%) marked the right definition (Figure 5).

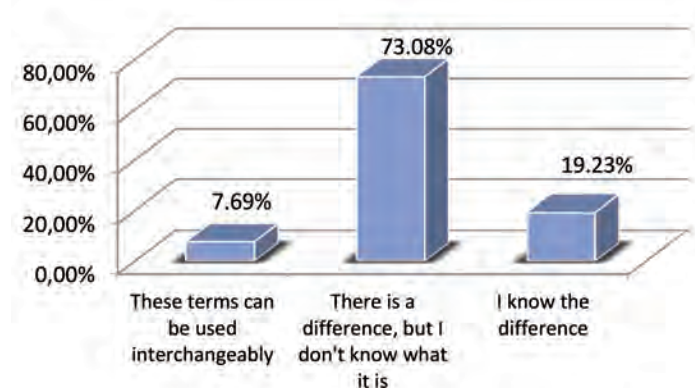


Figure 4. Knowledge of the difference between pro- and prebiotic

Source: own study.

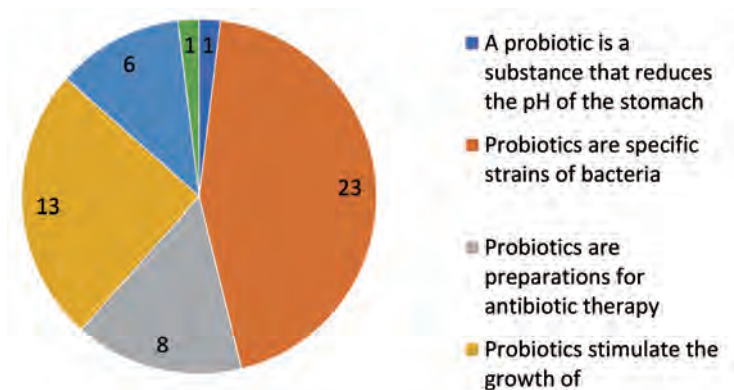


Figure 5. Definition of probiotic indicated by respondents [in the number of responses]

Source: own study.

When asked about the positive effect of probiotics on improving health, 69% of the respondents, answered unequivocally that they have a positive effect on health (Figure 6).

Similar results were obtained for respondents' opinions about the importance of probiotic foods (Figure 7).

Almost 80% of the respondents stated that probiotic foods have a health-promoting effect on the human body. A consequence of this opinion was that a significant proportion of the respondents (64%) declared that they use the food during antibiotic therapy, with 31% also supporting themselves with probiotics purchased from a pharmacy (Figure 8).

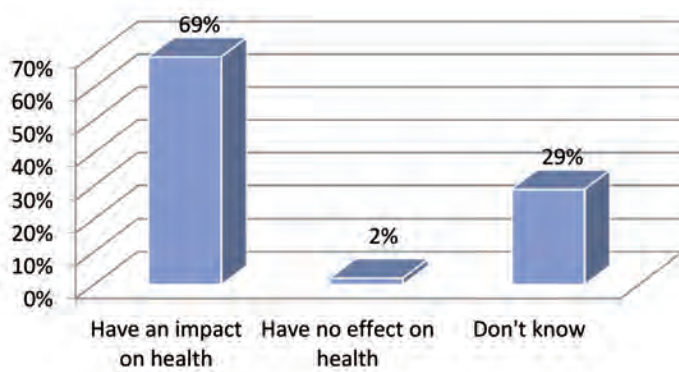


Figure 6. Effect of probiotic use on health improvement according to respondents

Source: own study.

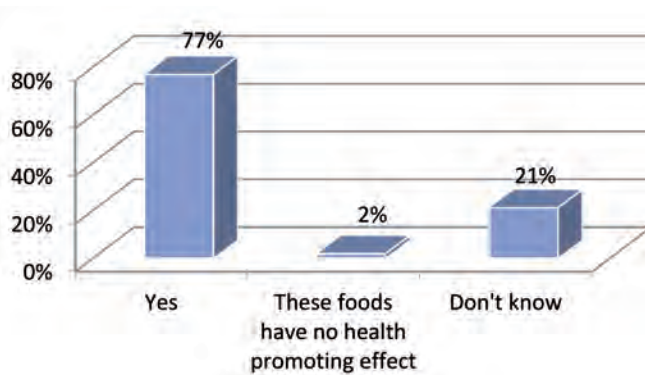


Figure 7. Health-promoting properties of probiotic foods in the opinion of respondents

Source: own study.

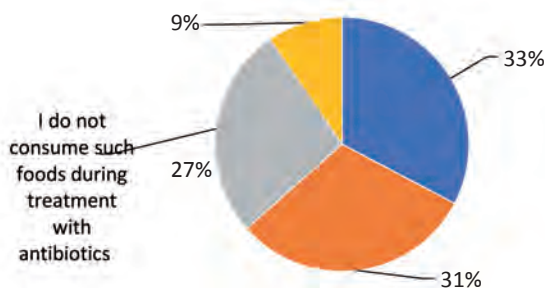


Figure 8. Use of probiotic foods during antibiotic therapy

Source: own study.

The next part of the study was aimed only at people who declared that they take or have taken probiotics and/or prebiotics in the past. Questions about the reasons or purpose of taking the above mentioned preparations were completed by 43 respondents.

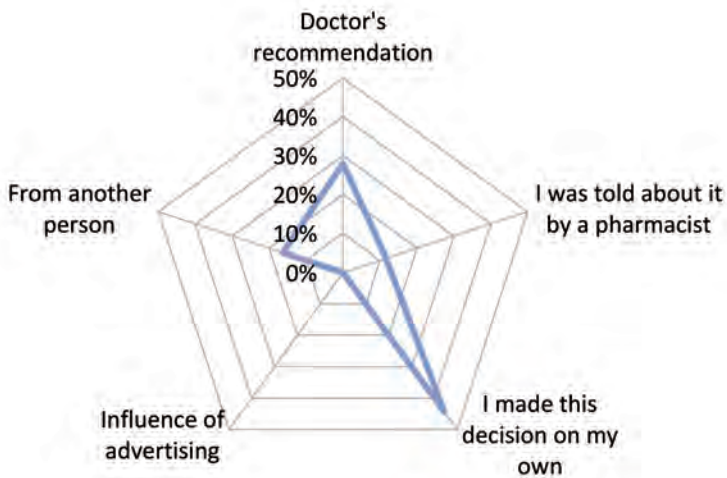


Figure 9. Source of decision to use probiotics

Source: own study.

The basic decision to use probiotics was influenced by the respondents themselves (44%) (Figure 9), some of them suggested a doctor's recommendation (28%). This decision was not influenced by advertising.

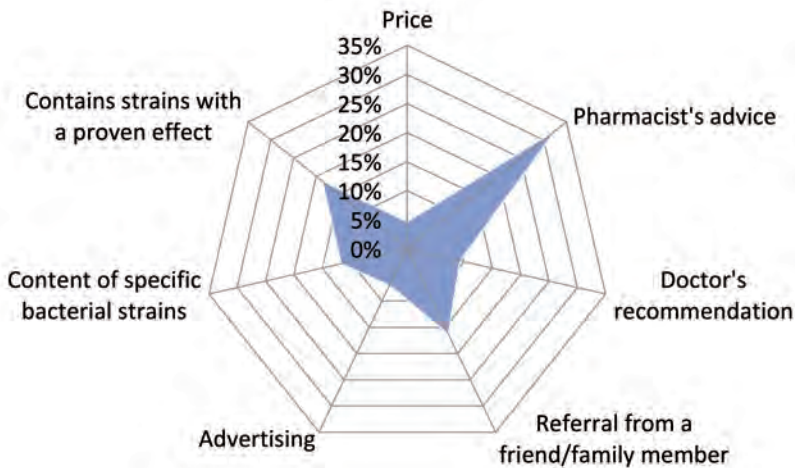


Figure 10. Factors influencing the choice of probiotic

Source: own study.

The further study revealed that when purchasing a probiotic (Figure 10), it were the respondents who were mainly guided by the advice of the pharmacist (33%).

The reason for reaching for probiotics by respondents (Figure 11) was mainly the need for protection during antibiotic therapy (79%). The use of probiotics by the respondents was also due to the desire to restore the natural microflora of the body (49%), which in a way is associated with antibiotic therapy, which sterilizes the intestinal microflora of the host. The reason for using probiotics by the respondents (Figure 11) was mainly the need for protection during antibiotic therapy (79%). The use of probiotics by respondents was also caused by the desire to rebuild the natural microflora of the body (49%), which in a way is associated with antibiotic therapy, which sterilizes the intestinal microflora of the host.

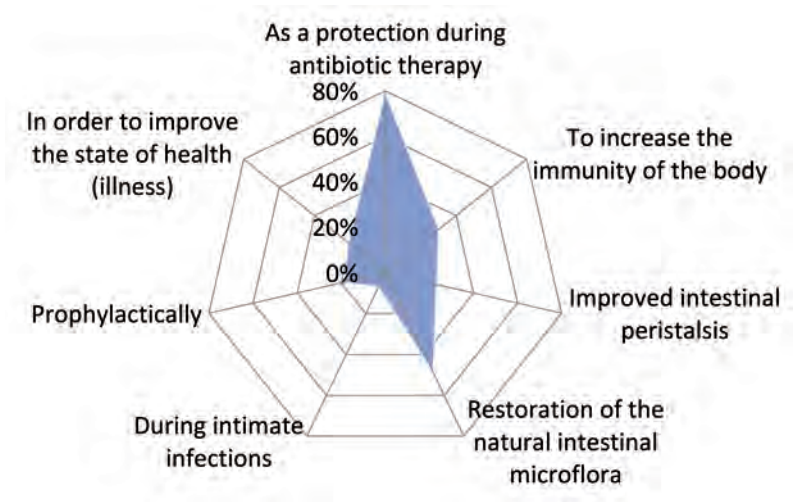


Figure 11. Reasons for reaching for post-probiotics

Source: own study.

The study showed that the primary place of purchase of probiotics and probiotic food was pharmacies (77%).

Conclusions

A detailed analysis of the study results shows that among the respondents who declared a good knowledge of the difference between a pro- and a prebiotic, 90% indicated the correct definition of a probiotic. However, among those who declared that they knew the difference between these terms, but could not indicate which one, 39% gave the correct answer about the essence of a probiotic and 63% about a prebiotic. The analysis of this question allows us to note that a significant proportion

of respondents (73%) cannot indicate the difference between pro- and prebiotic, and some of them interchanged their definitions. It is worth noting that among the respondents suffering from various diseases, 93% are taking or have taken probiotics/probiotic foods. They are eager to use such foods. The most frequently mentioned diseases include hypertension, atopic dermatitis, psoriasis, irritable bowel syndrome, depression, allergies, asthma, and thyroid disease. It is worth emphasizing that many of them are classified as civilization diseases. The research has shown that consumers use probiotic food during antibiotic therapy (33% of responses), and a similar group (31%) consumes such food in such circumstances, but they also support themselves with probiotic preparations bought at the pharmacy. Among the respondents who declared taking such foods, as many as 79% of them said that they use probiotic foods and probiotics as a shield during antibiotic therapy.

Analysis of the study results allows us to make some observations and indications. A small number of respondents declared taking probiotic foods/probiotics prophylactically. The introduction of information leaflets in this regard could be a good idea. The respondents pointed out a certain lack of information on prebiotics, e.g. in advertisements or recommendations of doctors/pharmacists. It would be worthwhile to inform clients/patients in detail and more often about the need to use them in order to nourish the beneficial microflora inhabiting the gastrointestinal tract.

References

- Biernat, J. (2001). *Żywnienie, żywność a zdrowie*. Wrocław: ASTRUM, 87–89.
- Błaszczak, A., Grześkiewicz, W. (2014). Żywność funkcjonalna – szansa czy zagrożenie dla zdrowia?, *Medycyna Ogólna i Nauki o Zdrowiu*, t. 2, nr 2, 214.
- Borycka, B. (2009). Functional properties of aronia pomace preparations. *Towar. Probl. Jakości*, 2, 56–63.
- Borycka, B. (2015). *Żywność nowej generacji – specjalnego zastosowania*. In: R. Borek-Wojciechowska (ed.), *Nowoczesna żywność część II*. Radom: Wydawnictwo Uniwersytetu Technologiczno-Humanistycznego, 11–43.
- Grajeta, H. (2004). Żywność funkcjonalna w profilaktyce chorób układu krążenia. *Adv Clin Exp Med*, 13, 3, 503–510.
- Jew, S., AbuMweis, S.S., Jones, P.J. (2009). Evolution of the human diet: linking our ancestral diet to modern functional foods as a means of chronic disease prevention. *J. Med. Food*, 12, 925–934.
- Karwowska, A., Bogacz, A. (2007). Żywność funkcjonalna w Polsce – dziś i jutro. *Przemysł Farmaceutyczny i Owocowo-Warzywny*, 12, 22.

Karpińska-Tymoszczyk, M., Danowska-Oziewicz, M., Draszanowska, A., Kurp, L., Skwarek, A. (2016). *Analiza postaw konsumentów wobec żywności pro biotycznej*. Bromat. Chem. Toksykol. – xlix, 3, 506–510.

Kasprzak, K., Niziński, P., Widelska, G. (2018). *Probiotyczna żywność funkcjonalna – wybrane prozdrowotne zastosowania*. In: E. Bednarski J., et al. (ed.), *Nauki Przyrodnicze i Medyczne: Żywnienie, sport oraz zdrowie*. Lublin: Instytut Promocji Kultury i Nauki Dr Jerzy Bednarski, 38–48, [http://Nauki Przyrodnicze i Medyczne: Żywnienie, sport oraz zdrowie \(CI\)](http://Nauki Przyrodnicze i Medyczne: Żywnienie, sport oraz zdrowie (CI)).

Kołożyn-Krajewska, D., Libudzisz, Z. (1999). *Jakość mikrobiologiczna żywności funkcjonalnej w aspekcie jej zdrowotności*. *ŻYWNOSĆ. Nauka. Technologia. Jakość. Suplement*, 4(21), 40.

Kołożyn-Krajewska, D. (2001). *Żywność probiotyczna w aspekcie bezpieczeństwa zdrowotnego*. *ŻYWNOSĆ. Nauka. Technologia. Jakość. Suplement*, 08, 4, 93–105.

Kołożyn-Krajewska, D., Tkaczyk, S., Salerno-Kochan, R., Witkowski, K., Śmigielska, H., Drzewieniecka, B., Jastrzębska, M., Kuzincow, J. (2016). *Towaroznawstwo 2.0 Potencjał innowacyjnego wzrostu*. Poznań: Komisja Nauk Towaroznawczych Polskiej Akademii Nauk, 13.

Nowak, A., Śliżewska, K., Libudzisz, Z. (2010). *Probiotyki – historia i mechanizmy działania*, *ŻYWNOSĆ. Nauka. Technologia. Jakość*, 4(71), 5–19.

Pucek, M. (2017). *Żywność nowej generacji – funkcjonalna, wygodna, transgeniczna*, CDR, Brwinów, 3, www.cdr.gov.pl [07.03.2019].

Śliżewska, K., Nowak, A., Barczyńska, R., Libudzisz, Z. (2013). *Prebiotyki – definicja, właściwości i zastosowanie w przemyśle*, *Żywność. Nauka. Technologia. Jakość*, 1(86), 5–20.

Świderski, F. (red.) (1999). *Żywność wygodna i żywność funkcjonalna*. Warszawa: Wydawnictwo Naukowo-Techniczne, 300–301.

Świderski, F. (red.) (2006). *Żywność wygodna i żywność funkcjonalna*. Warszawa: WNT.

Szponar, L. (1994). *Jakość zdrowotna żywności i racjonalne żywienie w zapobieganiu chorobom na tle wadliwego żywienia*. *Żyw. Człow. Metab.*, 1, 3–15.

Toffler, A. (1997). *Trzecia fala*. Warszawa: Państwowy Instytut Wydawniczy, 56.

4

THE REUSE OF FOOD IN THE HOUSEHOLDS IN THE OPINION OF RESPONDENTS

Izabela Cichocka¹, Jan Krupa¹, Andrzej Mantaj²

Abstract

Nowadays most societies are characterized by the attitude of consumerism, whose income is a derivative of the growth of consumption and not the increase in production. This phenomenon contributes to the overproduction of food its wastage. According to national statistics, one-third of purchased food items are wasted. The aim of this article is to present the respondents' opinions on the frequency and reduction of the amount of perishable food purchases and the universality of its re-use. A survey (n = 486) was conducted in the Podkarpackie Voivodeship. Pearson's chi-square test of independence was used to statistically evaluate the differentiation of respondent' opinions. Food wastage resulted from unsatisfactory quality of food products related to changes taking place in it during storage. Consumer errors (too large quantities of food purchased, too large portions of prepared meals, not paying attention to the use-by date) also contributed to food wasting. Statistically significant degree of re-use of products increases with the increase in the number of people in the household. The inconvenience of the re-use of food decreased with the age of the respondents and deterioration of the material situation. It seems reasonable to undertake actions aimed at improving the food system.

Keywords:

food wastage, food reuse, households, surveys

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Introduction

In 2017, the global population exceeded seven billion people and this phenomenon represents an upward trend (Current World Population, 2021). It is estimated that the population will reach 9.7 billion by 2050. As a result of the aforementioned phenomenon, the demand for food may increase by 60% (Martinez-Palou & Rohner-Thielen, 2011). In the meantime, experts from the FAO (Food and Agriculture Organisation of the United Nations) estimate that one third of food produced is lost or wasted all over the world. It constitutes approximately 1.3 billion tonnes (Pinstруп-Andersen, *et al.* 2021).

In Europe, 100 million tonnes of food products are thrown away on an annual basis. The estimated data obtained for the European Commission show that there is 173 kg of wasted food per one EU citizen (Stenmarck, *et al.* 2016). Meanwhile, the average amount of food produced in the member states of the European Union (EU) is 865 kg per person and thus in the aforementioned area 20% of the world food resources are wasted (Food Balance Sheet, 2021). On the scale of Poland nearly 9 million tonnes are wasted (Report: Don't waste food, 2020). Households themselves waste 2 million tonnes (especially in the towns) and the remaining 7 million tonnes are thrown away during the production or distribution process. According to estimated data, this number translates into 18 billion meals which could be distributed among 2 million people living in poverty. Only in Poland, approx. 1.8 million citizens have no opportunity to eat a hot meal every day due to their troubled material situation (Bieńkuńska, 2017).

In order to present the scale of the wastage problem in Poland, the Food Bank Report has been prepared, commissioned by the Federation of Polish Food Banks (FPFB). The national community of all 32 Food Banks has been making attempts to minimise food waste for 20 years. In this respect it has been cooperating with the commercial chains for a long time, working out the appropriate food collection procedures. According to the statistics included in the aforementioned report elaborated by the Food Banks, these organisations save approximately 80 thousand tonnes of food suitable for the human consumption annually, distributing it to 1.6 million people in need (Report: Don't waste food, 2020).

According to the provisions of the Act of 10 July 2018 19 July 2019 on Counteracting Food Waste, concerning the prevention of food waste, food sellers who operate a business with a surface area of more than 250 m² are required to enter into a contract to transfer food free of charge for the social purposes (Act on counteracting food waste, 2019). Furthermore, under Art. 5, charges for wasting food have been introduced. The charge may be reduced by the costs incurred by the seller related to conducting educational and information campaigns promoting prevention of food waste. Moreover, costs related to transport or distribution of foodstuff are deducted.

According to the current data published in 2018 by the FPPF, nearly half of the population (42%) admits to throwing away food. Within a month, a statistical Pole throws away about 4 kg of food that could still be partially used for human consumption. The main reasons for such a situation include, inter alia, a too large volume of purchases in relation to the current needs, an increase in the society's wealth and a lack of awareness and skills concerning food secondary management. Drawing attention to the issue of food waste and indicating the possibilities of its creative use are the primary activities undertaken by the Food Banks (Report: Don't waste food, 2020).

According to the national statistics, one third of the purchased food is wasted due to a fact that an expiry date is exceeded and a lack of skills to manage foodstuff. Moreover, many Poles do not have sufficient knowledge concerning a proper food storage; the most frequently wasted products include breadstuff (49%), fruit (46%) and highly processed meat (45%) (Bilska, *et al.* 2015).

In accordance with a classification proposed by Beretta, *et al.* food waste can be divided into three categories such as avoidable losses, possibly avoidable losses and unavoidable losses (Beretta, *et al.* 2013). The first of these categories refers to food and drinks thrown away due to their poor quality related to the perishing. The second group refers to products that are wasted by a certain group of consumers because of the organoleptic characteristics that are not appropriate to them, such as shape, colour or smell. The not edible parts of foodstuff under the normal circumstances are included in the 'unavoidable' group. The above classification may be useful in indicating the main reason for the loss of food masses intended for the consumption.

The objective of this paper is to present the respondents' opinions on the frequency and reduction of purchases of perishable foodstuff and the reasons for throwing away and thus wasting food. Moreover, an analysis of the prevalence, manners and limitations of food reuse and their determinants is presented.

Materials and methods

The analysis of the studied phenomena has been based on the results of the questionnaire survey conducted among 486 persons from the south-eastern part of Poland, mainly from Subcarpathia Province. From among the responses given in the survey questionnaire, the respondents have chosen one or have given ranks to these responses on a two- or three-grade scale, assigning 1 to the most important response(s). The respondents have been divided into groups, distinguished by sex, age (≤ 25 , 26–45 and > 45 years old), material situation of the household (poorer and better), a number of persons in a shared household

(1–2, 3–4 and >4) and a place of residence (villages/towns with up to and over 50 thousand inhabitants).

In the first part of the analysis, the frequencies of statements related to consumer behaviour, storage methods and processing of perishable foodstuff have been characterised. The scale of the reused food processing has been analysed, too. The second part of the analysis has been dedicated to the description of statistically significant correlations between the respondents' characteristics and the responses given by them. The nature of the data obtained has enabled them to collect it in the two-dimensional contingency tables with two or three rank categories in respect of the responses and variants of characteristics that describe the groups of the respondents.

A non-parametric χ^2 test has been used to statistically assess the variation in responses in the contingency tables. Prior to proceeding to verify a measure of the association between the variables on which the tables have been based, the null hypothesis of an independence of these variables has been assumed. While assuming p_{ij} as the probability that a randomly selected element belongs to class i and j due to the two variables included in the table, and p_i and p_j as the marginal probabilities in the rows and columns, the null hypothesis is formulated Aczel (2017).

$H_0: p_{ij} = p_i p_j$ for the indicators i, j , and the alternative hypothesis can be expressed:

$H_1: p_{ij} \neq p_i p_j$ for some pairs of indicators i, j .

The corresponding marginal probabilities have been estimated according to the formulas:

$$\hat{p}_{ij} = n_{i.} / n \quad \text{and} \quad \hat{p}_j = n_{.j} / n$$

The expected values in the analysed table, assuming the independence of the variables, have been determined as follows:

$$\hat{n}_{ij} = n \hat{p}_{i.} \hat{p}_{.j} = n(n_{i.} / n)(n_{.j} / n) = (n_{i.} n_{.j}) / n$$

The statistics of the χ^2 test has been calculated taking into account the Yates correction for 2x2 (Jóźwiak & Podgórski, 2014). The number of degrees of freedom has been determined as the product of the numbers of columns and rows in the tables minus 1. The null hypothesis has been rejected at the significance level $\alpha = 0.05$, when $\chi^2 \geq \chi^2_{\alpha, (k-1), (l-1)}$. Its magnitudes, denoted by the symbols '*' or '**', corresponded to a statistically significant (0.05) or strongly significant (0.01) relationship, which has been given in the tables next to each first value of the data describing the tested relationships.

Results of studies and their discussion

Tables 1 and 2 present the structure of the population under the study in terms of age, sex, number of persons in a shared household, material situation and place of residence.

These variables have been treated as the determinants of the analysed phenomena and have been used in the second part of the analysis.

The most numerous groups in the study have constituted people aged 25–45 years old. The majority of the study participants has been women (66%). The respondents mostly lived in the households consisting of 3–4 persons. In terms of a place of residence, a large part of the respondents has been from the rural areas (46.7%). The quantity of respondents who have assessed their material situation as poorer or better has been similar (48.8% and 51.2%, respectively).

Table 1. The characteristics of the surveyed persons

Itemisation		Number of persons	Percentage of persons
Age (in years)	<25	166	34.2
	25–45	243	50.0
	>45	77	15.8
Sex	women	321	66.0
	men	165	34.0
Number of persons in the household	1–2	103	21.0
	3–4	279	57.4
	>4	104	21.4
Place of residence	village	227	46.7
	town up to 50 thousand	126	25.9
	town over 50 thousand	133	27.4
Material situation	poorer	237	48.8
	better	249	51.2

Source: Authors' own study.

The phenomena under the study due to the prevalence of their occurrence have been characterized in the first part of the study, while the second part presents an assessment of the statistical significance of the relationships between these phenomena and their determinants. Due to the fact that not all respondents answered all the questions, the number of respondents is specified in the subject of each table. Taking into account that some products show a particular sensitivity

to the storage time, the frequency of purchases of perishable foodstuff has been analysed. Perishable foodstuff included the groups of food products such as meat, fish, dairy and fresh fruit and vegetables (Wrzosek, *et al.* 2014). Data on the frequency of purchases of this foodstuff (n = 486) is presented in Table 2.

Table 2. Frequency of shopping for perishable food items by respondents

Itemisation	Frequency of foodstuff purchase		
	daily	several times a week	once a week and less frequently
Number of persons	69	266	151
Percentage of persons	14.2	54.7	31.1

Source: Authors’ own study.

The studies have evidenced that more than half of the 486 persons surveyed purchase perishable foodstuff several times a week, and more than 14% do so on a daily basis. Due to the fact that purchasing too much perishable food is connected, among other things, with a higher risk of wasting it, the respondents try to limit their purchases of such products. The motives for this behaviour (n = 486) are presented in Table 3.

The vast majority of the surveyed persons (63.2%) report that controlling the amount of perishable food purchased is caused by the quick loss of freshness-related qualities. Thus, the results of the author’s study confirm the assumptions already mentioned in the work of Baretta, *et al.* (Beretta, *et al.* 2013). According to the authors of this paper, a deterioration of quality related to the time of transport and storage of food products is the main reason for the so-called ‘possibly avoidable losses.

Table 3. Reasons of limiting their purchases of perishable foodstuff by respondents

Prevalence of the phenomenon	Reasons for limiting purchases		
	preference for freshness	a lack of space to store products	limited possibilities to extend product shelf life
High	63.2	20.2	16.7
Average	20.8	37.2	42.0
Low	16.0	42.6	41.4

Source: Authors’ own study.

Furthermore, approx. 20% of the respondents states that one of the most important determinants of the aforementioned behaviour is a lack of space for

storing this foodstuff. A slightly Lower percentage of persons (16.7%) consider that they do not have sufficient possibilities to prolong the shelf life of food products, regardless of the manner in which this could be done.

The respondents (n = 479) have declared different reasons for throwing away foodstuff (Table 4).

Table 4. Reasons for throwing away food items by survey respondents

Prevalence of the phenomenon	Reasons for throwing food away						
	excessive purchases	not tasty/poor quality	oversized portions of meals	missed expiry date	inappropriate storage	infrequent reprocessing of leftover food	random events of staying away from home
High	45.9	36.3	35.9	32.8	17.7	16.5	14.8
Average	33.8	47.0	52.2	44.3	56.8	43.0	23.0
Low	20.3	16.7	11.9	23.0	25.5	40.5	62.2

Source: Authors’ own study.

The main reason for food wastage by the respondents has been primarily the excessive shopping. This reason has been indicated by nearly half of the respondents (45.9%). More than 1/3 of the survey participants has declared that the main reason for throwing away purchased food is its poor quality (mainly bad taste). This may indicate the unpredictable cases of encountering poor quality food on sale. A similar part of the respondents (35.9%) indicated that they throw away food because of the habit of preparing too large meal portions. This phenomenon is accompanied by forgetting the need to pay attention to the expiry date specified by the producer. About 18% of the respondents has indicated a lack of ability to store food properly as the reason for thro

wing it away. The rare reuse of food products has been declared by 16.5% of the respondents, and approx. 15% has indicated an inability to consume purchased food products due to an unplanned departure from their place of residence.

The reasons for wasting food, indicated by the respondents in this study, correspond with the reports of other authors. The respondents in the study by Żyromska, *et al.* have cited the following reasons for wasting food: too much shopping or not paying attention to the expiry date (Żyromska, Bilska & Kołożyn-Krajewska, 2020). Similar answers have been given by the respondents of Jungowska, *et al.* (Jungowska, *et al.* 2021). Too large quantities of purchased food and a lack of skills to store it properly have been indicated in studies by Przezgórska-Skobiej and Wiza (2021) and Ananda, *et al.* (2021).

One of the questions in the survey concerned the extent of food reuse. The prevalence of such activities (n = 486) is presented in Table 5.

Table 5. Degree of reuse of resulting surplus food products from meals

Itemisation	Types of meals	
	lunches	other meals
Number of persons	262	224
Percentage of persons	53.9	46.1

Source: Authors' own study.

In the assessment of the respondents, the extent of reuse of the resulting surplus of the food products, in the event of the preparation of lunches, is only slightly higher than the extent of reuse of the food products used in the preparation of other types of meals.

Reusing food is one of the methods of reducing food waste. The frequency of such activities among the respondents (n = 486) is shown in Table 6.

Table 6. The frequency of food waste reuse

Itemisation	Prevalence of the reuse of food waste		
	sometimes	frequently	almost always
Number of persons	69	266	151
Percentage of persons	47.3	35.2	17.5

Source: Authors' own study.

The data presented shows that nearly half of the persons surveyed (47.3%) do not bother to reduce the throwing away of food products by reusing them. This may also be a result of avoiding situations where food is perished. The inefficient management of the food products involves a loss of pecuniary expenditures as well as human labour (Bilska, *et al.* 2015).

The varied methods are used with regard to the food reuse. The frequency of practicing the selected methods (n = 486) is shown in Table 7.

The most common (60%) method of food reuse taking place in the households has been indicated as reusing it to prepare the new meals. More than 1/4 of the respondents placed a high value on subjecting the recovered food to the thermal treatment, and circa 12% of the respondents continued to use it unchanged.

Table 7. The ways of reusing food waste (%)

Prevalence of the phenomenon	Reuse of food waste		
	become an ingredient of other meals	upon appropriate thermal treatment	in the unchanged form
High	60.3	27.6	12.1
Average	20.4	58.8	20.8
Low	19.3	13.6	67.1

Source: Authors' own study.

The respondents (n = 486) have been asked to identify the factors that limit the food reuse (Table 8).

Table 8. The factors limiting food reuse (%)

Prevalence of the phenomenon	Limitations related to prevention of food waste generation			
	poor quality and taste of meals	a lack of time	a lack of idea	tediousness of preparations
High	35.4	27.4	20.0	17.3
Average	24.7	17.5	23.7	34.2
Low	39.9	55.1	56.4	48.6

Source: Authors' own study.

The main limitation of the food reuse has been found to be a low quality and poor taste of the meals prepared with it (35.4%). This was followed by a lack of time (27.4%) and a lack of ideas on how to prepare meals properly (20%). Among the exclusion factors, the respondents have also distinguished the inconvenience of preparing the meals from the reused foodstuff (17.3%).

The second part of the analysis is presented below, in which only those phenomena have been included that associations with their determinants have proved to be statistically significant.

Among the several determinants for controlling the amount of perishable foodstuff purchased, the statistical association with the characteristics of the respondents has showed the importance attached to the freshness of these products. Table 9 shows the criterion for limiting the amount of the purchase of perishable foodstuff (n = 486), which is the preference for freshness.

As can be seen from the data in Table 9, the importance of food freshness decreases with the age of the respondents. A reduction in the volume of purchases of the perishable products and, at the same time, the less frequent discarding of

the food products among the older respondents has been noted in the study by Neffe-Skocińska, *et al.* (2020).

Table 9. The importance of freshness of the foodstuff – differentiation by age of the respondents (%)

Reason for limiting purchases	Significance of problem	Age of respondents		
		≤25	26–45	>45
Preference for freshness of products	high	20.5**	16.9	7.8
	average	49.4	35.0	48.0
	low	30.1	48.1	44.2

* significance at p = 0.05 , ** significance at p = 0.01
Source: Authors’ own study.

The main reasons for throwing away food products according to the characteristics of the respondents (n = 479) are given in Tables 10 and 11.

Table 10. The rank of reasons for throwing away foodstuff – differentiation by age, sex and number of persons in a household (%)

Reasons for throwing away food	Scale of problem	Respondents’ characteristics							
		age (in years)			sex		quantity of persons in household		
		≤ 25	26–45	> 45	F	M	1–2	3–4	> 4
Excessive purchases	high	37.7**	53.1	40.8			28.4**	49.7	53.4
	average	35.2	28.6	47.4			41.2	34.2	25.2
	low	27.1	18.3	11.8			30.4	16.1	21.4
Food storage	high	23.4**	11.6	25.0	15.1*	22.8			
	average	52.5	62.7	47.4	56.8	56.8			
	low	24.1	25.7	27.6	28.1	20.4			

* significance at p = 0.05, ** significance at p = 0.01
Source: Authors’ own study.

The most frequent reason for the generating of the thrown-away foodstuff among the persons surveyed has turned out to be too excessive purchases, which appears to a greater extent in the households shared by more persons, as well as those in the better material situation. In the former case, it could be associated with a greater difficulty in determining the size of purchases, while in the latter, it did not cause severe financial consequences for the family. Chalak, *et al.* (2019) observed

in their study that the amount of wasted food is higher in case of the households shared by more persons, too.

Table 11. The rank of reasons for throwing away foodstuff – differentiation by lace of residence and material situation of the respondents (%)

Reasons for throwing away foodstuff	Scale of problem	Respondents' characteristics				
		place of residence			material situation	
		village	town (population)		poorer	better
			< 50 thousand	> 50 thousand		
Excessive purchases	high				36.9**	54.5
	average				40.3	27.6
	low				22.8	17.9
Random stay away from home	high	10.3*	13.8	23.5		
	average	21.9	24.4	23.5		
	low	67.8	61.8	53.0		

* significance at $p = 0.05$, ** significance at $p = 0.01$

Source: Authors' own study.

The inappropriate food storage as a reason for food disposal has been indicated more often by men, as well as the oldest and the youngest persons. Among the inhabitants of larger towns, a statistically significant reason for wasting food was a random stay away from home.

The frequency of reusing food products depending on the characteristics of the persons surveyed ($n = 486$) is presented in Table 12.

Table 12. The frequency of reuse food waste – differentiation by number of persons in a household and place of residence (%)

Prevalence of reuse of food waste	Respondents' characteristics					
	quantity of persons in household			place of residence		
	1–2	3–4	> 4	village	town (population)	
					< 50 thousand	> 50 thousand
Sometimes	58.2**	49.4	30.8	39.2**	50.0	58.7
Frequently	24.3	36.6	42.3	39.7	34.9	27.8
Nearly always	17.5	14.0	26.9	21.1	15.1	13.5

* significance at $p = 0.05$, ** significance at $p = 0.01$

Source: Authors' own study.

The degree of the reuse of food products statistically significantly differentiated the groups of respondents distinguished by the household size and place of residence. It has increased with an increase in the quantity of persons sharing the household, and it has also been greater in the small towns. This phenomenon may indicate a sparer lifestyle led by these groups of persons. Thus, the better the social and economic situation (1–2-person household, larger towns), the lower the propensity to the food reuse, as demonstrated in their studies by Szabo-Bodi, *et al.* (Szabó-Bódi, Kasza & Szakos, 2018) and Aschemann-Witzel, *et al.* (2019).

The significance of the food reuse according to respondents’ characteristics has turned out to be statistically significant only when food has been used as an ingredient in newly prepared meals. The variation of this phenomenon by sex (n = 486) is illustrated in Table 13.

Table 13. The food reuse as an ingredient of other meals – differentiation by sex of the respondents (%)

Reuse of foodstuff	Prevalence of the phenomenon	Sex	
		women	man
Becomes an ingredient in other meals	high	62.0*	57.0
	average	21.8	17.6
	low	16.2	25.4

* significance at probability of p = 0.05 , ** significance at probability of p = 0.01

Source: Authors’ own study.

The reuse of food products as the ingredients in other meals has been found to be more common among women. Also, in the studies of Annunziata, *et al.* (2020) and Bilska, *et al.* (Bilska, Tomaszewska & Kołożyn-Krajewska, 2020), it has been women who has generated less food waste by using the food products a second time, to prepare other meals.

The aforementioned may be related not only to their greater experience in this area, but also to their greater patience in carrying out the necessary work for this purpose.

From among the four factors limiting the reuse of food given in the first part of the analysis, the separate groups of the respondents differed in a statistically significant manner in the degree of inconvenience of the use of this method of counteracting food waste. The opinions of the respondents (n = 486) concerning the inconvenience of food reuse are summarised in Table 14.

Table 14. The inconvenience of food reuse – differentiation by age and material situation of the respondents (%)

Limitations on the food reuse	Scale of problem	Respondents' characteristics (683)				
		age (in years)			material situation	
		≤25	26–45	>45	poorer	better
Inconvenience of food preparation	high	18.1**	17.3	15.6	16.9*	17.7
	average	23.5	38.7	42.8	29.1	38.9
	low	58.4	44.0	41.6	54.0	43.4

* significance at probability of $p = 0.05$, ** significance at probability of $p = 0.01$

Source: Authors' own study.

The inconvenience of preparing meals as a reason for limiting the reuse of foodstuff decreased with the age of the respondents and in the event of the poorer material situation of the households. It is, of course, an open question to what extent these opinions have resulted from the situation in which the respondents found themselves, and to what extent they have resulted from their beliefs about the problem considered here.

Summary and conclusions

The main reason for wasting food has been indicated as purchasing too many food products in relation to the possibility of consuming them. According to the respondents' declarations, they have been making such purchases several times a week.

Food wastage has been in the next order with the unsatisfactory quality of the food products connected with the changes occurring in them during the storage. The consumer mistakes have been also factors impeding the prevention of wastage. The aforementioned categories have included the too large portions of prepared meals and not paying attention to the expiry date. More than half of the persons surveyed (53%) have used various manners of the food reuse. It is unsatisfactory that less than half of the respondents have failed to pay much attention to the concerned problem. In the vast majority of the cases (60%) the reuse of foodstuff has consisted of their inclusion in the newly prepared meals. The reuse of the foodstuff has been definitely more important to the youngest and the oldest respondents.

Among the factors limiting the food reuse, the poor quality and taste of meals made with the foodstuff, followed by a lack of time, ideas and inconvenience of the meal preparation of the highest importance. The unused foodstuff has been

most often used to prepare lunches in the households with 3-4 members and among the inhabitants of the rural areas.

The willingness to preserve freshness of the perishable foodstuff as an argument for limiting the amount of the food products purchased have proved to be statistically related to the age of the respondents and has been declared more frequently by the younger people. Prominently, the most frequent reason for throwing away food has turned out to be its purchase in the excessive quantities, which in the statistical terms that are significant have occurred more often in the households consisting of more persons and also among persons that are in the better material situation.

The inadequate storage of the food products as a cause of wastage and a subsequent disposal has been indicated predominantly by men, as well as the oldest and the youngest persons. The degree of the reuse of the foodstuff increased with the quantity of persons in the household. Furthermore, it has been at the lower level in the larger towns. As an ingredient in newly prepared meals, these products have been used more often by women than by men. The indications of the inconvenience of the food reuse decreased with an increase in age of the persons surveyed. Moreover, they have occurred in case of a weaker material situation of the households.

The results of the authors' study correspond with the reports of the literature on the subject. The phenomenon of counteracting food waste requires continuous work on developing consumer awareness, and the responsibility for food waste lies with all food chain entities. Taking into account the factors that both impede and encourage the food reuse, the development of sustainable local consumption should be pursued. Having adequate awareness of the causes of losses, it is easier to develop appropriate measures to minimize food waste (Kołożyn-Krajewska, *et al.* 2014). In fact, it is still necessary to take the proper actions aimed at improving the global food system.

References

Act on counteracting food waste (2019). Ustawa z dnia 19 lipca 2019 r. o przeciwdziałaniu marnowaniu żywności (Dz. U. z 2019 r., poz. 1680).

Aczel, A.D. (2017). *Statystyka w zarządzaniu. Pełny wykład*. Warszawa: PWN.

Ananda, J., Karunasena, G., Mitsis, A., Kansal, M., Pearson, D. (2021). Analysing behavioural and socio-demographic factors and practices influencing Australian household food waste. *Journal of Cleaner Production*, 306, 127280.

Annunziata, A., Agovino, M., Ferraro, A., Mariani, A. (2020). Household Food Waste: A Case Study in Southern Italy. *Sustainability*, 12(4), 1495. <https://doi.org/10.3390/su12041495>.

Aschemann-Witzel, J., De Hooge, I., Amani, P., Bech-Larsen, T., Oostindjer, M. (2015). Consumer-Related Food Waste: Causes and Potential for Action. *Sustainability*, 7(6), 6457–6477, <https://doi.org/10.3390/su7066457>.

Aschemann-Witzel, J., Giménez, A., Ares, G. (2019). Household food waste in an emerging country and the reasons why: Consumer's own accounts and how it differs for target groups. *Resources, Conservation and Recycling*, 145, 332–338.

Beretta, C., Stoessel, F., Baier, U., Hellweg, S. (2013). Quantifying food losses and the potential for reduction in Switz. *Waste Management*, 33, 764–73.

Bieńkuńska, A. (2017). *Jakość życia w Polsce*. Główny Urząd Statystyczny, Departament Badań Społecznych i Warunków Życia. Łódź: Zakład Wydawnictw Statystycznych.

Bilska, B., Grzesińska, W., Tomaszewska, M., Rudziński, M. (2015). Marnotrawstwo żywności jako przykład nieefektywnego zarządzania w gospodarstwach domowych. *Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu*, 7(1), 39–43.

Bilska, B., Tomaszewska, M., Kołożyn-Krajewska, D. (2020). Analysis of the Behaviors of Polish Consumers in Relation to Food Waste. *Sustainability*, 12(1), 304, <https://doi.org/10.3390/su12010304>.

Chalak, A., Abiad, M., Diab, M., Nasreddine, L. (2019). The Determinants of Household Food Waste Generation and its Associated Caloric and Nutrient Losses: The Case of Lebanon. *PLoS One*, 14(12): e0225789, doi:10.1371/journal.pone.0225789.

Current World Population [online]. United Nations Population Division, World Health Organization (WHO), Food and Agriculture Organization (FAO), International Monetary Fund (IMF), and World Bank, <http://www.worldometers.info/world-population/> [17.06.2021].

Food and Agriculture Organization of the United Nations: Food loss and waste and the right to adequate food: Making the connection (2018). Roma: FAO Publishing.

Food Balance Sheets. The Food and Agriculture Organization, <http://www.fao.org/faostat/en/#data/FBS> (17.02.2021).

Jóźwiak, J., Podgórski, J. (2014). *Statystyka od podstaw*. Warszawa: PWE.

Jungowska, J., Kulczyński, B., Sidor, A., Gramza-Michałowska, A. (2021). Assessment of Factors Affecting the Amount of Food Waste in Households Run by Polish Women Aware of Well-Being. *Sustainability*, 13(2), 976, <https://doi.org/10.3390/su13020976>.

Kołożyn-Krajewska, D., Wrzosek, M., Bilska, B., Krajewski, K. (2014). *Ryzyko powstawania strat i marnotrawstwa żywności a możliwość ich ograniczenia*. Kraków: Polskie Towarzystwo Technologów Żywności.

Martinez-Palou, A., Rohner-Thielen, E. (2011). *Health and food safety statistics*. Luxembourg: Statistical Office of the European Communities Office of the European Union.

Raport Nie marnuj jedzenia (2020). Federacja Polskich Banków Żywności, https://bankizywnosci.pl/wp-content/uploads/2020/10/Raport_NieMarnujJedzenia_2020.pdf (20.06.2021).

Neffe-Skocińska, K., Tomaszewska, M., Bilska, B., Kołożyn-Krajewska, D. (2020). Zachowania starszych konsumentów wobec zjawiska marnotrawstwa żywności. *ŻYWNOSĆ. Nauka. Technologia. Jakość*, 27, 1(122), 122–136, doi:10.15193/zntj/2020/122/327.

Pinstrup-Andersen, P., Rahmanian, M., Allahoury, A.M., Hendriks, S.G. *HLPE Reports series*. www.fao.org/cfs/cfs-hlpe/ [17.06.2021].

Przezbórska-Skobiej, L., Wiza, P. (2021). Food Waste in Households in Poland – Attitudes of Young and Older Consumers towards the Phenomenon of Food Waste as Demonstrated by Students and Lecturers of PULS. *Sustainability*, 13(7), 3601, <https://doi.org/10.3390/su13073601>.

Stenmarck, Å., Jensen, C., Quedsted, T., Moates, G., Buksti, M., Cseh, B. (2016). *Estimates of European food waste levels*. Stockholm: European Commission (FP7), Coordination and Support Action-CSA.

Szabó-Bódi, B., Kasza, G. Szakos, D. (2018). Assessment of household food waste in Hungary. *British Food Journal*, 120(3), 625–638, <https://doi.org/10.1108/BFJ-04-2017-0255>.

Toma, L., Costa Font, M., Thompson, B. (2020). Impact of consumers' understanding of date labelling on food waste behaviour. *Operational Research – An International Journal*, 20, 543–560, <https://doi.org/10.1007/s12351-017-0352-3>.

Wrzosek, M., Bilska, B., Kołożyn-Krajewska, D., Krajewski, K., Kondraszuk A. (2014). Określenie skali i przyczyn strat żywności w handlu detalicznym na przykładzie mleka i jego przetworów. *ŻYWNOSĆ. Nauka. Technologia. Jakość*, 93(2), 225–238.

Żyromska, E., Bilska, B., Kołożyn-Krajewska, D. (2020). Wybrane zwyczaje zakupowe mieszkańców województwa łódzkiego jako przyczyna marnotrawstwa żywności. *ŻYWNOSĆ. Nauka. Technologia. Jakość*, 27, 3(124), 143–157, doi:10.15193/zntj/2020/124/354.

ANALYSIS OF THE CONSUMPTION OF SELECTED FOOD PRODUCTS THROUGH THE CONCEPT OF MARKET SEGMENTATION

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Abstract

The purpose of the present research was to identify the socio-geographical market segments that are the most appealing to producers due to the high consumption of vegetables preserves and juices based on fruits and vegetables. The research employed secondary data provided by Polish Statistical Office through the online database. In order to compare the variance in the group means within a sample the one-way ANOVA was used and it was followed by Tukey post hoc tests. In the case of fruit and vegetable juices, the marketing efforts should primarily be directed to well-educated marriages with one child doing non-manual workers or being self-employed and consumers living in cities over 500 thousand citizens. In the case of vegetable preserves, dry vegetables and mushrooms preparations they should primarily be directed to retirees, households without children and individuals having higher education as well as to consumers living in the cities from 200 to 499 thousand citizens. The research may constitute a general basis for the market segmentation performed by the companies offering juices and preserves, as it indicates the market segments in which individuals consume the most of the above products.

Keywords:

market segmentation, food products, Poland, fruit and vegetable juices, vegetable preserves

Introduction

Fresh fruits and vegetables, as well as different products based on them like juices or preserves, are essential components of a healthy diet. Foods of fruit or vegetable origin are characterized by a high content of biologically active compounds, e.g. vitamins, polyphenols, minerals, plant sterols, dietary fibres

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(Septembre-Malaterre, *et al.* 2018). According to the World Health Organization (FAO/WHO, 2004) daily recommended intake of fruits and vegetables should be more than 400 g to improve the overall health and reduce the risk of some non-transmissible chronic diseases. Diets rich in fruits and vegetables contribute to reducing the risk of developing numerous diseases, like coronary heart disease, diabetes, obesity or stroke. Considering the positive influence of fruits, vegetables and products based on them, their consumption has received much attention, recently (Vereecken, *et al.* 2015). Therefore, many countries, including Poland, have implemented specific campaigns, strategies and programs (like: “5 servings of vegetables, fruit or juices!”, “Fruits in school”, “Juices and mousses – vitamins in the SMART form” or “Unusual properties of ordinary fruits”) to increase the consumption of fruits and vegetables among the populations. Moreover, increasing consumers’ health awareness, changes in eating habits and emerging nutritional trends like veganism or vegetarianism contribute to the greatest interest in the factors affecting the consumption of fruits, vegetables, juices or preserves among scientists and producers (Granato, *et al.* 2010).

Currently, there were relatively few scientific attempts to analyze the consumption of fruits and vegetables on the Polish market through the lens of market segments. The two studies identified reported the diversification of the level and structure of expenditure as well as the overall consumption of fruits and vegetables depending on the type of household (Jäder & Wawrzyniak, 2016; Murawska, 2018). However, in these studies, only the basic descriptive statistic tools were employed, which severely limited their explanatory power. Therefore, up to date, no attempt was undertaken to test if there were statistically significant differences between different groups of consumers of fruit and vegetable juices and vegetable preserves. Consequently, the current research problem is contained in the following question: what is the relation between socio-geographical characteristics and the consumption of fruit and vegetable juices and vegetable preserves? The purpose of the present research was to identify the socio-geographical market segments that are the most appealing to producers due to the high consumption of fruit and vegetable juices and vegetable preserves. The results indicate that in the case of fruit and vegetable juices the marketing efforts should primarily be directed to well-educated marriages with one child doing non-manual work or being self-employed and consumers living in the cities over 500 thousand citizens. In the case of vegetable preserves, dry vegetables and mushrooms preparations they should primarily be directed to retirees, households without children and individuals having higher education and consumers living in the cities from 200 to 499 thousand citizens.

The groundbreaking work of Smith (1956) has contributed to changing the perception of customers by enterprises. Considering numerous benefits for companies (e.g. superior understanding of customers and competitors, increase

in the profitability of market operations, allocations resources more effectively) coming from market segmentation, this approach has become a fundamental principle of marketing concepts (Dibb, *et al.* 2002).

The concept of market segmentation assumes a division into relatively homogenous groups of buyers characterized by similar purchasing preferences, service or product needs. From the company's point of view market segmentation is a useful and strategic tool that allows companies to gain a competitive advantage over their competitors. Identification of unique needs and attitudes of consumers in various segments allow the enterprises to implement specific and favourable activities (Aljukhadar & Senecal, 2011; Füller & Matzler, 2008). According to Kotler & Keller (2012) marketing research conducted by companies includes three basic stages: (1) market segmentation, (2) choice of the target market and (3) product positioning. The first step involves a determination of the segmentation base and characterization of the segment profile created. Subsequently, each of the divided segments is strictly evaluated in terms of attractiveness and potential benefits for the company, which leads to the selection of final, target segments. The last stage is based on determining, selecting and developing a specific product positioning concept for each of the selected target segments (Kotler & Keller, 2012).

In most cases, consumers may be considered as groups, classified according to geo-demographic characteristics and assumed to have familiar needs and attitudes. Basic criteria of customer segmentation include both observable and unobservable variables. The following factors are included in the first group: geographical (territorial range, size of the city, population density or climate), demographic (age, gender, education, social class, nationality, family size, family development phase and religion) and socioeconomic (income, social class, education and occupation). The latter variable contains life style, personality or value system (Wedel & Kamakura, 1998; Goyat, 2011; Kotler & Keller, 2012).

Considering the dynamic changes in the market i.e. globalization, direct marketing approaches or micro marketing, it is important to implement the most effective and profitable methods of market segmentation. The important consideration here is that the market segmentation should follow a certain logic, i.e. from the simple to the more sophisticated criteria. No doubt, the geographic and demographic segmentation is a foundation of market segmentation and the analysis concerning life style, personality or value system constitutes its further development and deepening. Thus, in the light of the lack of previous studies analyzing the consumption of fruits and vegetable juices and preserves on the Polish market through the lens of market segments, it appears rational to base the present study on the most fundamental bases of segmentation.

The article is structured as follows. The first chapter presents the current conceptual background behind the market segmentation, with special regard to

socio-geographical criteria. The second chapter explains the method of empirical research and provides the reader with the details of the study. Next, the paper presents the empirical results against the current research in the field. The paper terminates with conclusions.

Methods

In order to identify the socio-geographic market segments related to fruit and vegetable juices and vegetable preserves, the secondary data provided by Polish Statistical Office was employed. It presented the average yearly consumption of: (1) fruit and vegetable juices and (2) vegetable preserves, dry vegetables, mushrooms preparations. With respect to the previous studies and the availability of data, four criteria of customer segmentation were selected. Based on the adaptation of previous results, the research covered such cross sections as: (1) socio-economic groups (Albayrak & Aslan, 2009), (2) biological type of household (Albayrak & Aslan, 2009; Riediger & Moghadasian, 2008) (3) level of education of the reference person (Riediger, *et al.* 2007, Czernyszewicz, 2009) (4) households by class of locality (Riediger, *et al.* 2007; Hempel & Hamm, 2016). The data is publicly available and was obtained in the third quarter of 2019 through the online database provided by Polish Statistical Office.

The subject of the research was the relation between socio-geographical characteristics and the consumption of vegetables preserves and juices. The spatial scope of the research encompassed Poland. The time scope was determined as 2010 – 2018 due to the data availability in Polish Statistical Office. The organization of data prior to 2010 was different and several of the studied characteristics are missing. Moreover, gathering yearly observations in such a time frame guarantees that the minimal number of observations for the ANOVA to be run is collected, i.e. in each situation the sample size is at least one more than the number of groups.

To differentiate the market into homogeneous segments based on the consumption of fruit and vegetable juices and vegetable preserves several one-way independent analyses of variance (ANOVA) were used. The one-way ANOVA employed is a kind of statistical test, which compares the variance in the group means within a sample. Importantly, it considers only one independent variable. The purpose of ANOVA is to evaluate multiple mutually exclusive theories about the data, which makes it a hypothesis-based test. The one-way ANOVA was used as there was only one independent variable, i.e. “average monthly consumption per capita”. Moreover, the analyses were followed by Tukey post hoc tests. ANOVA was used to test if there were statistically significant differences between groups. Post-hoc comparison revealed between which groups the differences were statistically significant. The hypothesis testing was further complemented

by the descriptive statistics calculated. All the calculations were performed with the use of IBM SPSS Statistics 25.

Results

A one-way between subjects ANOVA was conducted to compare the effect of socio-economic groups, the type of biological households, the households by the level of education of the reference person and the class of household locality on medium monthly consumption of fruit and vegetable juice. The results are reported in Table 1. In addition, the descriptive data are provided in Table 2. There were statistically significant differences between groups was determined by one-way ANOVA [$F(5.48) = 117.506$, $p = 0.00$ for socio-economic groups, $F(4.40) = 35.28$, $p = 0.00$ for type of biological households, $F(3.32) = 165.609$, $p = 0.00$ for the level of education of the reference person, $F(5.48) = 29.065$, $p = 0.00$].

Table 1. One-way ANOVA for the fruit and vegetable juice consumption across the socio-economic groups, the type of biological households, the households by level of education of the reference person and class of the household locality

Groups		Sum of Squares	df	Mean Square	F	Sig.
Socio-economic groups	Between Groups	3.611	5	0.722	117.506	0
	Within Groups	0.295	48	0.006	–	–
	Total	3.906	53	–	–	–
Type of biological household	Between Groups	1.146	4	0.287	35.28	0
	Within Groups	0.325	40	0.008	–	–
	Total	1.471	44	–	–	–
Level of education of the reference person	Between Groups	3.327	3	1.109	165.609	0
	Within Groups	0.214	32	0.007	–	–
	Total	3.542	35	–	–	–
Class of the household locality	Between Groups	1.590	5	0.318	29.065	0
	Within Groups	0.525	48	0.011	–	–
	Total	2.115	53	–	–	–

Source: own development.

Post-hoc comparison using the Tukey test indicated that the mean score for non-manual labour position ($M = 1.28$, $SD = 0.10$) was significantly different than the manual labour position, farmer, retirees and pensioners conditions. However, the self-employed condition ($M = 1.23$, $SD = 0.08$) did not significantly differ from the manual labour condition. Taken together, these results suggest that the socio-economic groups to which individuals belong do have an effect on the quantity of fruit and vegetable juice consumed. While people doing the non-manual works and the self-employed consume the most, these are farmers that consume the less.

Analysis of variance was also carried out depending on the type of biological household – marriage without children, marriage with dependent children (one, two, three and more) and mother or father with dependent children. Statistically significant differences at the $p < 0.5$ were observed between the type of biological household and the consumption of juices based on fruit and vegetables. Moreover, the data from descriptive statistic (Table 2) imply that the type of household essentially determines the consumption of fruit and vegetable juices. Marriages with one child and two children consume the most juices, $M = 1.29$ and $M = 1.16$ respectively. However, it seems surprising that marriages with three or more children consume the least juices ($M = 0.82$). According to Tukey's post-hoc comparison, the mean score for the position of marriages with one child ($M = 1.29$, $SD = 0.08$) was significantly different from all conditions.

Also, this study clearly indicates that class of household locality has a great impact on the consumption of juices. Mainly in large agglomerations, like cities from 200 to 499 thousand citizens and cities with over 500 thousand citizens, the consumption of fruit and vegetable juices are the highest compared to smaller cities and country. In the first case consumers drinks 1.13L ($SD = 0.06$) monthly and in the second case it is 1.33L monthly ($SD = 0.1$). Tukey's post-hoc comparison indicated that juice's consumption in cities with over 500 thousand citizens was statistically significantly different from all other locations.

The effect of the level of reference person's education (higher, secondary/post-secondary, vocational or primary education) on the consumption of fruit and vegetable juice was evaluated. Table 2 suggests that the higher education condition is characterized by the largest consumption of juices. Post-hoc comparison using Tukey's test indicate that the mean score for the higher education of the reference person ($M = 1.40$, $SD = 0.11$) was significantly different than other studied conditions.

Finally, Figure 1 gives an overview of juice consumption in relation to different provinces in Poland. The chart demonstrated that the highest consumption of juices (in litres per person) is in the Mazowieckie and Śląskie voivodeships. While in the Lubelskie voivodeships such consumption is the smallest. Other voivodeships are characterized by a similar level of consumption of the examined goods.

Table 2. Descriptive statistics for the fruit and vegetable juice consumption across the socio-economic groups, the type of biological households, the households by level of education of the reference person and class of household locality

Conditions	N	M	SD	Std. Error	95% Confidence Interval		Min	Max
					Lower Bound	Upper Bound		
Socio-economic group								
Manual labour positions	9	0.82	0.07	0.02	0.77	0.87	0.74	0.91
Non-manual labour	9	1.28	0.10	0.03	1.21	1.35	1.21	1.51
Farmers	9	0.63	0.08	0.03	0.57	0.69	0.53	0.79
Self-employed	9	1.23	0.08	0.03	1.17	1.29	1.16	1.43
Retirees	9	0.76	0.06	0.02	0.71	0.80	0.68	0.87
Pensioners	9	0.67	0.09	0.03	0.60	0.74	0.59	0.85
Total	54	0.90	0.28	0.04	0.82	0.97	0.53	1.51
Type of biological household								
Without children	9	0.99	0.07	0.02	0.93	1.04	0.94	1.16
Marriage with 1 child	9	1.29	0.08	0.03	1.23	1.35	1.21	1.46
Marriage with 2 children	9	1.16	0.07	0.02	1.11	1.21	1.07	1.30
Marriage with 3 or more children	9	0.82	0.12	0.04	0.73	0.91	0.70	0.99
Mother of father with dependent child/children	9	1.14	0.10	0.03	1.06	1.22	0.96	1.26
Total	45	1.08	0.18	0.03	1.02	1.14	0.70	1.46
Level of education of the reference person								
Higher	9	1.40	0.11	0.04	1.30	1.47	1.29	1.64
Secondary/post-secondary	9	0.99	0.08	0.03	0.93	1.05	0.91	1.16
Vocational	9	0.75	0.07	0.02	0.70	0.81	0.67	0.86
Primary	9	0.58	0.06	0.02	0.53	0.62	0.50	0.67
Total	36	0.93	0.32	0.05	0.82	1.04	0.50	1.64
Class of household locality								
Less than 20 thousand citizens	9	0.89	0.08	0.03	0.82	0.95	0.78	1.05
20–99 thousand citizens	9	0.98	0.07	0.02	0.92	1.04	0.9	1.14
100–199 thousand citizens	9	1.08	0.08	0.03	1.02	1.15	1	1.25
200–499 thousand citizens	9	1.13	0.06	0.02	1.08	1.17	1.02	1.25
500 thousand and more citizens	9	1.33	0.1	0.03	1.25	1.41	1.19	1.52
Country	9	0.79	0.18	0.06	0.66	0.93	0.67	0.83
Total	54	1.04	0.19	0.03	0.98	1.09	0.67	1.52

Source: own development.

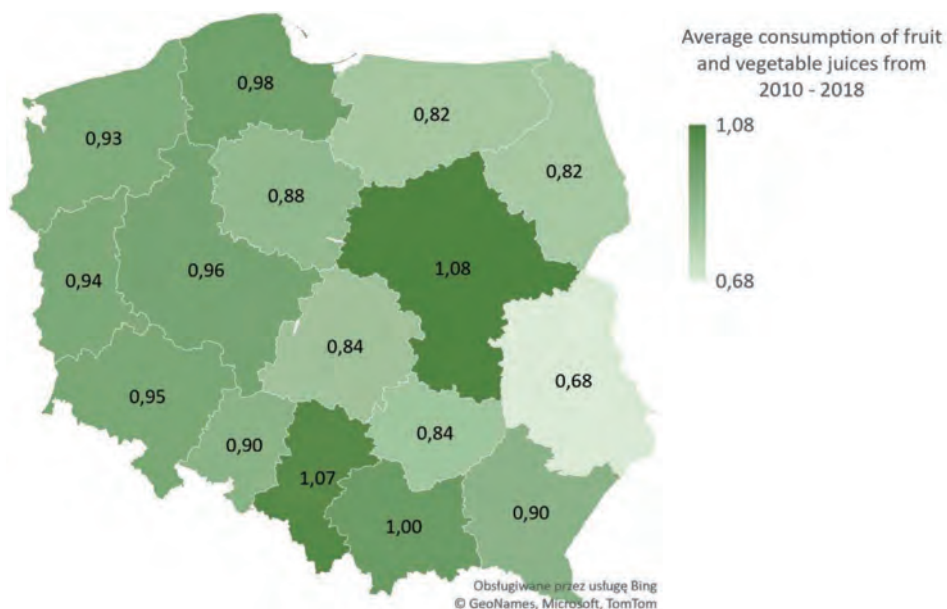


Figure 1. Average consumption of fruit and vegetable juices from 2010 to 2018 across voivodeships in Poland

Source: own development.

In the second step, the one-way ANOVA was performed to compare the influence of socio-economic groups, the type of biological households, the households by the level of education of the reference person and the class of household locality on medium monthly consumption of vegetable preserves, dry vegetables and mushrooms preparations. The results are presented in Table 3. In addition, descriptive statistics are provided in Table 4.

There was a significant effect of socio-economic groups on the medium monthly consumption of vegetable preserves, dry vegetables and mushrooms at the $p < .05$ for the six conditions [$F(5.48) = 36.785$, $p = .000$]. Furthermore, the consumption depended on the type of biological household. Also in this case, statistically significant differences were observed at the $p > .05$ [$F(4.40) = 86.472$, $p = 0.00$]. The level of education of the reference person significantly affected the consumption at $p > .05$ [$F(3.32) = 14.102$, $p = 0.00$]. Finally, the class of household locality also influenced the studied category at $p > .05$ [$F(5.48) = 39.896$, $p = 0.00$]. The results suggest that socio-economic group to which an individual belongs influences the quantity of vegetable preserves, dry vegetables and mushrooms preparations consumption. In this case, the retirees and pensioners consume most of the analyzed category and farmers consume the least. Tukey's post-hoc comparison determined that the mean score for retirees' position ($M = 0.99$, $SD = 0.08$) was significantly different than the manual labour positions, farmers and self-employed conditions.

Table 3. One-way ANOVA for the vegetable preserves, dry vegetables and mushrooms preparations consumption across the socio-economic groups, the type of biological households, the households by level of education of the reference person and class of household locality

Groups		Sum of Squares	df	Mean Square	F	Sig.
Socio-economic groups	Between Groups	0.881	5	0.176	36.785	0
	Within Groups	0.230	48	0.005	–	–
	Total	1.112	53	–	–	–
Type of biological household	Between Groups	1.388	4	0.347	86.472	0
	Within Groups	0.161	40	0.004	–	–
	Total	1.548	44	–	–	–
Level of education of the reference person	Between Groups	0.191	3	0.064	14.102	0
	Within Groups	0.144	32	0.005	–	–
	Total	0.335	35	–	–	–
Class of household locality	Between Groups	0.938	5	0.188	39.896	0
	Within Groups	0.226	48	0.005	–	–
	Total	1.163	53	–	–	–

Source: own development.

In the case of the type of biological household, the descriptive analysis indicates that households without children consume most of the vegetable preserves, dry vegetables and mushrooms preparations. Tukey's post-hoc comparison showed that the consumption within this type of biological household was significantly different from that in the other tested types of households ($M = 1.14$, $SD = 0.06$).

Higher education was a factor influencing the larger consumption of vegetable and mushroom-based products. The analysis indicated that the individuals characterized by primary education consume the least of the given category. Tukey's post-hoc comparison indicated that the consumption amongst individuals having higher education ($M = 0.96$, $SD = 0.04$) was significantly different from those having vocational ($M = 0.79$, $SD = 0.07$) and primary education ($M = 0.79$, $SD = 0.09$).

Subsequently, also in this product category as with juices, consumption of the vegetable preserves was the largest in the biggest cities – from 200 to 499 thousand citizens ($M = 1.07$, $SD = 0.08$) and over 500 thousand citizens ($M = 1.06$, $SD = 0.02$). Tukey's post-hoc comparison showed that there are statistically significant differences between mentioned cities and cities with less than 20 thousand citizens, 20 to 99 thousand citizens and country.

Table 4. Descriptive statistics for the vegetable preserves, dry vegetables and mushrooms preparations consumption across the socio-economic groups, the type of biological households and the households by level of education of the reference person

Conditions	N	M	SD	Std. Error	95% Confidence Interval		Min	Max
					Lower Bound	Upper Bound		
Socio-economic group								
Manual labour positions	9	0.76	0.07	0.02	0.72	0.83	0.69	0.88
Non-manual labour	9	0.91	0.04	0.01	0.88	0.94	0.87	0.99
Farmers	9	0.61	0.05	0.02	0.57	0.65	0.51	0.68
Self-employed	9	0.86	0.05	0.02	0.83	0.90	0.81	0.94
Retirees	9	0.99	0.08	0.03	0.93	1.05	0.89	1.12
Pensioners	9	0.95	0.10	0.04	0.87	1.03	0.84	1.14
Total	54	0.85	0.14	0.02	0.81	0.89	0.51	1.14
Type of biological household								
Without children	9	1.14	0.06	0.02	1.09	1.19	1.06	1.23
Marriage with 1 child	9	0.92	0.06	0.02	0.88	0.96	0.85	1.02
Marriage with 2 children	9	0.75	0.06	0.02	0.70	0.79	0.68	0.84
Marriage with 3 or more children	9	0.62	0.07	0.02	0.57	0.67	0.55	0.75
Mother of father with dependent child/children	9	0.89	0.07	0.02	0.84	0.94	0.77	0.97
Total	45	0.86	0.19	0.03	0.80	0.92	0.55	1.23
Level of education of the reference person								
Higher	9	0.96	0.04	0.01	0.93	0.99	0.92	1.02
Secondary/post-secondary	9	0.89	0.06	0.02	0.85	0.94	0.82	0.98
Vocational	9	0.79	0.07	0.02	0.73	0.84	0.70	0.91
Primary	9	0.79	0.09	0.03	0.72	0.86	0.69	0.94
Total	36	0.86	0.10	0.02	0.82	0.89	0.69	1.02
Class of household locality								
Less than 20 thousand citizens	9	0.84	0.07	0.02	0.79	0.89	0.77	0.93
20–99 thousand citizens	9	0.92	0.08	0.03	0.85	0.98	0.82	1.06
100–199 thousand citizens	9	1.01	0.07	0.02	0.95	1.07	0.9	1.12
200–499 thousand citizens	9	1.07	0.08	0.03	1.01	1.13	0.99	1.22
500 thousand and more citizens	9	1.06	0.02	0.01	1.04	1.07	1.02	1.10
Country	9	0.69	0.06	0.02	0.65	0.74	0.62	0.79
Total	54	0.93	0.15	0.02	0.89	0.97	0.62	1.22

Source: own development.

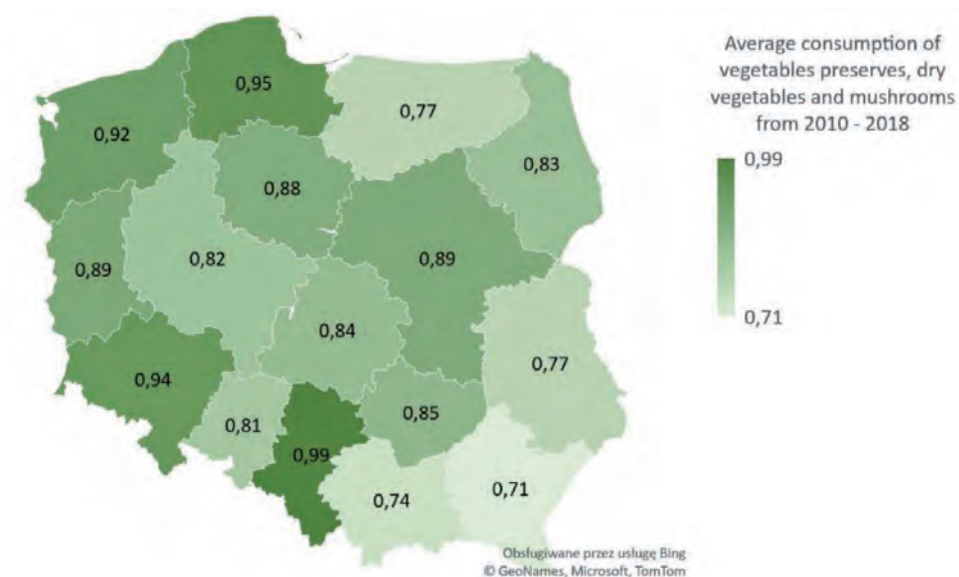


Figure 2. Average consumption of vegetables preserves dry vegetables and mushrooms from 2010 to 2018 across voivodeships in Poland

Source: own development.

Moreover, Figure 2 represents the average consumption of vegetable preserves, dry vegetables and mushrooms across voivodeships. The largest consumption of studied product categories take place in the Śląskie, Pomorskie, Dolnośląskie and Zachodnio-pomorskie voivodeships. On the other hand, Podkarpackie, Małopolskie, Lubelskie and Warmińsko-Mazurskie voivodeships are characterized by the lowest consumption.

Rest of the voivodeships in the analyzed period were distinguished by a comparable level of consumption of examined product category.

Discussion

It should be mentioned that the Polish juice market is the 4th largest market in terms of consumption in Europe. According to data provided by European Fruit Juice Association (AIJN, 2019) the consumption of juices in Poland has grown over the five past years from 699 to 837 million liters in 2018. This product category has significantly benefited from marketing support from leading producers and The Polish Association of Juice Producers (KUPS). Additionally, the Polish market stands out from other European markets in terms of taste preferences. Polish consumers prefer apple, orange and especially vegetable flavors of juices, like carrot and tomato (AIJN, 2019).

It should be mentioned that in the structure of consumption of vegetables and vegetables preserves category, which is characterized by general decline, the share of vegetable and mushrooms preserves has been systematically increasing for several years (from 7.8 kg/person in 2014 to 8.52 kg/person in 2018) (Makosz, 2019).

What is interesting, the research conducted by Czernyszewicz (2009) revealed that socio-economic characteristics of consumers like level of education significantly affected the frequency of juice consumption. Research conducted in Poland demonstrated that the correlations between the consumers' socio-economic features and the forms of fruit consumption (included juices) undergo dynamic changes in the character, strength and direction of effect. In partially agreement with the findings of the present study, the authors (Riediger, *et al.* 2007) observed a significant association with higher education and income with fruits and vegetables intake by Canadian population. It should be mentioned that these factors are interrelated, a better education has an impact on the work performed and thus on the household income. Also, similarly to the presented paper, the research conducted in Brazil showed that level of education and income were important variables in the buying process of ready-to-drink juices and fruit nectars (Santos, *et al.* 2018). The level of education and knowledge about the examined categories were significantly related. The main reason that led respondents to consume ready-to-eat juices and nectars was practicality, followed by the quality of the product and price. What is important, the price was associated with the level of education. In the case of nectars, the choice of this product category, was correlated with increasing education, price and practicality. According to research a higher level of education encourages more thoughtful shopping and health concerns (Santos, *et al.* 2018). Moreover, based on the systematic review of socio-economic differences in food habits across Europe (regarding fruit and vegetable consumption) there is clear evidence that higher socio-economic status (particularly educational level and occupational status) was associated with greater consumption of fruits and vegetables (Sanchez-Villegas, *et al.* 2003).

The study conducted in USA showed that among others: the level of education, gender, age and race/ethnicity, have significantly affected the consumption of fruit and vegetables (including fresh products, juices and preserves) (Demydas, 2010). In this regard, the research resulted in the identification of three main clusters: 1. Low-intake F&V consumers, 2. Consumers of healthier F&V options and 3. Intensive fruit juice consumers. Characteristics of the first cluster (e.g. lower education, non-Hispanic black race, unhealthy lifestyles) are consistent with the results of our studies. Furthermore, the second cluster was characterized by higher education and income level, being older and married, which is also in line with the presented research. However, on contrary, the third cluster was represented by younger respondents, males and with lower household income. Thereby, 20% of the respondents consumed fruit only in the form of juice.

Furthermore, similar to the presented paper, the study (Riediger, *et al.* 2007) showed that the living arrangements may affect the eating habits. It was shown that adolescents living with two parents are more likely to consume more fruits and vegetables as compared with adolescents living with only one parent or living in other types of arrangements (Riediger, *et al.* 2007). Another research including Canadian population but with the focus on elderly people demonstrated that marital status was significantly associated with the fruits and vegetables consumption (Riediger & Moghadasian, 2008). Married respondents were most likely to consuming more fruits and vegetables compared to their common-law counterparts. On the other hand, the authors (Dehghan, *et al.* 2011) showed that single/never married respondents demonstrated a slight increase in fruit intake compared to the other groups (like married/common law and widow/separated/divorced respondents).

Considering the place of residence, partially agreed to the presented study, the authors (Riediger & Moghadasian, 2008) proved that higher population numbers in the surveyed provinces of Canada did result in higher consumption of fruits and vegetables. Their studies showed that highest intake of fruits and vegetables took place in three largest provinces in Canada – British Columbia, Quebec and Ontario.

Conclusions

In relation to the purpose of the present research, which was to identify the socio-geographical market segments that are the most appealing to producers due to the high consumption of vegetables preserves and juices, the following conclusions may be stated. In the case of fruit and vegetable juices, the marketing efforts should primarily be directed to well-educated marriages with one child doing non-manual workers or being self-employed while less focused on farmers, large families, single parents or individuals having lower education. In the case of vegetable preserves, dry vegetables and mushrooms preparations the marketing efforts should primarily be directed to retirees, households without children and individuals having higher education while less focused on individuals occupying manual labour positions, farmers and self-employed having vocational and primary education. The results are summarized in Table 5.

In the presented research, the original questions were answered. However, the research was not free of limitations. First, the time series provided by Polish Statistical Office, that could have been used in the research encompassed only the period of 2010–2018 due to the different organization and content of data prior to 2010. Longer time series could produce more meaningful results. Second, the employment of secondary data means that the precision of analysis could have been only as high as the data provided, i.e. it was not possible to

Table 5. The socio-geographical market segments that are the most appealing to producers

Groups	Fruit and vegetable juice	Vegetable preserves, dry vegetables and mushrooms preparations
Socio-economic groups	non-manual position and the self-employed	retirees
Type of biological household	marriages with one child	households without children
Level of education of the reference person	higher	higher
Class of household locality	Cities with 500.000 and more citizens	Cities with from 200.000 to 499.000 citizens/ Cities with 500.000 and more citizens

Source: own development.

introduce any other socio-economic group, type of biological household, class of household locality or level of education beyond the ones characterized by Polish Statistical Office. Concerning further research, as stated previously, the market segmentation should follow a certain logic, i.e. from the simple to the more sophisticated criteria. Therefore, a promising direction for further research is the introduce such variables as e.g. life style, personality or value system into the segmentation in order to develop further and deepen the considerations presented in the present research.

References

- AIJN (2019). AIJN Liquid Fruit Market Report. *European Fruit Association*.
- Albayrak, M., Aslan, Z. (2009). A comparative study of consumer preferences for manufacturer or private labelled food products. *African Journal of Business Management*, 3(11), 764–772, <https://doi.org/10.5897/AJBM09.261>
- Aljukhadar, M. Senecal, S. (2011). Segmenting the online consumer market. *Marketing Intelligence & Planning*, 29(4), 421–435, <https://doi.org/10.1108/02634501111138572>
- Czernyszewicz, E. (2009). Effect of some socio-economic characteristics of consumers on the forms of fruit consumption. *Polish Journal of Food and Nutrition Sciences*, 59(1), 81–86.
- Dehghan, M., Akhtar-Danesh, N., Merchant, A.T. (2011). Factors associated with fruit and vegetable consumption among adults. *Journal of Human Nutrition and Dietetics*, 24(2), 128–134, <https://doi.org/10.1111/j.1365-277X.2010.01142.x>

Demydas, T. (2010). Consumer segmentation based on the level and structure of fruit and vegetable intake: An empirical evidence for US adults from the National Health and Nutrition Examination Survey (NHANES) 2005–2006. *Public Health Nutrition*, 14(6), 1088–1095, <https://doi.org/10.1017/S1368980010003745>.

Dibb, S., Stern, P., Wensley, R. (2002). Marketing knowledge and the value of segmentation. *Marketing Intelligence & Planning*, 20(2), 113–119, <https://doi.org/10.1108/02634500210418536>.

FAO/WHO. (2004). Fruit and vegetables for Health. *Report of a Joint FAO/WHO Workshop, September, 1–3*, <https://doi.org/10.4324/9781315159874-13>.

Füller, J., Matzler, K. (2008). Customer delight and market segmentation: An application of the three-factor theory of customer satisfaction on life style groups. *Tourism Management*, 29(1), 116–126, <https://doi.org/10.1016/j.tourman.2007.03.021>.

Goyat, S. (2011). The basis of market segmentation: a critical review of literature. *European Journal of Business and Management*, 3(9), 45–55.

Granato, D., Branco, G.F., Nazzaro, F., Cruz, A.G., Faria, J.A.F. (2010). Functional foods and nondairy probiotic food development: Trends, concepts, and products. *Comprehensive Reviews in Food Science and Food Safety*, 9(3), 292–302, <https://doi.org/10.1111/j.1541-4337.2010.00110.x>.

Hempel, C., Hamm, U. (2016). Local and/or organic: a study on consumer preferences for organic food and food from different origins. *International Journal of Consumer Studies*, 40(6), 732–741, <https://doi.org/10.1111/ijcs.12288>.

Jąder, K., Wawrzyniak, J. (2016). Changes in the Consumption of Fruits and Vegetables and Their Preserves in Poland in 1999–2013 and the Phenomenon of Sustainable Consumption. *Journal of Agribusiness and Rural Development*, 9(3), <https://doi.org/10.17306/jard.2015.45>.

Kotler, P., Keller, K.L. (2012). *Marketing Management* (14th). Prentice Hall.

Makosz, E. (2019). Rynek owoców i warzyw. *Agencja Rynku Rolnego*, 3, 10–16.

Murawska, A. (2018). Zróżnicowanie konsumpcji owoców i warzyw w różnych typach polskich gospodarstw domowych. *Handel Wewnętrzny*, 2(2 (373)), 294–304.

Riediger, N.D., Moghadasian, M.H. (2008). Patterns of Fruit and Vegetable Consumption and the Influence of Sex, Age and Socio-Demographic Factors among Canadian Elderly. *Journal of the American College of Nutrition*, 27(2), 306–313, <https://doi.org/10.1080/07315724.2008.10719704>.

Riediger, N.D., Shoostari, S., Moghadasian, M.H. (2007). The Influence of Sociodemographic Factors on Patterns of Fruit and Vegetable Consumption in Canadian Adolescents. *Journal of the American Dietetic Association*, 107(9), 1511–1518, <https://doi.org/10.1016/j.jada.2007.06.015>.

Sanchez-Villegas, A., Martínez, J.A., Prättälä, R., Toledo, E., Roos, G., Martínez-González, M.A. (2003). A systematic review of socioeconomic differences in food habits in Europe:

Consumption of cheese and milk. *European Journal of Clinical Nutrition*, 57(8), 917–929, <https://doi.org/10.1038/sj.ejcn.1601626>.

Santos, A.B., Bottoni, S. de S., Silva, D.A., de SÃO JOSÉ, J.F.B., da SILVA, E.M.M. (2018). Study of the consumers of ready-to-drink juices and fruit nectars. *Food Science and Technology*, 38(3), 504–512, <https://doi.org/10.1590/1678-457x.09417>.

Septembre-Malaterre, A., Remize, F., Poucheret, P. (2018). Fruits and vegetables, as a source of nutritional compounds and phytochemicals: Changes in bioactive compounds during lactic fermentation. *Food Research International*, 104(August 2017), 86–99, <https://doi.org/10.1016/j.foodres.2017.09.031>

Smith, W.R. (1956). Product Differentiation and Market Segmentation as Alternative Marketing Strategies. *Journal of Marketing*, 21(1), 3, <https://doi.org/10.2307/1247695>.

Vereecken, C., Pedersen, T.P., Ojala, K., Krølner, R., Dzielska, A., Ahluwalia, N., Giacchi, M., Kelly, C. (2015). Fruit and vegetable consumption trends among adolescents from 2002 to 2010 in 33 countries. *European Journal of Public Health*, 25, 16–19, <https://doi.org/10.1093/eurpub/ckv012>.

Wedel, M., Kamakura, W.A. (1998). *Market Segmentation. Conceptual and Methodological Foundations*. Kluwer.

SUSTAINABLE CONSUMPTION OF FILTERING FACEPIECE RESPIRATORS DURING COVID-19 OUTBREAK

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Abstract

International outbreak of SARS-CoV-2 infection has pushed pressure on governments in finding immediate solutions to shortage of filtering facepiece respirators (FFRs) and other protective equipments. Italian government, to avoid the stringent quality standards imposed on FFRs that could slow the production, issued a ministerial decree to allow manufacturers to accelerate the production. Starting from a hypothetical composition and design, we calculated the carbon footprint (CF) of a KN95 type FFR manufactured in Taranto, comparing two different materials, PET (polyethylene terephthalate) and PP (polypropylene). The results showed that production of textile non-woven sheets composing the mask and disposal, were the main contributors to CO₂ – eq. emission followed by packaging and assembly. FFRs made in PET have a higher CF than PP masks. To reduce CF and make a sustainable consumption of FFRs during COVID-19 outbreak, both minimizing textiles area (by smart shaping) and right choice of raw materials (in this case PP is preferred to PET) result in the best options.

Keywords: SARS-COV-2, facial respirators, KN95, carbon footprint, PET, PC, Taranto

Introduction

In September 2019 at Wuhan (China), SARS-CoV-2, was identified in relation to a series of severe acute respiratory illnesses to patients, which led to death. On

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February 11, 2020 the Director-General of the WHO (WHO, 2020) declared the pandemic, called COVID-19, whereas SARS-CoV-2 spread throughout the world due to its high transmission capacity. In Italy the virus arrived in the first months of 2020, initially in the north of the country and soon increasing the number of infected individuals. In March 2020 the entire country was in lockdown to prevent spreading of the contagion and among the prevention advises there was social distance, hand washing and the use of FFRs. Soon a shortage of the last devices, determined an urgent need of supplying but stringent quality requirements were an impediment. To aid textile manufacturers producing facepiece respirators, in accelerating the supply of a huge amount of devices to protect population the Italian government issued a decree on March 17, 2020 named “Cura Italia” (Ministerial decree n. 18, 2020) in which, at the article n. 15, it was stated that usual quality requirements normally requested for devices used by sanitary personnel and workers (personal protective equipment) were waived. The only requisite was to comply with the European standard EN 14683:2019 (EN 14683:2019, 2019) provided the device was not intended for the personal protection of sanitary staff. Soon began an intensive production of these masks and their subsequent disposal with the related environmental impact which needs to be analyzed. The literature has very few examples of environmental impact quantification of FFRs. In a work of Vozzola E. *et al.* (Vozzola, Overcash & Griffin, 2018) the Life Cycle Assessment (LCA) on isolation gowns used as sanitary equipment was performed considering two possible alternatives: reusable (polyester made) and disposable (polypropylene made) isolation gowns, in which a functional unit (FU) of 1,000 uses of the reusable gowns obtained by laundry operations has lower environmental impacts than one-use equipment; it was demonstrated that laundry operations with the environmental issues due to water, detergents, and energy consumption does not affect the overall damage. The production of the isolation gowns in fact was the largest contributor to the environmental impacts. Rizan *et al.* (Rizan, Reed & Bhutta, 2021) estimated an emission of green-house gases of 22–31 g CO₂ – eq. per type IIR and IIIR surgical masks made of polypropylene, whereas Klemes *et al.* (Klemeš, Fan & Jiang, 2020) estimated 59 g CO₂ – eq. per mask. Finally Giungato *et al.* (Giungato, *et al.* 2021) calculated a carbon footprint of 32.7 g CO₂ – eq. per type IIR mask made in the city of Taranto, Italy and an abatement of 85% of carbon footprint by laundry reuse per single use.

In this paper we have analyzed the carbon footprint of the production and disposal of FFRs hypothetically produced in the city of Taranto, whose composition and assembling were compliant to the data used by Giungato *et al.* (2021). However, compared to the previous work we have considered two different types of polymers, assessing the influence of the material choice. The study involves the transportation of the non-woven fabrics from their production site (located in the northern of Italy) to the city of Taranto (Apulia region, in the south of Italy)

the assembly, packaging and transportation to the final users in a 100 km range comprising in the province of the city.

Materials and Methods

The analysis took place using the OpenLCA software with Ecoinvent 3.7 database (Wernet, *et al.* 2016; OpenLCA, 2021). The carbon footprint was implemented according to the ISO 14067:2018 (ISO, 2018), to evaluate the greenhouse gases emissions as indicated in the Kyoto Protocol released directly or indirectly from cradle (manufacturing of textile, transportation, use) to grave (disposal by incineration). The model used for the characterization step was the IPCC – GWP100, included in the “CML baseline impact assessment methods” developed by the University of Leiden (OpenLCA, 2012). In this way, direct and indirect greenhouse gases emitted and computed as CO₂ – equivalents over a fixed period of 100 years were computed. The model was implemented following the international standards and guidelines (ISO, 2006a, 2006b), considering goal and scope definition, FU, system boundary, life cycle inventory (LCI), life cycle impact assessment (LCIA) and life cycle interpretation. The FU was one packed FFR, the secondary data chosen for polymer production were the granulate production of PET and PP. It should be noted that the materials used in the layers composing the FFRs are manufactured with spunbond and meltblown processes. The production of PP with the first one process exists in the Ecoinvent database whereas not in the case of PET. Moreover PP and PET non-woven fabrics made with the meltblown processes are not present in the Ecoinvent database. The granulate production was chosen as the study involves a comparative LCA and the absence of the spunbond and meltblown processes is the same in the two alternative scenarios proposed. Weight of the FFRs were calculated by adding the masses of the tissues (computed considering dimensions and mass per unit of area) composing the different layers (Table 1). Packaging represents 16% of the overall weight of the FFRs and 95% of the packaging consists of a cardboard box while 5% of a low-density polyethylene packaging film (Vozzola, Overcash & Griffin, 2018). After use phase packaging was incinerated in a municipal solid waste plant with energy and metals recovery, the usual scenario in the location. Transportation has been computed, with a small lorry with max payload of 5 t. The FFRs produced were packaged and transported to the final users in a 100 km range from the assembly location. System boundaries of the study and interconnected processes were reported in Figure 1. Energy mix used is the Italian energy grid mix. Elastic laces were supposed to be made of synthetic rubber, aluminum strips were considered to improve nose adherence, energy consumption for sewing and packaging have been taken from literature (Vozzola, Overcash & Griffin, 2018). The FFR modelled is composed of four layers of non-woven fabrics with a mass to area sufficient to

have a enough filtering capacity to be considered useful for personal protection against COVID-19 spreading, for this reason the respirator conformed to the EN 14683:2019 norm the European standard applicable also to masks intended exclusively for the personal protection of sanitary staff and it is also assimilable to a N95 (USA standard), FFP2 (European standard), KN95 (Chinese standard) DS/DL2 (Japanese standard), KF94 (Korean standard).

Table 1. Inventory analysis of one FFRs (functional unit)

Textiles	4 layers of non-woven fabrics (PET, PP)
Area mass (g/m ²)	40
Dimensions (mm ²)	32,400
Mass (g)	5.184
Elastic laces (g)	0.45
Aluminum strip (g)	0.23
Packaging film (g/apiece)	0.08
Cardboard box (g/apiece)	1.56
Manufacturing (kWh/kg)	0.296
Transportation of textile (km)	980 + 100
Bacterial Filtration Efficiency (%)	100
Differential Pressure (Pa/cm ²)	59

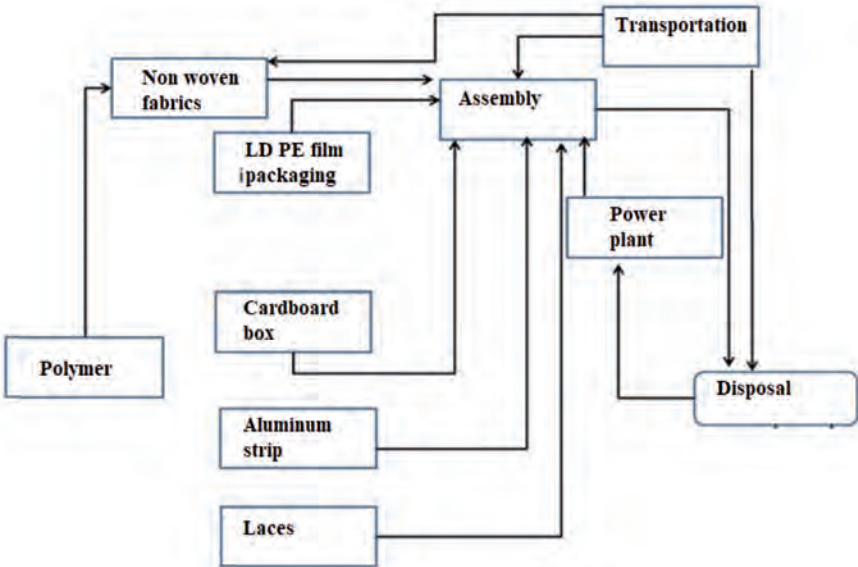


Figure 1. The system boundary and interconnected processes of the system studied

Results

Carbon footprint of a FFR in PP assembled according to the above mentioned inventory analysis is 19.5 g CO₂ – eq. per piece, with process contributions given in Figure 2. This figure should be compared with the values in the existing literature as the work on gowns (4) as the emission is about 3.60 g CO₂ – eq. per g of mask versus a 3.32 CO₂ – eq. per g of this work, with data of Rizan *et al.* (Rizan, Reed & Bhutta, 2021) who reported a range of 22–31 g CO₂ – eq. per mask (type IIR and IIIR surgical masks made of PP), that of Klemes *et al.* (Klemeš, Fan & Jiang, 2020) with 59 g CO₂ – eq. per mask and that of Giungato *et al.* of 32.7 g CO₂ – eq. per mask (type IIR surgical masks made of PP) (Giungato, *et al.* 2021). We can observe that the greatest emission of CO₂ equivalent derives from the production of non-woven fabrics in PP fibers (79%), followed by the incineration (10%), the production of cardboard boxes (6%), and assembly of textiles (5%). Negligible are contributions from the transport of the fabrics.

The value of the carbon footprint of the PET-made FFR is 29.3 g CO₂ equivalent. As can be seen from Figure 2, 72% of emissions derive from the production process of PET non woven fabrics, 19% from incineration of FFRs, 6% from the production of cardboard packaging, 3% from the electricity used in the assembly process and negligible quantities from the transport of the fabrics.

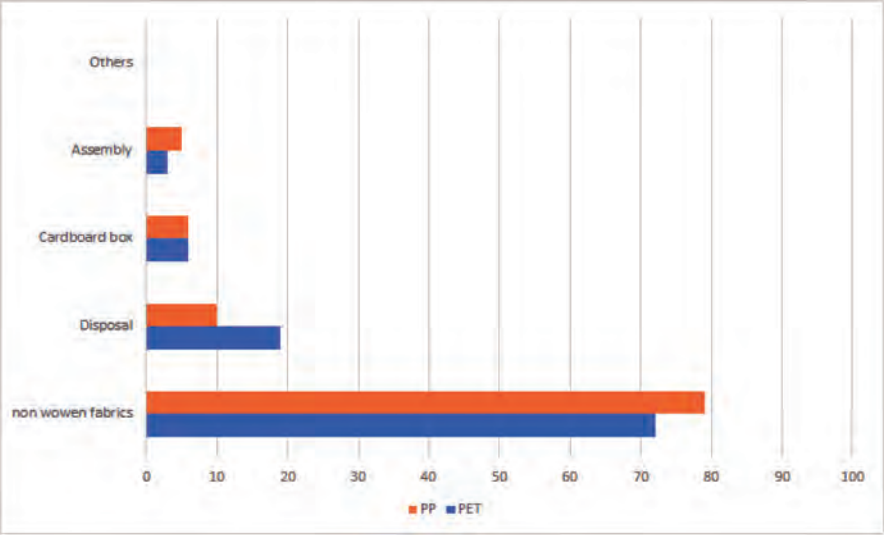


Figure 2. Process contribution to the carbon footprint of the filtering facepiece respirators (percentage) made in PP and in PET

The choice of the base material (PET or PP) is decisive to lower the CF of the final device, followed by the disposal method. The area of the final product plays an

important role in carbon footprint mitigation strategies of the FFR. It should be noted that a FFR is composed of four layers of a non-woven fabric cut to conform to the mean face form of the owner, to avoid leaks of unfiltered air, preventing SARS-CoV-2 from entering the lung system. Cutting and shaping are necessary to adapt the FFR to the face physiognomy of the user. To lower the area of the FFR a shape re-engineering of the device is advisable as the CF is linearly correlated to the area (Giungato, *et al.* 2021) provided the same filtration performances and structure stability remain in the improved device.

PET-FFRs have higher CF with respect to PP and this is due to the contribution of polymer production. A possible strategy to reduce the carbon footprint of the mask under study could be that of composing the filtering layers in a different way as to assemble PP and PET layers alternatively. In this case the behaviour of the CF versus the percentage of the PP (or versus the number of layers of PP) is reported in Figure 3. If all the 4 layers were made in PET, the CF was the sum of the CFs of a single layer made in PET (29.3 g CO₂ – eq.), but when only one layer of PET is replaced by a layer made in PP (25% of PP) the CF falls to 26.85 g CO₂ – eq. When the single layers of PET were replaced with layers of PP, CF reached that of 4 layers of PP (19.5 g CO₂– eq.).

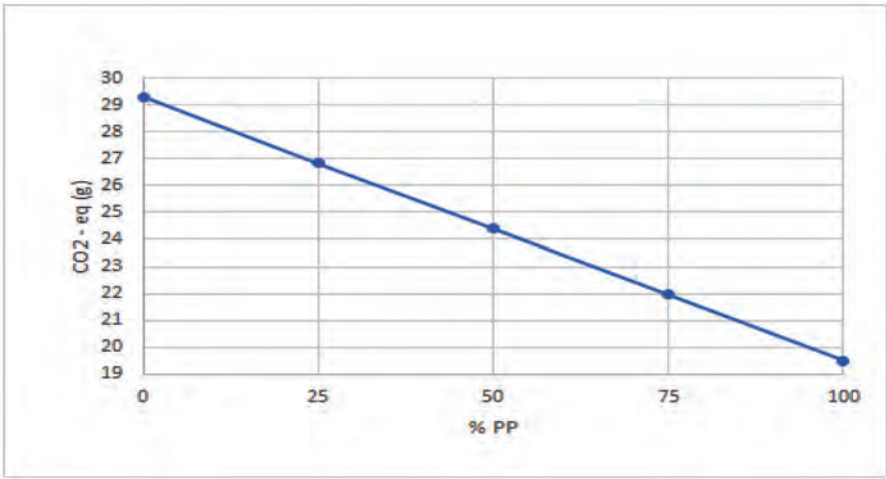


Figure 3. Carbon footprint versus %PP of the FFRs made as multilayers of PP and PET

Discussion

CF of the FFR comes basically from non-woven textile production, starting from raw materials (crude oil and granulate by polymerization) ending with non-woven fabrics, transportation, sewing, transportation to the final user, use and disposal.

Transport, packaging and assembly contributions are negligible as can be noted by the data obtained. In our study the contributions of packaging and of elastic laces and aluminum strips were negligible (it should be considered also that the FFR is disposed in a municipal solid waste incinerator in which recycling of aluminum strips happen). The reason for the incineration as the only disposal alternative come from the recommendations of the Italian Higher Institute of Health (Istituto Superiore di Sanità, 2020). FFRs and surgical masks coming from households are classified as urban wastes to be included in the unsorted waste and put in the European List of Waste code EER 200301. Other protective equipments are considered special wastes classified in the EER 150203 code including “Absorbents, filter materials, rags and protective clothing”. As there are no recommended recycling and washing procedures, shortage of FFRs has put pressure on the government which resulted in raising both the consumption of masks and the global production of PP and PET, producing pollution from microplastics (Fadare & Okoffo, 2020). As the number of FFRs sold and used in one day in Italy is high, small lowering of CF will result in huge amounts of greenhouse gases emissions saved. Recycling of PET and PP, washing and reuse of the devices, recycling of the aluminum strips and elastic laces, may contribute highly to the carbon footprint mitigation of the entire life cycle of FFRs. In the case of a mixed strategy of composition, due to marketing or economic reasons, replacement of PP layers with PET layers of a multilayer FFR, will result in a proportionally increase in CF.

Conclusions

CF in the life cycle of FFRs hypothetically produced in the city of Taranto, computed by using the LCA methodology, has been studied considering two alternative scenarios: non-woven fabrics composed of PET and of PP. Starting with the transportation of the textiles from the production site (located in the North of Italy) to the city of Taranto (Apulia region) the device is assembled by sewing the fabrics, to produce the FFRs, that will be packaged and transported to the final users in the province of Taranto. The computed values are of 29.3 g CO₂ – eq. apiece, in the case of PET-made fabrics and of 19.5 g CO₂ – eq. apiece, in the case of PP-made fabrics. Due to marketing or economic reasons, if a mixed composition strategy is deemed useful, replacement of PP layers with PET layers of a multilayer FFR, it will result in a proportionally increase in CF.

The main contributors to greenhouse gas emission are textile production processes, followed by the disposal, whereas the production of the cardboard box composing the packaging, that of packaging film and the transportations and assembly have negligible contributions. It should be noted that production of polymers, assembling and disposal happen in Italy, but the situation can dramatically change in the case of import of non-woven fabrics from other

countries. A shape reengineering is essential to reduce CF of FFRs provided leakages were reduced to the best low value, to prevent contagion. Obviously searching for less impacting materials, reuse with washing, and use of recycled PP or PET are the future developments in the way toward the reduction of environmental impacts of such protective equipment.

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Conflicts of Interest: The authors declare no conflict of interest.

References

EN 14683:2019 – Medical face masks – Requirements and test methods.

Fadare, O.O., Okoffo, E.D. (2020). Covid-19 face masks: A potential source of microplastic fibers in the environment. *Science of The Total Environment*, 737, 1–4, <https://doi.org/10.1016/j.scitotenv.2020.140279>.

Giungato, P., Rana, R.L., Nitti, N., Cavallari, C., Tricase, C. (2021). Carbon Footprint of Surgical Masks Made in Taranto to Prevent SARS-CoV-2 Diffusion: A Preliminary Assessment. *Sustainability*, 13, 6296, 1–9, doi:10.3390/su13116296.

ISO 14067: 2018. Greenhouse Gases – Carbon Footprint of Products – Requirements and Guidelines for Quantification. International Organization for Standardization. Milan Polytechnic, Nota tecnica v 5.0 del 04/05/2020, available at: <https://www.regione.lombardia.it/wps/wcm/connect/0c81f5f1-ef90-4417-afe2-8d659c21b4ab/NOTA+TECNICA+2-1+-+Scheda+materiali+approvati.pdf?MOD=AJPERES&CACHEID=ROOTWORKSPACE-0c81f5f1-ef90-4417-afe2-8d659c21b4ab-n4n8iMs>, (accessed 25 June 2021).

ISO, 2006a. 14040:2006 – Environmental Management – LCA – Principles and Framework.

ISO, 2006b. 14044:2006 – Environmental Management – LCA – Requirements and Guidelines.

Istituto Superiore di Sanità (2020). Interim guidance to manage disposable facial masks and gloves coming from household and non-household sources, Version May 18. COVID-19 ISS Working group Environment and Wastes (in Italian), available online: https://www.iss.it/documents/20126/0/20200519+Rapporto+ISS+COVID-19+n.+26_2020.pdf/221a18a2-1de8-5e34-e577-2a121baaa231?t=1589885416433 (accessed 21 October 2020).

Klemeš J.J., Fan Y.V., Jiang P. (2020). The energy and environmental footprints of COVID-19 fighting measures – PPE, disinfection, supply chains. *Energy*, 211, 118701, 1–10, doi:10.1016/j.energy.2020.118701.

Ministerial decree n. 18 (2020). “Cura Italia” published on March 17, in the Official Bulletin n. 70, Misure di potenziamento del Servizio sanitario nazionale e di sostegno economico per famiglie, lavoratori e imprese connesse all'emergenza epidemiologica da COVID-19.

OpenLCA (2021). Impact assessment methods 2.0.5, <https://nexus.openlca.org/database/openLCA%20LCIA%20methods> (accessed 25 June 2021).

OpenLCA (2021). Vers. 1.6.3, available online at: www.openlca.org (accessed 25 June 2021).

Rizan, C., Reed, M., Bhutta, M.F. (2021). *Environmental impact of Personal Protective Equipment distributed for use by health and social care services in England in the first six months of the COVID-19 pandemic*, medRxiv, 250–263, doi:10.1101/2020.09.21.20198911.

Vozzola, E., Overcash, M., Griffing E. (2018). Environmental considerations in the selection of isolation gowns: A life cycle assessment of reusable and disposable alternatives. *American Journal of Infection Control*, 46(8), 881–886, doi:10.1016/j.ajic.2018.02.002.

Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., Weidema, B. (2016). The ecoinvent database version 3 (part I): overview and methodology. *The International Journal of Life Cycle Assessment*, 21(9), 1218–1230, <<http://link.springer.com/10.1007/s11367-016-1087-8>> [12/10/2020]. Ecoinvent 3.7 database, available online at: <https://nexus.openlca.org/database/ecoinvent>.

WHO (2020). Coronavirus press conference 11 February, 2020, https://www.who.int/docs/default-source/coronaviruse/transcripts/who-audio-emergencies-coronavirus-full-press-conference-11feb2020-final.pdf?sfvrsn=e2019136_2 (accessed 18 July 2020).

CHANGES IN THE USE OF MICROWAVE OVENS DURING THE COVID-19 PANDEMIC BY HOUSEHOLDS OF POZNAN UNIVERSITY OF ECONOMICS AND BUSINESS STUDENTS

Krzysztof Melski¹

Abstract

The pandemic COVID-19 drastically changed the way of live for many people, by forcing them to stay at home, whether as part of remote work/ learning or having to stay in isolation temporarily. Staying at home longer than before and limited access to restaurants, bars and food stores had to affect consumers' culinary behaviour. This phenomenon should also be reflected in changes in the frequency and way of use of microwave ovens as a part of modern human lifestyle. The main topic of the study was the identification of changes in the use of microwave ovens by a select group of consumers during the first period – nine months of the pandemic COVID-19. This work presented results of inquiry carried out among households of students of Commodity Science and Management and Production Engineering, Poznan University of Economics.

In general, a quarter of respondents declared that frequency of microwave oven use has increased. The greatest increase in the frequency of use of microwave ovens was recorded in terms of defrosting food and heating pre-prepared meals. The results obtained confirmed significant impact of COVID-19 pandemic on change in consumer behavior in the studied area.

Keywords: microwave oven, COVID-19, household

Introduction

Microwave ovens are currently standard equipment of more than two thirds of Polish households, as important tool for conducting numerous culinary processes

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(Piskiewicz & Radziukiewicz, 2018). The prevalence of microwave ovens in Polish households and the ways and frequency of their use have been the subject of only several studies (Korzeniowska-Ginter & Tkacz, 2018; Czarniecka-Skubina, 2016). Due to the specificity of microwave heating and the social, cultural and nutritional conditions of Polish consumers, it act as an auxiliary device rather than a basic one (Melski, 2012).

The COVID-19 pandemic has significantly remodelled the modern world, including the lives of consumers in terms of work, leisure, people-to-people contacts and culinary behaviour. The need to stay at home longer than before, the closure or restriction of all kinds of catering establishments activities and the switch to food delivery directly to the house, are factors that could seriously affect the culinary behaviour of consumers. The research problem was to determine the direction of changes in the use of microwave ovens during the COVID-19 pandemic. The research hypothesis was formulated as follows: in the studied group of households, longer time spent at home by household members combined with pandemic restrictions significantly increased the number of home cooking operations, also supported by microwave ovens.

Methods

The small number of reports and results of research on consumer behavior in the observed area and the need to refer to the previously studied group of consumers were determined the choice of the group of consumer to be study. The first-year students of the two courses of The Poznan University of Economics and Business: Commodity Science and Management and Production Engineering were subjected to the study. The selection of the tested group was based on many years of research considering this groups, which allowed not only to examine consumer behaviour through questions directly related to the pandemic period, but also to observe long-standing trends (Melski, 2018). Although this selection of the study group gives only a fragmented picture of the phenomenon, it embeds it in a broader time perspective.

The study was carried out in the form of survey. A set of questionnaires has been prepared in order to collect information from microwave oven users. The questionnaire was composed of 20 items giving the inquired people a possibility to choose his answer among indicated items.

The questions were divided into several groups: the use of a microwave oven, the dishes used, the pros and cons of microwave heating, knowledge of microwaves, their impact on human health and changes of microwave food heating habits during pandemic. The results of the first and last groups of questions were used in the presented analysis.

The survey was conducted on 161 (It was over 90% of active students) students of the first year of two The Poznan University of Economics and Business courses: Commodity Science and Management and Production Engineering. The study was conducted between November and December 2020 by completing an on-line questionnaire. The manual explicitly asks them for answers regarding their family home. As the respondents have just started their studies, the behaviour regarding student dormitories and other accommodation was too modest to be studied. The structure of the study group is shown in Table 1.

Table 1. Structure of the study group – students of 1st year courses: Commodity Science and Management and Production Engineering, The Poznan University of Economics and Business

Variable	Feature	Number of	Percentage
Gender	Women	98	61
	Men	63	39
Place of leaving	Village	49	30
	Small city, under 10 ⁴ inhabitants	16	10
	Medium city from 10 ⁴ to 2 · 10 ⁵ inhabitants	43	27
	Big city, over 2 · 10 ⁵ inhabitants	53	33
Number of persons in the household	1	7	4
	2	29	18
	3	36	22
	4	56	35
	5 and above	33	20
Household quarantine*	no	112	70
	yes	44	27
	refusal to answer	5	3
* from the beginning of the pandemic (March 2020) to the time of the survey (November December 2020)			

Results and analysis

128 among the households surveyed (79.5%) posses microwave oven, which is 20% above the national average – 64.6% in 2020 (Polish Statistic, 2021). It should be noted, however, that the study involved middle-aged people more open to modern solutions.

An analysis of the questionnaires received indicates an increase in the frequency of use of microwave ovens, which is declared in one quarter of the households surveyed (Figure 1).

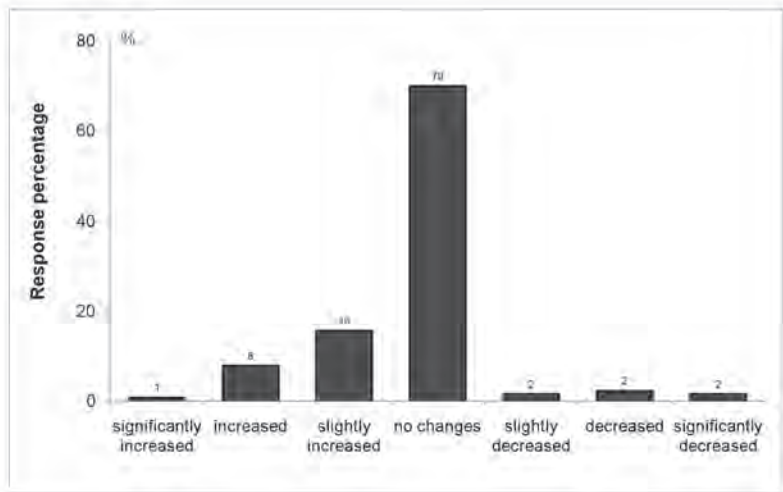


Figure 1. Changes of microwave oven usage frequency during COVID-19 pandemic (rounded to full units)

In order to compare current results with the data obtained during the research from previous years, the results of the analyzed surveys were objectified by determining for each individual editions the coefficient of microwave oven use F_{μ} , expressed by the formula:

$$F_{\mu} = 0.01 \sum f_i k_i$$

where:

- f_i – percentage of responses per category,
- k_i – coefficient taking values according to Table 2.

Table 2. Value of k_i coefficient for answer according to frequency of use microwave oven in household

frequency of use microwave oven	k_i
4 and more times a day	1
2–3 times a day	0.5
once on a day	0
once per 2-3 days	-0.5
occasionally	-1

F_{μ} takes values from -1 to 1, with negative values showing standardized indications at the level of less than once a day. Positive values, on the contrary, more than once a day. For $F_{\mu} = 0$ the mean frequency of use microwave oven is estimated as once a day.

As indicated in Figure 2, during 18 years of research, a clear tendency to reduce declared frequency of microwave ovens use, with a tendency to stabilize at $F_{\mu} = -0.25$ has observed. However, the value of $F_{\mu} = -0.2$ obtained in 2020 is about 20% higher, deviating in size and direction from the trend observed in previous studies.

This clearly corresponds to the results of the current study (Figure 1) and confirms supposed scenario no 1 – longer time spent at home and pandemic restrictions have significantly increased the number of household culinary operations supported by microwave ovens.

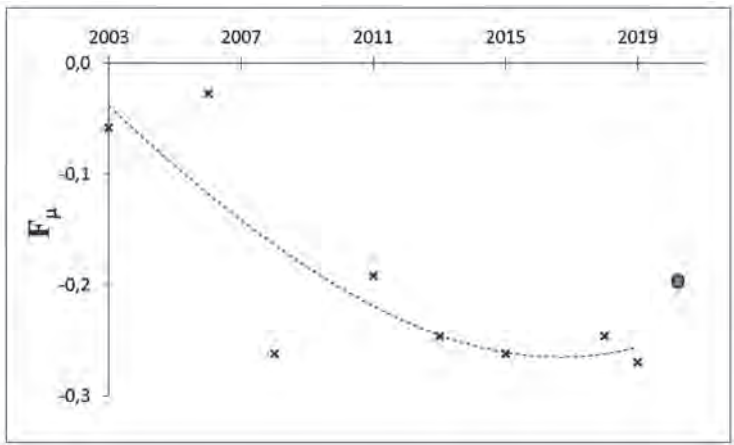


Figure 2. The changes of declared frequency of using microwave in household express as the F_{μ} ratio

Analysing the structure of the responses obtained in terms of the intensity of microwave use in the run-up to the pandemic, it is clear that the greatest increase in the frequency of its use was declared by people using this device at a moderate frequency – once +/- twice a day (Figure 3). It follows that in households where the microwave oven has already been used, their use has been intensified. However, where it was rather a kitchen gadget, the frequency of its use increased only slightly. In the case of households that use microwave ovens very intensively, there were much fewer indications for an increase in the frequency of use this device. It is difficult, with a high intensity of use, to observe or become aware and mark relatively small changes in the survey.

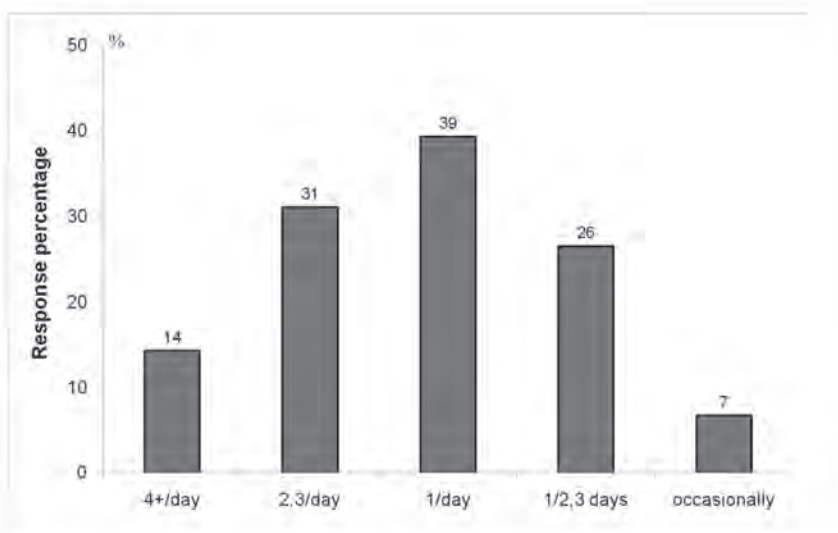


Figure 3. Dependence of more frequent use of the microwave oven during the COVID-19 pandemic on the declared frequency of microwave oven use

A comparison of the declared distribution of heating processes carried out in microwave ovens in 2020 with the results of analogous research from 2003–2018 (eight cycles) is presented in Figure 4. In the case of cooking, there was a decrease of 26% compared to 2019. Other culinary operations were performed more often: heating previously prepared meals – 11%, preparing snacks – 27%, defrosting food – 38%, heating dinner kits – 46%.

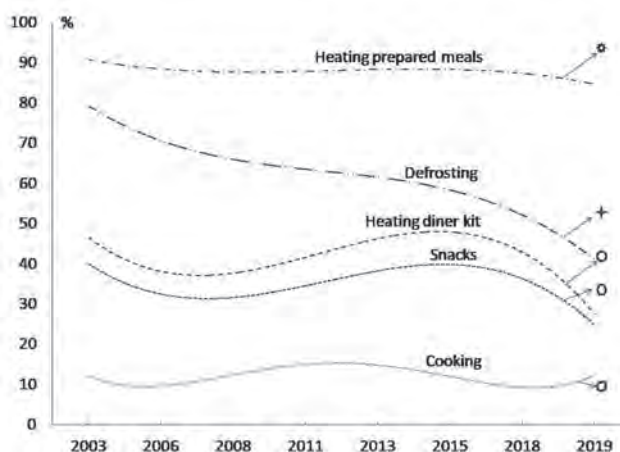


Figure 4. Percentage of microwave oven users using it to selected culinary processes: lines – the results of earlier surveys, points – year 2020

This distribution corresponds to the most widely declared applications of microwave ovens in the last two decades. It's clearly indicates an increase in the use of auxiliary functions of the microwave oven, with a clear decrease, to the values of even marginal, cooking. The observed effect may also indicate an intensification of classic household culinary processes, aided by defrosting food in microwave ovens, which is probably related to the need to prepare and consume meals at home. Its intensification was also influenced by larger than before pandemic accumulation of food stocks in households.

Especially products with extended shelf life, including deep-frozen ones. This phenomenon could be linked to limited access to grocery stores during the pandemic. It may result from both administrative restrictions on access to stores and a reduction in the frequency of purchases by consumers themselves.

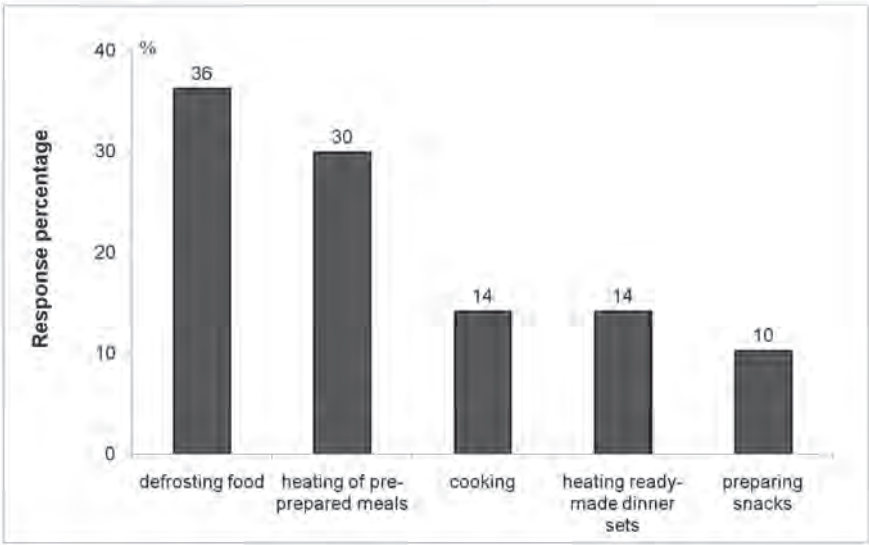


Figure 5. Percentage of microwave oven users using it to selected culinary processes: lines – the results of earlier surveys, points – year 2020

The results presented above refer only to the prevalence of the use of microwave ovens. A picture of changes in the intensity of the use of microwave ovens divided into individual culinary processes during the COVID-19 pandemic is shown in Figure 5. It show clear, more than twice as high as the others, dynamics of intensification of auxiliary processes in the form of defrosting food products and heating previously prepared meals. The result above confirms previous observations about the use of microwave ovens mainly for auxiliary culinary processes (Melski, 2012).

Conclusions

The results of the survey show opposite direction of changes declared in the last survey than the trends observed in previous surveys. A new factor decisively influencing the social, economic and personal life of Poles in the period between the last surveys was undoubtedly the COVID-19 pandemic. The pandemic has caused profound changes in the way we live, including the way we work, spend our free time, prepare and eat meals. On the other hand, it should also be taken into account that, due to the longer period asked in the survey – nine month, the picture of the trend shown could be darkened by the overlap of general changes in consumer behaviour not directly linked to restrictions on citizens' consumption and lifestyles connecting with pandemic. However, the rapid reversal of long-term trends and clear indications of an increase intensity of microwave ovens use during the pandemic strongly indicate significant impact of COVID-19 pandemic on change in consumer behavior in the studied area. Such a picture of the phenomenon unequivocally confirms the research hypothesis.

References

- Czarnecka-Skubina, E., Trafiałek J., Kocon, D., Pielak, M. (2016). Wykorzystanie kuchenek mikrofalowych do przygotowania potraw w polskich gospodarstwach domowych. *ŻYWNOSĆ. Nauka. Technologia, Jakość*, 109(6), 140–151.
- Korzeniowska-Ginter, R., Tkacz, K. (2015). Wykorzystanie kuchni mikrofalowych w gospodarstwach domowych. *Inżynieria i aparatura chemiczna*, (5), 257–258.
- Melski, K. (2012). *Towaroznawcza ocena opakowań żywności stosowanych w technice mikrofalowej*. Poznań: Wydawnictwo Uniwersytetu Ekonomicznego.
- Melski, K. (2018). Wykorzystanie kuchenek mikrofalowych w gospodarstwach domowych studentów UEP – stan obecny, tendencje. In: M., Paździor, J., Żuchowski, R., Zieliński (ed.), *Selected problems of Industrial Products Quality, Wybrane problemy jakości wyrobów przemysłowych*. Radom: Uniwersytet Technologiczno-Humanistyczny, 75–84.
- Piskiewicz, L., Radziukiewicz, M. (2018). Zasoby dóbr trwałych w gospodarstwach. *Wiadomości statystyczne*, 10(689), 37–55.
- Statistical Yearbook of the Republic of Poland 2020 (2020). Warsaw: Statistics Poland.

PURCHASING PREFERENCES OF CRAFT BEER CONSUMERS BEFORE COVID-19 AND COVID-19 DRIVEN CHANGES

Leszek Matuszak¹

Abstract

The aim of the publication is to present the purchasing habits of craft beer consumers, as well as to analyze changes in distribution methods in 2018 and in 2021.

Craft beer/brewery is defined as “small”, “quality oriented”, “independent” and “known from people responsible for product”.

Group of over 800 beer consumers were examined – they were recruited from beer festivals, personal interviews with employees of craft breweries and ordinary consumers of craft beers from leading fan pages. There were also used data from craft beer web pages and online offer of most micro/craft breweries in Poland.

Main conclusions of paper was difference between “hard” craft beer consumers – before COVID-19 situation they were consuming craft beers in multitaps (craft beer pub with wide range of selection of craft beers). In 2020 and 2021 new sales channel were created.

Introducing lockdown of pubs and restaurants induces changes in business models for craft breweries – new way of selling beers online, changing philosophy of business (way of designing products, way of distribution). Its results were visible in financial and production results of 2020. Craft breweries sector adapts to changes - some companies undertook different strategies in area of distribution, product design and general business philosophy.

Keywords: craft beer, consumer preferences, COVID-19 impact

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Introduction

Poland was always important player among beer producers in Europe and all over the world. It is also one of the countries with most consumed beer per capita (from 30 liters per capita in early nineties, 80 liters in 2005 to over 100 liters in 2019). Most of this is produced by large international brewing concerns owning Polish breweries (Kompania Piwowarska, Grupa Żywiec and Carlsberg Polska) [Kopeć & Mitera, 2014]. In Polish stores and pubs (or restaurants) dominated one beer style – Pale Lager (called also International Pale Lager or “eurolager” supplemented by pilsners (lager style beer) [Kopyra, 2012], wheat beers and bock beers. Share of small regional breweries offering other styles (baltic porters, dark lagers, strong lagers or grodziskie) was small and insignificant.

Popularity of lager style induced creation of market niche for different styles directed to more demanding consumers looking for more specific taste and styles. It was also caused by ease of travel and crossing borders between different European countries.

All mentioned earlier factors caused phenomenon called “the craft beer revolution” started by PINTA brewery in 2011 (launching beer in in style of American India Pale Ale – “Atak chmielu” (eng. Attack of the hop) – beer, that had bitterness and used hop species extremely different from existing beers. The craft beer revolution was preceded by a long period of consolidation and homogenization in the global beer industry that began in the late 19th or early 20th century and lasted for most of the 20th century (in USA and in Europe – egg. in the United States the number of macrobreweries fell from 421 in 1947 to only 10 by 2014, in Belgium the number of breweries declined from more than 3000 in 1900 to 143 in 1980) (Garavaglia & Swinnen, 2020; Wojtyra, 2020). In Poland this process was different – market was consolidated (TOP 3 had over 80% of market share), but existed over 70 breweries. In 2019 number of breweries increased to over 420.

Analyzing number of new beers introduced to market it was 82 in 2013 to over 2400 in 2019 (with decrease in 2020) (Figure 1).

Evolution of craft beer market can be explained by socioeconomical reason or by resource-partitioning theory – after consolidation of market and selling homogenous product there is space for “luxury product” or for “competitive fringe” where smaller companies compete not by price, but by other factors (taste, style, ability to adapt to consumer needs and ither). Dynamic of introducing new product was presented on Figure 1 (Wojtyra, 2020; Wojtyra & Grudzień, 2017; Chlebicka, Fałkowski & Lichota, 2017).

Presence of COVID-19 caused rapid changes in dynamics of market growth (linear regression model indicated on almost 3000 new beers introduced in 2020: $R^2 = 0.98$, predicted through linear regression $y_{2020} = 2865$). It also generated

changes in consumer preferences in area of distribution connected with different selling strategies.

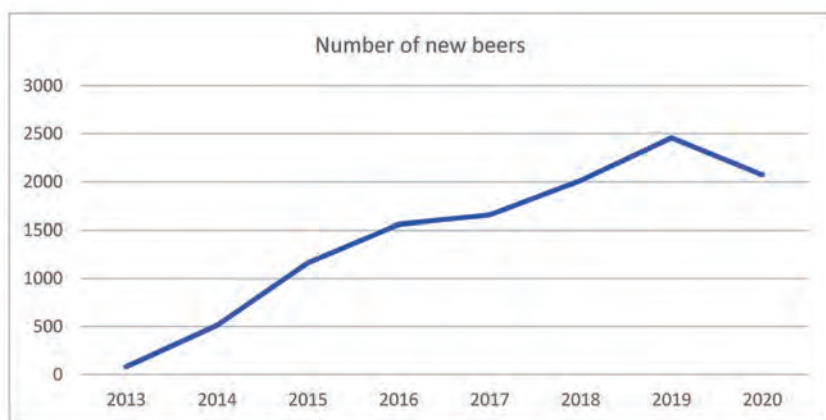


Figure 1. Numbers of new craft beers introduced to market

Source: based on: (Wojtyra, 2020; PiwnaZwrotnica.pl reports from 2014–2020).

Research among craft beer consumers in 2018 – buying habits

Group of over 800 beer consumers were examined – they were recruited from beer festivals, personal interviews with employees of craft breweries and ordinary consumers of craft beers from leading fan pages. To further examination only consumers declaring drinking beers were chosen.

In paper following questions will be examined:

- do you consume craft beer? (possible variants: only “concern beer”; mainly concern, but trying other; drinking both; mainly craft, but trying concern beer; drinking only craft beer) – it will be called in paper “profile of consumption”,
- how many different beers have you consumed during last 12 months? (to 10; 11–20; 21–50; 51–100; 101–250; 251–500; over 500),
- how often do you consume beer?
- where do you buy beer (supermarket/grocery store/pub/in specialty craft beer store/via mail)?
- where do you consume it?

Questions will be analyzed broken down into age groups, sex and place of residence.

For easier analysis group of consumers divided between different profiles of consumption were labeled as:

- group A – drinking only concern beer (n = 80),

- group B – drinking mainly concern, but trying other (n = 204),
- group C – drinking both kinds (n = 168),
- group D – drinking mainly craft, but trying concern beer (n = 230),
- group E – drinking only craft beer (n = 130).

Since 2021 data offer of Polish craft breweries was analyzed (in area of selling beer remotely).

In analysis chi-square tests were used. For comparison also non-parametric tests were used (because of ordinal scale in question about frequency and place of buying/consumption).

There are statistically significant relationship ($p < 0.0001$) between declared range of number of drunk beers and preferred beer type (concern/craft beer) – most consumers declaring drinking craft beer only consumer over 100 different beers during past 12 months (it refers also to joined group of “craft beer only” and craft beer, but trying concern one).

In case of drinking concern beer (or occasionally craft ones) majority drink up to 10 (48%) or up to 20 different beers (78%).

Comparing frequency of drinking beer and profile of consumption, there are also statistically significant relationship ($p < 0.0001$). Most of craft beer drinking consumers are drinking beer once per week or even less often. In case of consumer drinking concern beer most of them (75%) consume beer 2–3 per week or more often. Concern beer consumer drinks more frequently, but it is usually most popular beers, bought in supermarket) (Meyerding, Bauchrowitz & Lehberger, 2019; Smith, *et al.* 2016).

Analyzing place of purchase few conclusions can be made:

- over 75% of two groups mainly drinking concern beer are buying beer in supermarket or discount store,
- over 10% of craft beer enthusiast avoid this kind of stores.

There are statistically significant relationship ($p < 0.0001$) between frequency of buying beer in discount store or supermarket and profile of consumption.

There are also statistically significant relationship ($p < 0.0001$) between frequency of buying beer in beer specialty store and profile of consumption. Over 70% of group D and E are customers of this kind of stores. In case of group A and B only 2% are buying in these stores more often.

Customers from group A and B are buying more frequently also in local groceries (60% of the buy there frequently – in case of group E it is less than 7%, and for combined group D and E it is less than 16%. Relationship between profile of consumption and place of buying beer is statistically significant ($p < 0.0001$).

In case of pubs/bars relationship between frequency and profile of consumption is statistically insignificant ($p = 0.13$). That means, that all beer consumers (both concern- and craftbeer- lovers) buy and drink beer in pubs in the same way/frequency.

There were another way of buying beer – it was remote buy (e.g. Mikkeler Beer Club, Craft Beer Club, Beer52 and many others). It was used regularly only by less than 2% of all respondents, but in case of group E, it was over 7% of them (and over a half of buying beer regularly via beer mails and other subscriptions. In 2018 Mikkeler Beer Club was the most popular service offering foreign beers, but the quitted in Poland because of law regulations. Evolution of distribution of craft beer will be described later.

Research among craft beer consumers in 2018 – consuming habits – place of consumption

Consumers were asked where (and how often) they are consuming beer. They were asked about:

- at home/at friends,
- in pub/bar/restaurant,
- in specialty pub/multitap,
- on countryside (near river/lake/on the beach),
- on the party.

In order to identify statistically significant differences chi-square tests were conducted.

Summary of result is shown in Table 1.

Table 1. Place of consumption vs. different profile of consumption – results of chi-square tests

Place of consumption	p-value	Most popular place for:	Least popular place for
At home/at friends	0.030	Groups C, D, E	Group A
In pub/bar/restaurant	0.000	Groups A, B	Group D
In specialty pub/multitap	0.000	Group D	Groups A, B
On countryside (near river/ lake/on the beach)	0.000	Group B	Group D
On the party	0.000	Groups A, B	Group D

Source: based on own research.

In all cases relationship between profile of consumption and frequency of consumption was statistically significant.

What's interesting, there are difference between profile D and E in place of beer consumption. Group D strongly prefers specialty pubs, but doesn't prefer "ordinary" pubs or drinking on countryside. Craft-beer drinking groups (C, D, E) prefer drinking at home (at friends (e.g. beer sensory panels)).

Summarizing preferences of profile group can mislead to proper conclusions, because these groups are not homogenous.

In order to define and describe preferences of place of buying and place of consumption beers cluster analysis were conducted.

Research among craft beer consumers in 2018 – consuming habits – cluster analysis

In cluster analysis k-means methods were chosen in order to differentiate groups of consumers. All variables were standardized and in calculations Z-scores were used. After consideration it was decided, that 3 cluster will be the best option.

List of 13 variables used in cluster analysis:

- Do you consume craft beer?
- How many different beers have you consumed during last 12 months?
- How often do you consume beer?
- At home/at friends (place of consumption),
- in pub/bar/restaurant (place of consumption),
- in specialty pub/multitap (place of consumption),
- on countryside (near river/lake/on the beach) (place of consumption),
- on the party (place of consumption),
- supermarket (place of purchase),
- grocery store (place of purchase),
- pub (place of purchase),
- in specialty craft beer store (place of purchase),
- via mail (place of purchase).

Three homogenous group were identified:

- Group 1 (31% of total consumers participating in survey),
- Group 2 (29% of total consumers participating in survey),
- Group 3 (40% of total consumers participating in survey).

Description of group is shown in the form of heatmap, where red means low values (least often/low frequency), orange/yellow fields indicate medium values and green means high values (most often/high frequency of purchase/consumption) (Table 2).

Table 2. Heatmap of results of cluster analysis

	Cluster		
	Group 1	Group 2	Group 3
Do you consume craft beer?			
How many different beers have you consumed during last 12 months?			
How often do you consume beer?			
At home/at friends (place of consumption)			
In pub/bar/restaurant (place of consumption)			
In specialty pub/multitap (place of consumption)			
On countryside (near river/lake/on the beach) (place of consumption)			
On the party (place of consumption)			
Supermarket (place of purchase)			
grocery store (place of purchase)			
pub (place of purchase)			
in specialty craft beer store (place of purchase)			
via mail (place of purchase)			

Source: based on own research.

Composition of group considering profile group is shown on Figure 2. In Cluster 1 and cluster 3 only 4 profile groups are present – in cluster 1 there are no consumers from group E. By analogy, in Cluster 3 there are no consumers from group A.

Cluster 1 prefers concern beer, but sometimes tries new tastes (more different beers than cluster 2), consumes beer in pubs, on the party, on the countryside. They buy beers in supermarket and pubs, but also in specialty stores. They rarely goes to multitaps and don't user beer subscription.

Cluster 2 consumes only few kinds of beer, they buying it in pubs or supermarket. They drink beer less frequent and did this on party, countryside. They don't enter multitaps.

Cluster 3 drink mostly craft beer – with high frequency and wide range of brands. They buying beers in specialty craft beer store, on grocery stores and via email. Cluster 3 prefers drinking in specialty pubs (multitaps) or at home. They enters pubs or party less often – it can be said, that beer is drunk not by the way, but on purpose (it was confirmed during interviews and talks during fairs and beer festivals).

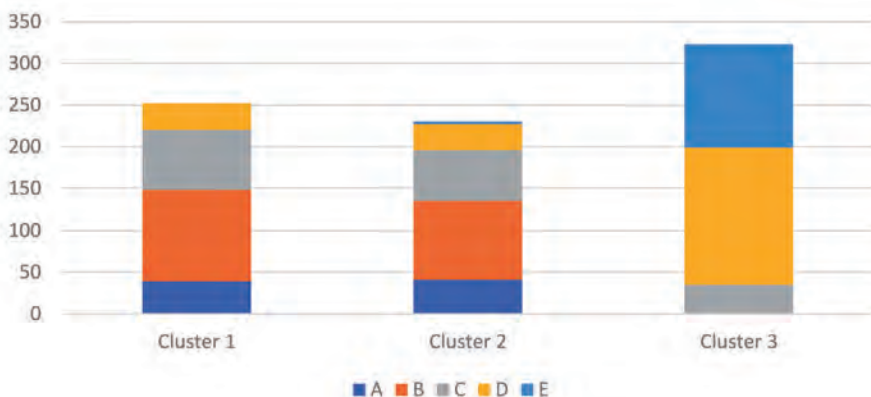


Figure 2. Composition of group considering profile group

Source: based on own research.



Figure 3. Assignment profile groups to different clusters

Source: based on own research.

Craft beer market in 2021 – changes in way of distribution

In 2018 most of craft beer was distributed among specialty stores, multitaps/craft beer pubs and festivals. Only few breweries were selling their products in discount stores chain or supermarket (like Lidl, Auchan). There were also few regional breweries selling via grocery stores (in convenience store chain like Żabka). It doesn't refer to restaurant breweries, that sold beer only on place and sometimes during beer events (festivals). Selling beers online wasn't popular (mainly because of law regulations it was impossible to sell beer online with posting service – existing in Poland beer subscription club offers its subscribers buying online with personal pickup, most popular subscription service in Poland (Mikkeler Beer Mail from Denmark) withdrew from Poland in 2019).

COVID-19 pandemic state caused (forced) changes in distribution model. Closing pubs, restaurants (lockdown), postponing or cancelling festivals, fairs and other restrictions – number of stationery and contract breweries is stable.

More and more producers introduce beers in cans – in 2017 only 1 craft brewery sold canned beer, in 2018 there were 3 breweries with canned beer in offer, in 2019 number increased to 13 and in 2020 33 breweries sold canned beer (not including regional breweries and big concerns).

It helps selling online (cans are lighter, broke-resistant and with better shape to fit in package) additionally craft breweries have chosen few ways of avoiding law restrictions (Act on the provision of educational services, 2019; Consumer Rights Act, 2019) (Table 3):

- catering service (beer is delivered for catering service provided by seller – consumer can give up being serviced and get only package with beers,
- agreement with the place of issue of the item – consumer is buying beer with personal pickup and then orders delivery company to deliver it,
- agreement of reservation and pickup – consumer reserves order and then orders delivery company to deliver it – this is most popular options in case of having by shop/brewery concession for selling alcohol.

It is still unpopular options to broaden distribution channels, but perspective of next lockdown forced flexibility and changing way of thinking – more and more of breweries are selling beers via discount stores (in Lidl in 2017 craft beer from Poland were very rare (available only for website with pick up at store)). In 2020 – 2021 at least 20 different craft breweries are selling beers in Lidl (and some of them have offered exclusive packs with glasses and other gadgets).

Table 3. Way of selling beer online by craft breweries

Catering service	Agreement with the place of issue of the item	Agreement of reservation and pickup
<ul style="list-style-type: none">• Browar Harpagan• Browar Stu Mostów	<ul style="list-style-type: none">• Browar Trzech Kumpi• Browar Tenczynek	<ul style="list-style-type: none">• Browar Lubicz• Browar Tenczynek• Krafklub.pl

Source: based on: based on own research.

The other way was opening own pubs (not only in brewery, but also in large cities (like Pinta brewery).

Summary and conclusions

Every rapid and unexpected phenomenon is leading to changes. In case of craft beer market changes affected:

- way of distribution (more online selling),
- way of packaging (in 2 years there were 1100% increase in number of breweries offering cans),
- not relying only on craft beer events (fairs, festivals, specific events),
- offering beer not only in specialty stores (but also in discount stores and convenience store).

Survey from 2018 has shown, that craft beer consumer is different from typical beer drinker – there is different style of consuming:

- beer sensoric panels and trying many beers in small portions,
- using special applications to check-in and rate beer (in order to know, what is worth trying, what are trends and “what’s on taps”),
- different styles of buying.

Often it is not only small or large beer, but some beers are bought in 100 ml samples (just to try). It is a different purpose of drinking beer – it is not drinking by the way (at the party, at the stadium, during television transmission). Mainly it’s drinking for reason – to try new styles, new interpretation, to check new beer food pairing.

References

Act on the provision of educational services, 2019.

Act on the provision of electronic services of July 18, 2002, Ustawa o świadczeniu usług drogą elektroniczną z dnia 18 lipca 2002 r. (Dz. U. z 2019, poz. 123 ze zm.).

Chlebicka, A.J. Fałkowski, Lichota J. (2017). From Macro to Micro: The Change of Trendsetters on the Polish Beer Market. In: C. Garavaglia, J. Swinnen (eds.), *Economic Perspectives on Craft Beer: A Revolution in the Global Beer Industry*. London: Palgrave Macmillan.

Consumer Rights Act, 2019 in polish – Ustawa o prawach konsumenta z dnia 30 maja 2014 r. (Dz. U. z 2019, poz. 134 ze zm.).

Elzinga, K.G. (2013). The beer industry. In: J. Brock (ed.), *The Structure of American Industry*. 12th Edition. Waveland Press Inc.

Garavaglia, C., Swinnen, J. (2020). *Economic Perspectives on Craft Beer*. Springer Nature: Basel, Switzerland, 2018, 10.1007/978-3-319-58235-1.

Howard, P.H. (2014). Too big to Ale? The globalization and consolidation in the beer industry. In: M. Patterson, N. Hoalst-Pullen (eds.), *The geography of beer. Regions, environment, and societies*, 155–165, Springer: Dordrecht.

Kopeć, M., Mitera, K. (2014). Rozwój piwowarstwa w Polsce w okresie poakcesyjnym (Development of brewing in Poland in the pre-accession period). *Progress in Economic Sciences*, 1, 75–83.

Kopyra, T. (2012). Piwowarstwo w Polsce 2012. *Piwowar* (9), 10–13.

Meyerding, S.G.H., Bauchrowitz, A., Lehberger, M. (2019). Consumer preferences for beer attributes in Germany: A conjoint and latent class approach. *J. Retail. Consum. Serv.*, 47, 229–240, doi: 10.1016/j.jretconser.2018.12.001.

Siemieniako, D., Kubacki, K., Glinska, E., Krot, K. (2011). National and regional ethnocentrism: A case study of beer consumers in Poland. *British Food Journal*, 113(3), 404–418.

Smith, R., McKinney, C., Caudill, St., Mixon, F. (2016). Consumer ratings and the pricing of experience goods: hedonic regression analysis of beer prices. *Agricultural and Food Economics*, 4, doi: 10.1186/s 40100-016-0068-3.

Wojtyra, B., Grudzień, Ł. (2017). Development of the beer industry in Poland in the period of “the craft beer revolution” (2011–2016). *Studies of the Industrial Geography Commission of the Polish Geographical Society*, 31(1): 52–67, doi: 10.24917/20801653.311.4.

Wojtyra, B., Kossowski, T.M., Březinová, M., Savov, R., Lančarič, D. (2020). Geography of craft breweries in Central Europe: Location factors and the spatial dependence effect. *Appl. Geogr.*, 124, 102325, doi: 10.1016/j.apgeog.2020.102325.

Wojtyra, B. (2020). How and why did craft breweries ‘revolutionise’ the beer market? The case of Poland. *Moravian Geographical Reports*, 28(2), 81–97, <https://doi.org/10.2478/mgr-2020-0007>.

<http://www.zwrotnica.com.pl/> – reports about craft beer market in Poland (number of breweries, new styles, new packages) – reports from 2013–2020 [7.07. 2021].

RESEARCH ON CONSUMER PREFERENCES RELATED TO FOOTWEAR USED BY PEOPLE PRACTICING SKATEBOARDING. STATISTICAL ANALYSIS AND SELECTED QUALITATIVE ASPECTS

Adam Miratyński¹

Abstract

Skateboarding as an extreme sport has been gaining popularity over the previous years. This is strongly impacted by two factors: the fact that skateboarding is now recognized as an Olympic sport and secondly due pandemic circumstances where individual sports have been gaining more interest. The expanding amount of skateboard users creates a excessive demand for skateboard gear including skateboarding shoes.

The following article focuses on technical and design aspects of shoes dedicated for skateboarding. Moreover it serves to introduce and analyze the results of a survey carried on 108 skateboarders, who answered questions regarding their skateboard shoe preferences.

Using methods of statistic analysis on achieved results, the research led to conclusions that there are strong connections between particular groups of skateboarders and their preferences in choosing a specified type of shoe.

The study proves that specific zones on skateboard shoes are more exposed to abrasion and damage than others. In regard to frequent use and various evolutions performed on a skateboard this information is crucial to understanding modern skateboard shoe design and technological innovations.

The conducted study leads to knowledge about customer preferences among skateboarders and can be an important impulse to develop new technological solutions or improve those existing.

Keywords: footwear, sport, quality, consumer, design.

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Introduction

Skateboarding as an extreme sport has been gaining popularity over the previous years (Lange, 2021). This is strongly impacted by two major factors: the fact that skateboarding is now recognized as an Olympic sport and was scheduled to be in the 2020 Tokyo Olympics (Batuev & Robinson, 2017) and secondly due the unfortunate pandemic circumstances where individual sports have been gaining more interest (Akabas, 2021). The expanding amount of skateboard users creates a excessive demand for skateboard gear including skateboarding shoes, which are crucial for safety and comfort (Gilbreath, 2020).

Footwear is the most important part of every skateboarding athlete's outfit. It has a decisive impact not only on the comfort and effectiveness of evolutions performed by a skateboarder but also his safety. The level of protection provided by this particular element of apparel can be crucial in avoiding serious injuries (Frederick, *et al.* 2006).

This article serves to bring closer the issues related to development of the sport discipline of skateboarding by focusing on the footwear used by professional and nonprofessional athletes around the world. In this section the author will try to bring closer the main construction details of skateboard shoes, their basic layout and different manufacturers solutions. The second section contains detailed information on consumer preferences and a statistical analysis of the survey results. The aim of the research was to find out the expectations, habits and consumer preferences of the users of this type of footwear. They can be used as a guideline for manufacturers, whose priority is to provide the best quality and achieve a permanent relationship with their customers.

The article uses a variety of sources, ranging from books, magazines, articles and publications as well as websites, and promotional materials provided by selected manufacturers of footwear used and dedicated to skateboarders.

Characteristics of skateboarding footwear components

Contemporary skateboarding footwear features various material combinations, colorways and technological solutions. This type of shoes can be divided however into categories based on main construction elements and different production methods. This includes distinctive sole types (Cupsole or Vulc) and the selection of uppers, their height and used materials (Vogel, *et al.* 2010).

The wear and tear of shoes in this sport is a destructive process, which greatly influences fast deterioration of their initial characteristics. Each pair has a specific life cycle, depending on the manufacturing technology, quality and type of materials used by the manufacturing company. Durability is also affected by

consumer skill, conditions of use, and maintenance. However, no matter how a skateboarder operates his footwear, the manufacturer should (also for safety reasons) ensure the highest quality of the product it provides (Gomez, 2012).

Overview of soles and insoles

The skateboarding shoe's sole is one of the most important factors and has a direct impact on its performance. It depends on various elements of shoe construction, technology, type of material, pattern and texture. All combined define the shoe's durability and its "feel". This is a subjective evaluation by the consumer and characterizes those features of the shoe that cause it not to restrict the movement of the foot and allows a close to natural feel of the ground. This parameter is commonly known among skateboarders as "boardfeel" (Hua, 2018).

Nowadays, manufacturers increasingly decide to use different types of soles in the same models of shoes, matching their offer to the demand and customers preferences.

Contrary to daily use footwear design, where sole leather would be the main ingredient, a modern skate shoe sole consists of the following elements: for Cupsole it is the midsole and outsole (rancourtandcompany.com, 2016), for vulcanized shoes it is the foxing tape and outsole (Vans, 2015).

The outsole is in constant contact with skateboard griptape or the terrain it pushes off. It is exposed to significant friction forces generated by different types of surfaces. It must meet all the requirements for grip, stability and flexibility, as well as being durable and abrasion resistant (Nevitt, *et al.* 2009). Some brands decide to put additional cushioning systems integrated with the outsole. Once successfully introduced to the market, the designs also become a manufacturer's trademark. As an example the company Vans created a well known pattern called the *Waffle* (Lombard, 2015).

Some companies experiment with one-piece soles, which combine outsole and midsole elements into one specialized element. This type of solution was presented by the aforementioned Vans, creating a hybrid of cup sole and Vulc sole in the Kyle Walker Pro model (vans.pl, 2021).

The midsole, typical for Cupsole shoes, is a layer located between the outsole and the upper. It serves to absorb shock and is often made of EVA foam, as well as other plastics such as Phylon or Lunarlon (Motawi & Motawi, 2018).

Manufacturers using midsoles, implementing the results of their own laboratory research, have decided on different technologies for their implementation. In this way, patents used by individual brands were created (adidas.com, 2020; Collins, *et al.* 2019; Jones, 2020; news.nike.com, 2013; Person, 2004):

- Boost from Adidas,
- Lunarlon, Hyperfeel and Zoom from Nike,
- Unilite from DC,
- STI Evolution from Sole Technology,
- Pro UltimateWaffle from Vans.

The topic of insoles lays mostly in the individual needs of each wearer. For many decades skateboard shoe companies did not pay enough attention to insoles sold with their products. Today however, with the raise of athletic and physical awareness this particular element is gaining more recognition. Nowadays, replaceable insoles are a common thing and the user may freely choose and adapt them to his needs (Vee, 2021).

There is a wide range of models on the market, which offer various functions and technologies. The variety stretches from simple insoles made from thin foam to insoles with gel or air cushions in the heel area. Different thicknesses, profiles and shapes are widely available. Many companies decide to have individual types of insoles used in their shoes. The curvature of the insole is also customized. Basically, however, the design philosophy comes down to making the center of the insole from EVA foam, and around it is created an additional profile that holds the foot in one position, not allowing it to move from side to side (Crabtree, *et al.* 2009). In addition, manufacturers often choose to use antibacterial technologies to maintain better sensory properties. One of the most popular solutions are provided by *Ortholite*. These systems increase breathability and have antibacterial properties, preventing the growth of microorganisms (ortholite.com, 2021).

Separately sold insoles are an independent segment of the skateboarding footwear market. This particular branch offers products which can be fitted or trimmed to the individual shape of each foot. Over the recent years, custom insoles have been gaining popularity and recognition among athletes. They are characterized by more effective shock and impact absorption and therefore provide greater protection against injuries. For example, models from Etcetera Insoles offer have specially fitted elements made of rigid plastics, supporting the longitudinal arch of the foot and protecting it against injuries (tactics.com, n.d.).

Currently, the best known and most popular are products of Footprint Insole Technology company, which uses an innovative technology of polyurethane fibers, converting kinetic energy into heat. These insoles comply with rigorous standards that account for quality and shock absorption abilities. These standards are (fpinsoles.com, 2019):

- ASTM F1614: 2006 (Standard Test Method for Shock Attenuating Properties of Materials Systems for Athletic Footwear),
- ASTM F1976-13 (Standard Test Method for Impact Attenuation of Athletic Shoe Cushioning Systems and Materials).

Characteristics of Vulc and Cupsole

As mentioned earlier, there are two main sole systems used in skateboarding footwear:

- vulcanized – Vulc,
- Cupsole.

Vulcanized shoes are characterized by greater flexibility and provide a better feel of the skateboard under the feet but lose on the durability and structural consistency side. Cupsoles on the other hand, provide more strength and cushioning at the cost of additional weight and lesser flexibility (Dudes, 2016).

First shoes made specifically for skateboarding were made using vulcanized soles. The greatest advantage of these soles is in their high flexibility and low profile. This allows a better feel of the board under the riders feet. Thanks to a thin outsole and practically no foam or textile additives, these products are significantly lighter than Cupsoles. Vulc soles are also simpler in terms of construction, as they only consist of a thin rubber outsole and rubber foxing tape which connects the sole to the upper part of the shoe (findsourcing.com, 2018). Some models can feature simple cushioning elements, however they do not absorb impact and shock as well as Cupsoles. Because vulcanized soles do not use additional seaming, they are less durable and more prone to defects throughout usage (Dudes, 2016). The process of vulcanization is carried out in ovens, where at high temperatures the glue binds the outsole with foxing tape to the shoe's upper.

Thanks to a lightweight construction, vulcanized shoes have the ability to break in instantly. This allows the skateboarder to have maximum performance of the shoe immediately after putting them on. Unlike Cupsole models, Vulc does not need a period of stretching or adapting it up by the user (findsourcing.com, 2018).

It is worth mentioning that one of the biggest disadvantages of vulcanized products is their greater abrasion value which directly impacts their shorter life. Manufacturers usually use NBS 400, 800 or 1200 rubber for their soles; these compounds have the best adhesion to abrasion ratio (Kim & Kim, 2014).

Cupsole soles on the other hand are consist of two or more modules, fused together, which are then connected to the upper of the footwear. The outer sole is glued to the midsole, which is additionally sewn into the shoe. The midsole is made of light and flexible EVA foam, or another similar technology, depending on the manufacturer (Hanhi, *et al.* 2007). It serves as a shock absorber, while the outsole is responsible for ground contact and traction. The raw material used to make the outsole is usually polyurethane. Because of thick soles, these shoes are heavier, less flexible and take much longer to adapt to the wearer's foot than a vulcanized sole (findsourcing.com, 2018).

With a more solid profile and extra stitching, these soles are much better at dampening shock and vibration. It is a desirable feature, especially in places where the athlete's joints are overloaded, decreasing the danger of limb exposure to injuries connected with falls (Giesswein Int, 2019).

Upper materials

To manufacture uppers, companies use a variety of raw materials, ranging from a wide variety of plastics, fabrics to natural leather. The particular model of a shoe can be offered in many material configurations and any color scheme. Footwear companies are required to mark their products with pictograms, which make it easier for consumers to choose the product that best suits their needs (Hua, 2018).

The most popular and widely used raw material used in the production of the upper is suede leather. It is characterized by high durability and resistance to forces acting on the shoe during sports activities. Its durability and high resistance to abrasion makes it well able to cope with the contact of skateboard sandpaper (James, 2021). Additionally, it is stretchable and becomes softer with use. Thanks to this properties, it adapts well to the foot, allowing the selection of tight-fitting shoes that will begin to mold to the foot's shape over time (Christ, 1989). In models combining suede with synthetic materials, suede can be commonly found in areas most prone to damage, such as the toecap. To ensure better circulation, manufacturers opt for perforations or ventilation inserts. The name "suede" is often used by manufacturers as a general term for rough animal skin, but unfortunately companies do not specify the exact type of animal raw material used in the production process (James, 2021).

Shoe brands also often use grain leather, which unlike suede leather, is characterized by a smooth texture. While in contact with sandpaper (griptape), grain leather is subject to quick and extensive abrasion, which affects the visual perception of footwear. Similar properties are exhibited by patent leather (coated leather), which may also be used for making uppers. Coated leather usually has a colored layer or an additional artificial coating (Hua, 2018).

It is worth mentioning that producers often decide to reinforce the uppers in critical wear points with various types of additives. *Duracap* made by Vans can be an example of such technologies. This particular solution covers the toecap with a layer of rubber in order to increase abrasion resistance (vans.com, n.d.).

An alternative to all sorts of leather shoes is the use of textile materials also commonly known as canvas (Lombard, 2015). This group of fabrics includes all

woven, knitted and bonded materials. Uppers of this kind are constructed out of (Hua, 2018):

- natural fibers (of organic origin such as wool, linen, hemp),
- synthetic fibers (nylon, viscose).

Footwear made of fabrics is characterized by high flexibility, however it is less commonly used by skateboarders due to its lower abrasion resistance compared to leather (skatedeluxe.com, n.d.).

Synthetic-based shoes, also known as vegan shoes, are another group of products on the market. The range offered in this category is getting richer. You can find shoes that are really dedicated to vegetarians or vegans (e.g. produced by iPath) or shoes that use the latest digital technologies and solutions (scanning, 3-D printing) and try to set new trends in this category (vegankicks.com, n.d.).

Study objective

The main scope of the carried study was to acquire knowledge about the consumer assessment of quality and performance of footwear dedicated for skateboarding. People practicing skateboarding are a very specific group of costumers, as they are stretched between fashion trends, brand influences and the authentic performance and durability of products available on the market. They may not always be considered as the main sales target by footwear companies but it is their input that creates this particular sport discipline.

Study methods

The selected method of quantitative research was based on a constructed survey questionnaire. This method has been chosen because of the need to explore experiences, observations and preferences of consumers/users of skateboarding footwear. Therefore grants the opportunity to collect and analyze numerical data obtained in the survey process. This research allowed to seek and understand the relationships between the quality of materials and methods of shoe manufacturing (laboratory tests are planned to be conducted in the future) in relation to consumer preferences. Combining user knowledge with laboratory research on material quality will be crucial in the process of creating the “ideal skateboard shoe”. Thus providing a tool that grants manufacturers to better meet the needs of their customers.

The complexity and diversity of footwear dedicated for skateboarding allows consumers to choose the type of shoe that meets their requirements best.

However, there is often a disparity in the quality of footwear, even among same models from one manufacturer. Such situation may be caused, among others, by differences in the quality of raw materials, such as suede used for the uppers, or by working conditions in various factories producing a given shoe.

People who practice skateboarding were chosen as the target group for this study. Respondents have been selected from various groups of age, gender and experience. Simple random selection has been picked as it is believed to be the most objective form of representing a specific society (Escher, 2020). Participants were asked to fill an anonymous personal metric in which they stated their seniority and experience in skateboarding (frequency of riding and number of years spent on a skateboard). The group of respondents included both men and women with their age stretching from less than 15 to over 45 years of age. The characteristics of this research did intend not to interfere with ones private details and were strictly aimed at the sport activity habits. Every single skateboarder has freely accepted to take part in it. Younger participants were treated according to the Article 2 of the ESOMAR Code, as the research took into account the age and maturity of the respondents.

The research did not intent to gender segregate respondents with particular proportions. Nevertheless once summarized the ratio proved statistically that skateboarding has greater popularity among men. This is a reflection of many statements found in foreign articles and websites. For example according to skatereview.com, 22.9% are female, 77.1% are male (skatereview.com, 2020).

The survey was conducted in a places designed for this type of sport (skatepark, indoor hall) as well as places where skateboarders often meet (square, park, monument). This choice of location was intended to increase the comfort and freedom of each participant. Thus, respondents should not feel discomfort related to the “formality” of this event. Above all, the researcher paid attention to be flexible and explain any ambiguities and adapt to the availability and preferences of respondents.

During the survey, skateboarders completed a questionnaire along with a metric: age, gender, years of sports participation and frequency of riding. This also allowed for more convenient grouping of respondents and their preferences.

An important aspect of the survey was to obtain knowledge regarding the quality, lifespan, design and even damage and defects of the subject's shoes. This last element is very important due to the fact that used skateboard shoes are not subject to the complaint procedure from manufacturers or retailers. This is an important issue from the users point of view as one may find shoes with hidden or material defects that tend to aggravate while practicing sport, causing irreversible changes and the need for repair or replacement. This feedback gives very

important information for both the researcher and especially the manufacturer, who should be held responsible for the quality of products he provides.

The paper survey was evaluated and transferred along with the results into an online form for statistical processing. Statistical tools allowed to thoroughly explore the essence of consumer needs, expectations and opinions. The analysis of the data collected in the survey helps to explore the needs of the skateboard community as they have every right to expect from the manufacturers involvement and knowledge of their needs. The data collected can be used as a tool to improve existing products on the market or consider a new line of footwear with changed and enhanced characteristics.

Table 1. Numeric overview of respondents

Attribute	Answer	Amount	Percentage
Gender	woman	28	25.9
	male	80	74.1
Age	bellow 14 years old	2	1.9
	15–20 years	18	16.7
	21–25 years	44	40.7
	26–30 years	33	30.6
	31–35 years	8	7.4
	36–40 years	2	1.9
	more than 45 years	1	0.9
Years spent skateboarding	less than 1 year	7	6.5
	1–3 years	19	17.6
	4–5 years	14	13.0
	6–10 years	27	25.0
	11–15 years	28	25.9
	16–20 years	8	7.4
	more than 20 years	5	4.6
Frequency of skateboarding	everyday	9	8.3
	5–6 times a week	15	13.9
	3–4 times a week	40	37.0
	1–2 times a week	23	21.3
	less than once a week	21	19.4

Source: own elaboration.

The study was aimed at a group of over a 100 skateboarders. This number of participants is believed to be sufficient to represent the consumer preferences

among skateboarding community (Mazurek-Łopacińska & Sobocińska, 2011). Answers were given by 28 women and 80 men which gives a total of 108 interviewees. This figure corresponds with the ratio of male to female skateboarders mentioned above. The predominance of men can be combined with the specificity of extreme sports as this gender is more likely inclined to take greater risks. Table 1. shows the exact proportions of surveyed skateboarders according to basic attributes.

As can be seen in the table, the numbers clearly show that skateboarding is significantly popular within people in their twenties. This group is the grand majority of respondents as over 70% of the interviewees come from this age spread.

Furthermore it is worth noting that skateboarders questioned about their years dedicated to this sport activity claim to have spent much more than 3 seasons. It can therefore be assumed that these people have extensive experience and well-grounded opinions about skateboard shoes. Their knowledge can be thus used as a benchmark of consumer satisfaction.

The largest group of respondents (40 people) declared that they practice this sport at least 3 to 4 days a week. 23 respondents stated that they train 1 or 2 times a week. Less than 20% of respondents stated that they decide to skateboard less often than once a week. This information is also highly important, as the skateboarders who claim to have more activity will be a reliable source of information about the wear and tear of footwear.

Consumer preferences presentation

In the actual survey part, respondents were asked to state how frequent do they wear their skateboarding shoes. This question was intended to gain knowledge about the regularity of picking this particular type of footwear, regardless of its actual use. The percentage proportions to this question are shown in the pie chart (Figure 1).

The respondents vast majority of responses (83 people) declared that they wear skateboard shoes every day. The second largest group was 22 interviewees, who do not wear this type of footwear more than three times a week. This confirms the statement about their high versatility and popularity among users.

Another question on the list discussed the attributes which determine the choice of a particular shoe. Skateboarders were asked to pick the characteristic which they feel were most important. Table 2 contains amounts and percentage details of answers given by respondents.

As seen in the table above, features that are most desired by users are mainly, durability of materials (77 responses), a high traction sole (69 responses) and a

good “feel” of the skateboard (64 responses). Respondents are less concerned about high-tech solutions (12 people) and low weight (14 people). It is worth mentioning that more than a half of the surveyed group chooses by their preferred manufacturer.

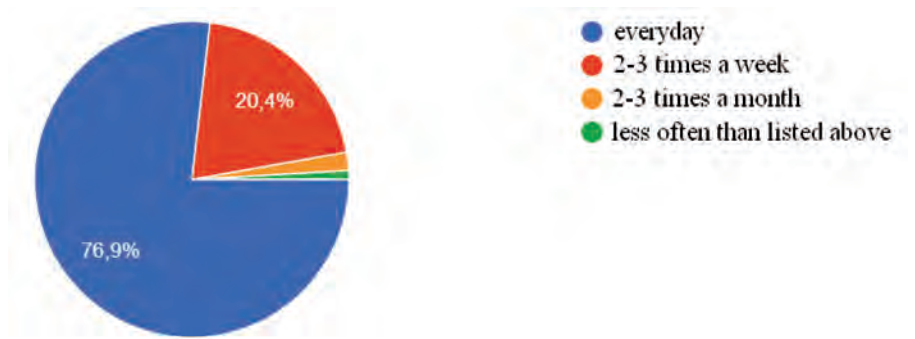


Figure 1. Frequency of wearing skateboard shoes

Source: own elaboration.

Table 2. Features that determining consumer choice when purchasing

Feature	Amount	Percentage
Low weight	14	13.0
Simple design	51	47.2
Special technologies	12	11.1
Optimal boardfeel	64	59.3
Durability of materials	77	71.3
Short adaptation time	17	15.7
Good cushioning	36	33.3
Adhesive sole (good traction)	69	63.9
Brand	57	52.8

Source: own elaboration.

The destruction of shoes occurs from the very first contact with the skateboard and the ground it moves on. The more frequent and intensive usage of footwear, the greater the damage it inflicts on the materials. In another question respondents were asked to identify the areas that they felt were most likely to undergo this process. For this purpose, a model of the shoe in two projections with marked points was used in Figure 2.

The highest number of votes was cast for point number 2, which in most skateboard shoes is located at the junction of the toe box with the middle part

of the upper. In this area, there is a change in the shape of the sole. There is a slight curvature of the foot. Point 2 is exposed to the contact with the tabletop sandpaper while performing one of the basic evolutions, which is the jump up called the *Ollie* (Frederick, *et al.* 2006).



Figure 2. The most common areas of damage to skateboard footwear

Source: own elaboration.

Point 5, representing the front of the outsole, was identified by respondents as the second most vulnerable spot. This spot is subject to constant contact with the skateboard while moving and also directly touches the ground while pushing off. In addition, there is a tendency among some skaters to “rub” (correcting the alignment of the foot) when preparing to perform an evolution. This habit can directly affect the life of the sole (Nevitt, *et al.* 2009). On the other hand 63 votes were given for point number 1 symbolizing the very tip of the nose and the edge of the sole it connects to. The indicated place is used when giving rotation to the skateboard. Point 3 was selected by 35 respondents. This location may be prone to abrasion when performing an upward jump, similar to point 2. 19.4% of respondents indicated the area around the back of the heel collar is likely to be abraded due to poor shoe placement and removal or due to shoe design flaws.

Interdependencies research

All hypotheses concerning interdependencies between responses to subsequent questions of the questionnaire were statistically verified using the χ^2 method of independence (Mynarski, 2003). A significance level of 0.05 was assumed. The

decision to reject (or not to reject) the null hypothesis was based on the value of the test probability level (p), which indicates the lowest level of significance at which the calculated value of the test statistic leads to the rejection of the null hypothesis.

Due to the formal requirements of χ^2 method, with respect to observed counts, whenever one category of response to a question was indicated by an insufficient number of respondents, before proceeding with the analysis, that category was combined with the adjacent one, which resulted in the accumulation of the corresponding observed counts. This procedure was performed in the following cases:

- Age – the categories „less than 14 years old” and „15–20 years old” were combined; the new category was named „under 20 years old”,
- Age – a new category „over 30” was created (from combining the three categories),
- Number of years spent skateboarding – the categories „less than 1 year” and „1–3 years” were combined; the new category was named „less than 4 years”,
- Number of years spent on the board – the categories „4–5 years” and „6–10 years” were combined; the new category was named „4–10 years”,
- Number of years spent skateboarding – categories were combined: „11–15 years”, „16–20 years” and „more than 20 years”; the new category was called „more than 10 years”,
- Question 2 – a new category „less often” was created (from combining three categories).

Calculated values of χ^2 as well as the probability test of “ p ” for correlations study. Lack of χ^2 and “ p ” values in particular cells indicates the fact that some tests could not be performed due to low empirical amounts. Results of this calculations are presented in Table 3. The values of the corresponding percentages were also calculated. Based on this data, the direction of correlations was interpreted.

Based on the equations (values of “ p ” lower than 0.05 allow to reject the hypothesis of independence), the following correlations were rejected: gender-construction, gender-adaptation, age-feeling, years spent skateboarding-construction, years spent skateboarding-boardfeel, years spent skateboarding-amortization, frequency of skateboarding-low weight, frequency of skateboarding-feeling, frequency of skateboarding-durability, frequency of skateboarding-brand, frequency of wearing shoes-low weight, frequency of wearing shoes-specialized technology.

This exclusion allowed to calculate percentage designation for the following aspects. Table 4 contains the percentage indications of responses to question number 5 according to metric characteristics and responses to question number 2.

Table 3. Responses to question number 5 of the survey according to metric details and responses to question number 2 (results of test of independence χ^2)

Attribute Respon- dent	Low weight		Simple design		Special technologies		Optimal boardfeel		Durability of materials		Short adaptation time		Good cushioning		Adhesive sole		Brand	
	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p
Gender	0.17	0.680	4.44	0.041*	0.01	0.938	1.34	0.247	0.25	0.615	4.22	0.040*	0.02	0.877	0.93	0.335	0.12	0.732
Age	–	–	4.32	0.229	–	–	0.78	0.854	3.22	0.359	–	–	1.02	0.795	1.72	0.633	3.56	0.313
Years spent skateboarding	0.17	0.919	5.94	0.042*	1.95	0.377	11.72	0.003*	1.06	0.587	0.46	0.796	9.52	0.009*	0.57	0.752	1.82	0.401
Frequency of skateboarding	8.12	0.044*	0.51	0.917	–	–	12.91	0.005*	8.21	0.042*	–	–	1.14	0.766	3.40	0.334	10.34	0.016*
Frequency of wearing skateboard shoes	8.31	0.038*	1.01	0.316	4.07	0.044*	0.14	0.705	0.84	0.358	0.44	0.505	0.41	0.519	0.001	0.989	0.01	0.929

Source: own elaboration.

Table 4. Percentage indications of choices determined by different respondent groups

Respondent		Attribute	Low weight	Simple design	Special technologies	Optimal boardfeel	Durability of materials	Short adaptation time	Good cushioning	Adhesive sole	Brand
			Percentage of indications%								
Gender	Female	10.71	32.14	10.71	50.00	75.00	3.57	32.14	71.43	50.00	
	Male	13.75	52.50	11.25	62.50	70.00	20.00	33.75	61.25	53.75	
Age	Up to 20 years	4.76	33.33	9.52	57.14	80.95	19.05	38.10	57.14	61.90	
	21–25 years old	20.45	43.18	11.36	63.64	70.45	18.18	34.09	61.36	43.18	
	26–30 years	9.09	60.61	15.15	57.58	72.73	9.09	33.33	72.73	54.55	
	over 30	10.00	50.00	0.0	50.00	50.00	20.00	20.00	60.00	70.00	
Years spent skateboarding	Less than 4 years	11.54	30.77	3.85	30.77	76.92	11.54	23.08	57.69	46.15	
	4–10 years	12.20	46.34	14.63	70.73	73.17	17.07	51.22	65.85	48.78	
	More than 10 years	14.63	58.54	12.20	65.85	65.85	17.07	21.95	65.85	60.98	
Frequency of skateboarding	Almost daily	0.00	50.00	4.17	70.83	87.50	8.33	29.17	62.50	79.17	
	3–4 times a week	12.50	45.00	15.00	72.50	72.50	20.00	32.50	70.00	47.50	
	1–2 times a week	13.04	43.48	13.04	52.17	52.17	13.04	30.43	69.57	52.17	
	Less than once a week	28.57	52.38	9.52	28.57	71.43	19.05	42.86	47.62	33.33	
Frequency of wearing skateboard shoes	dDaily	15.66	44.58	14.46	60.24	73.49	14.46	34.94	63.86	53.01	
	Less often	4.00	56.00	4.00	56.00	64.00	20.00	28.00	64.00	52.00	

Source: own elaboration.

The percentage values summarized in the table above clearly indicate that:

1. A higher percentage of men than women purchase Skate shoes based on design and adaptation,
2. The highest percentage of feel-driven Skate shoe shoppers is among 21–25 year olds and the lowest among 30+ year olds,
3. The highest percentage of skate shoe shoppers based on construction is among those who have been skateboarding for more than 10 years and the lowest percentage among those who have been skateboarding for less than 4 years,
4. A lower percentage of skate shoe shoppers based on feel is found among those who have been skating for less than 4 years and a higher percentage among all other groups,
5. A higher percentage of skate shoe shoppers based on cushioning is found among 4–10 year olds and lower among other groups,
6. The highest percentage of skate shoe shoppers who are design-conscious is among those who skate less than once a week and the lowest among those who skate almost every day,
7. The highest percentage of skate shoe shoppers who buy shoes based on feel is among those who skate almost every day or 3–4 times a week and the lowest among those who skate less than once a week,
8. The highest percentage of skate shoe shoppers who purchase shoes based on durability is among those who skate almost daily and the lowest among those who skate 1–2 times per week,
9. The highest percentage of skate shoe shoppers who buy skate shoes based on durability is among those who skate almost every day and the lowest among those who skate less than once a week,
10. A higher percentage of skate shoe shoppers targeting light weight or specialized technologies is found among daily skaters and a lower percentage among less frequent skaters.

Table 5 contains calculations for responses to question number 13 in relation to respondent characteristics and answers given in question number 2.

Values of $p < 0.05$ allowed to reject the hypothesis of independence for the following correlations: gender-zone 3, age-zone 3, years spent skateboarding-zone 1, years spent skateboarding-zone 3, years spent skateboarding-zone 5, frequency of skateboarding-zone 1, frequency of skateboarding-zone 3, frequency of skateboarding-zone 5, frequency of wearing shoes-zone 3. This process allowed conducting percentage calculations pointing out zones of the shoe which are most prone to damage based on responses from different consumer groups.

Data presented in Table 6 responses to question number 13 according to metric characteristics and responses to question number 2.

Table 5. Responses to question number 13 as a function of metric characteristics and responses to question 2 (results of test of independence 2)

Respondent \ Zone	Zone 1		Zone 2		Zone 3		Zone 4		Zone 5		Zone 6		Zone 7	
	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p
Gender	0.004	0.947	–	–	3.85	0.047*	2.53	0.112	1.74	0.187	0.09	0.757	0.09	0.757
Age	3.40	0.334	–	–	8.05	0.045*	3.37	0.338	4.49	0.213	–	–	–	–
Years spent skateboarding	9.34	0.009*	–	–	8.28	0.016*	0.74	0.691	10.07	0.006*	0.99	0.610	3.50	0.174
Frequency of skateboarding	13.80	0.003*	–	–	16.77	0.001*	4.53	0.209	8.83	0.032*	3.78	0.285	–	–
Frequency of wearing skateboard shoes	0.90	0.304	1.20	0.273	6.18	0.013*	0.64	0.420	1.99	0.158	0.01	0.936	0.24	0.620

Source: own elaboration.

Table 6. Percentage indications of most frequent shoe damage zones determined by different respondent groups

Respondent		Zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
			Percentage of indications%						
Gender	Female		60.71	96.43	17.86	28.57	53.57	21.43	21.43
	Male		60.00	87.50	37.50	15.00	67.50	18.75	18.75
Age	Up to 20 years		42.86	90.48	33.33	28.57	47.62	19.05	14.29
	21–25 years old		65.91	86.36	18.18	15.91	63.64	29.55	27.27
	26–30 years		63.64	96.97	45.45	12.12	75.76	6.06	12.12
	Over 30		60.00	80.00	50.00	30.00	60.00	20.00	20.00
Years spent skateboarding	Less than 4 years		34.62	88.46	19.23	19.23	38.46	23.08	30.77
	4–10 years		68.29	90.24	24.39	21.95	68.29	21.95	19.51
	More than 10 years		68.29	90.24	48.78	14.63	75.61	14.63	12.20
Frequency of skateboarding	Almost everyday		58.33	87.50	66.67	16.67	79.17	20.83	8.33
	3–4 times a week		77.50	90.00	25.00	10.00	65.00	25.00	15.00
	1–2 times a week		60.87	91.30	21.74	30.43	69.57	21.74	8.70
	Less than once a week		28.57	90.48	19.05	23.81	38.10	4.76	52.38
Frequency of wearing skateboard shoes	Everyday		62.65	91.57	38.55	16.87	67.47	19.28	20.48
	Less often		52.00	84.00	12.00	24.00	52.00	20.00	16.00

Source: own elaboration.

The values summarized in the table below indicate that:

1. A higher percentage of males than females indicate zone 3 as the location where damage is most common.
2. The highest percentage indicating zone 3 as the most frequent location of damage is in the 26–30 age group and the lowest in the 21–25 age group.
3. A lower percentage (compared to other groups) indicating zone 1 as the most frequent point of damage, occurs in the group spending less than 4 years on the board.
4. The highest percentage indicating zone 3 or 5 as the most frequent zone of injury is in the group spending more than 10 years on the board and the lowest in the group spending less than 4 years on the board.
5. The highest percentage indicating zone 1 as the most frequent point of injury is in the group riding 3–4 days per week and the lowest in the group riding less than 1 time per week.
6. The highest percentage (compared to the other groups) indicating zone 3 as the most frequent place of damage is found in the group of almost daily boarders.
7. The highest percentage indicating zone 5 as the most frequent point of injury is in the group riding almost daily and the lowest in the group riding less than once a week.
8. A higher percentage indicating zone 3 as the most frequent location of damage is found in the daily users group and a lower percentage in the less frequent users group.

Conclusions

The results of the survey allow to gain basic knowledge about the consumer preferences of people riding a skateboard. Most factors behind the choice of a certain shoe is eventually a matter of one's individual decision. However analyzing the results it is possible to notice dependencies between particular answers. There are certain patterns that indicate main consumer behaviors within different groups of skateboarders. Yet some of the characteristics of a shoe are a common choice regardless of one's experience or sport frequency. This is an important factor for any manufacturer to put emphasis specific aspects of their products.

A mutual tendency can also be observed in the “destruction zones” analysis where skateboarders, based on their experience, pointed out the areas of the shoe that are most prone to abrasion/destruction. Furthermore the collected material will allow to create a catalog of features of the “perfect skate shoe” and to prepare guidelines for designers and manufacturers of this type of footwear.

On the other hand it is worth mentioning that skateboard shoes have not been classified as sports shoes, which makes them technically, ordinary shoes for everyday use. Due to this fact their quality is not measurable within certain sport standards. Moreover, it should be noted that practicing the sport of skateboarding in shoes designed for this purpose excludes any complaint procedures related to their defects created in the production process. This article serves to be a step in the process of encouraging manufacturers to put more emphasis on codifying skateboarding shoes and placing them within the boundaries of sport equipment followed by implementing necessary standards.

The presented study should be interpreted as an introduction to a series of laboratory research on shoe quality. Gaining awareness of the consumer reception is pays a critical role in planning different approaches to quality of products. The author intends to perform various test of skateboarding footwear based on knowledge acquired from the presented survey, individual experience, guidelines from skateboarders combined with adaptation of selected footwear standards. Analyzing the relationships between certain questions contained in the research it was possible to propose specific methods in order to laboratory test materials used in the manufacturing process.

References

Adidas (2020, February 18). *What is Boost?* Adidas US. <https://www.adidas.com/us/blog/373504>. Retrieved on 2021-06-21.

Akabas, L. (2021, February 22). *Americans More Active in 2020 as Solo Sports Gain During Pandemic: Data Viz*. Sportico.com, <https://www.sportico.com/business/commerce/2021/sfia-report-2020-covid-1234623194/>. Retrieved on 2021-06-21.

Batuev, M., Robinson, L. (2017). How skateboarding made it to the Olympics: an institutional perspective. *International Journal of Sport Management and Marketing*, 17(4/5/6), 381, <https://doi.org/10.1504/ijsmm.2017.087446>

Buyer's Guide: Skateboarding Insoles. Tactics. (n.d.), <https://www.tactics.com/info/buyers-guide-skateboarding-insoles>. Retrieved on 2021-06-21.

Christ, J.W. (1989). *Technologia obuwia: podręcznik dla zasadniczej szkoły zawodowej*. Wydawnictwa Szkolne i Pedagogiczne, 78–80.

Collins, C., Release, P., Read, D., Magazine, F.S. (2019, August 26). *Introducing The AVE Pro Featuring Vans' Ultimate Waffle Cupsole*. Manual Magazine, <https://manualmagazine.com/2019/08/26/introducing-the-ave-pro-featuring-vans-ultimate-waffle-cupsole/>. Retrieved on 2021-06-21.

Crabtree, P., Dhokia, V.G., Newman, S.T., Ansell, M.P. (2009). Manufacturing methodology for personalized symptom-specific sports insoles. *Robotics and Computer-Integrated Manufacturing*, 25(6), 972–979, <https://doi.org/10.1016/j.rcim.2009.04.016>

Dudes, T. (2016, May 12). *Cupsole vs Vulcanized Skate Shoes: The Great Argument*. Phatman Boardshop, <https://phatmanboardshop.com/cupsole-vs-vulcanized-shoes-the-great-argument/>. Retrieved on 2021-06-21.

Everything about Skate Shoes. skatedeluxe Skate Shop. (n.d.), <https://www.skatedeluxe.com/blog/en/everything-about-skate-shoes/>. Retrieved on 2021-06-21.

Escher, I. (2020). *Introduction to marketing research*. Toruń: TNOiK, 5–6, <https://doi.org/10.13140/RG.2.2.14595.66082>.

FindSourcing-Vulcanization (2018), <https://www.findsourcing.com/articles/construction/vulcanization>. Retrieved on 2021-06-21.

Frederick, E.C., Determan, J.J., Whittlesey, S.N., Hamill, J. (2006). Biomechanics of Skateboarding: Kinetics of the Ollie. *Journal of Applied Biomechanics*, 22(1), 33–40, <https://doi.org/10.1123/jab.22.1.33>.

Giesswein Int. (2019). *What is an EVA sole?* Giesswein Int, <https://us.giesswein.com/blogs/News/what-is-eva-sole/>. Retrieved on 2021-06-21.

Gilbreath, A. (2020, July 31). *CA skateboarders and COVID-19: Demand up, equipment down*. Capitol Weekly, <https://capitolweekly.net/ca-skateboarders-and-covid-19-demand-up-equipment-down/>. Retrieved on 2021-06-21.

Gomez, B. (2012). *How Did Nike Get the Swoosh into Skateboarding? A Study of Authenticity and Nike SB*. Media Studies – Theses. 3, https://surface.syr.edu/ms_thesis/3.

Hanhi K., Poikelispää M., Tirilä H-M. (2007). *Elastomeric Materials*, 47–48. The Laboratory Of Plastic And Elastomer Technology, Tampere University of Technology.

Hua, P. (2018, September 3). *How to Choose Skate Shoes – Tips, Advice, & Selection*. Athlete Audit. <http://athleteaudit.com/how-to-choose-skate-shoes/>. Retrieved on 2021-06-21.

Impact Protection. Footprint Insole Technology (2019, April 9), <https://www.fpinsoles.com/every-foot-is-different/impact-protection/>. Retrieved on 2021-06-21.

Inside Access: The Story of Nike Lunarlon. Nike News. (2013, December 10), <https://news.nike.com/news/inside-access-the-story-of-nike-lunarlon>. Retrieved on 2021-06-21.

James, V. (2021, February 10). *Suede vs Canvas: 9 Differences Between Suede and Canvas*. SewingIsCool.com, <https://sewingiscool.com/suede-vs-canvas-differences/>. Retrieved on 2021-06-21.

Jones, R. (2020, April 21). *KNOW YOUR TECH: DC Shoes Unilite is Suited for Skating and Training*. Complex, <https://www.complex.com/sneakers/2013/12/know-tech-dc-shoes-unilite-suited-skating-training>. Retrieved on 2021-06-21.

Kim, J.-H., Kim, G.-H. (2014). Effect of rubber content on abrasion resistance and tensile properties of thermoplastic polyurethane (TPU)/rubber blends. *Macromolecular Research*, 22(5), 523–527, <https://doi.org/10.1007/s13233-014-2077-y>.

Lange, D. (2021, February 22). *Participants in skateboarding US 2019*. Statista, <https://www.statista.com/statistics/191308/participants-in-skateboarding-in-the-us-since-2006/>. Retrieved on 2021-06-21.

Lombard, K.-J. (2015). *Skateboarding: subcultures, sites and shifts*. Routledge, 185.

Mazurek-Łopacińska K., Sobocińska M. (2011). *Badania marketingowe: metody, nowe podejścia i konteksty badawcze*. Wydawnictwo Uniwersytetu Ekonomicznego, 13–23.

Motawi, W., Motawi, A. (2018). *How shoes are made*. Wade Motawi, 54–55.

Mynarski, S. (2003). *Analiza danych rynkowych i marketingowych z wykorzystaniem programu Statistica*. Wydawnictwo Akademii Ekonomicznej.

Nevitt, M., Determan, J., Felix, A., Cox, J. (2009). Frictional requirements of skateboarding shoes during a push-off. *Footwear Science*, 1(sup1), 34–35, <https://doi.org/10.1080/19424280902977145>

Person (2004, January 6). *Sole Technologies Institute*. Transworld SKATEboarding, <https://skateboarding.transworld.net/news/sole-technologies-institute/>. Retrieved on 2021-06-21.

Pro Classics (n.d.), <https://www.vans.com/signature-pro-classics.html#proPerformance>. Retrieved on 2021-06-21. Rancourt & Co. (2016, May 13).

<https://www.rancourtandcompany.com/blog/2016/05/13/whats-deal-cup-sole-shoes/>. Retrieved on 2021-06-21.

Technology. OrthoLite. (2021, June 7), <https://www.ortholite.com/technology/>. Retrieved on 2021-06-21.

Vans Pro Skate introduce the Kyle Walker Pro featuring Vans Wafflecup. Vans PL. (n.d.), <https://www.vans.pl/news/vans-pro-skate-introduces-the-kyle-walker-pro-featuring-vans-wafflecup.html>. Retrieved on 2021-06-21.

Vans (2015). *Presentation of the brand, Classics line and selected models*, materials received from Vans.

Vee, R. (2021, June 11). *Best Skate Shoes for Flat Feet*. SkateboardersHQ, <https://www.skateboardershq.com/best-skate-shoes-for-flat-feet/>. Retrieved on 2021-06-21.

vegankicks.com. (n.d.), <https://www.vegankicks.com/the-world-of-vegan-skate-shoes-and-why-they-matter/>. Retrieved on 2021-06-21.

Vogel, D., Blümlein, J., Schmid, D. (2010). *Made for skate: the illustrated history of skateboard footwear*. FauxAmi Exhibitions, Skateboard Museum Stuttgart in association with Gingko Press.

45 Skateboarding Stats You Need To Know – Skate Review: A premium skateboarding blog. Skate Review | A premium skateboarding blog.

<https://www.skatereview.com/skateboard/skateboard-stats/>. Retrieved on 2021-06-21.

CONSUMERS' PREFERENCES ON LOW-LACTOSE ICE CREAM MARKET

Agnieszka Palka¹

Abstract

Frozen desserts are one of the many kinds of desserts available on the market. Due to the growing interest in this type of desserts, producers introduce innovative improvements, newer and better versions to the market, which are designed to meet the requirements of various consumer groups and to obtain profits from sales throughout the whole year. Lactose-reduced ice creams are made mainly for people who are lactose intolerant. The most popular substitutes for “traditional” ice cream for consumers excluding lactose from their diet can be made on the basis of soybean or rice extracts. A popular lactose-free products are sorbets, which do not content milk. Milk-based ice cream are still popular, therefore the paper deals with the assessment of consumer preferences towards frozen desserts with reduced lactose content. The aim of the study was to assess the preferences of the respondents towards lactose-free ice cream and ice cream with reduced lactose content. Lactose-reduced frozen desserts were consumed occasionally, as a seasonal product. The decisive factor in the selection was the taste and price of the product, not its composition. The lactose content in frozen desserts was mainly noted by consumers of age over 50 years.

Keywords: ice cream, lactose intolerance, lactose-reduced ice cream, consumer preferences, survey

Introduction

On the frozen dessert market, innovative product forms are appearing, from sorbets, through ice creams for vegans, to ice creams with reduced fat or lactose

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content, frozen cakes, pies and many, many more. Due to the growing interest in these products, manufacturers are increasingly launching newer and better versions of them on the market, which are designed to meet the requirements of various consumer groups. They are introducing innovative improvements, which is related to the dynamic development of the ice cream industry, as well as the amount of ice cream purchased. The market of frozen desserts (an assortment of sweetened products, fixed by the action of low temperatures) is developing, their availability is easier, but in Poland there is still a belief that these products are seasonal (Palka, 2015). With globalisation, the economy is developing, and it has also influenced the awareness of society. Interest in leading a healthy lifestyle has increased (Goryńska-Goldmann & Ratajczak, 2010). Consumers have more knowledge about diseases and food allergies, which leads to more frequent checking of product composition. This leads to an increasing elimination of specific ingredients in the human diet (Zatwarnicki, 2014). Lactose intolerance is one of the most common gastroenterological problems faced by modern consumers (Fidler, Lisowask & Walkowiak, 2009). Genes may also be responsible for the deficiency of this enzyme in most cases, but lactase deficiency may also be caused by diseases such as celiac disease, Crohn's disease, as well as viral and bacterial infections (Szilagyi & Ishayek, 2018).

Three forms of lactase deficiency, responsible for the hydrolysis of lactose into bioavailable monosaccharides, can be distinguished: alactasia – congenital lactase deficiency, adult hypolactasia – primary lactase deficiency, it is a natural condition in a large part of the human population, secondary lactase deficiency – acquired (Rychlik & Marszałek, 2013).

During abnormal digestion, lactose is consumed in the gastrointestinal tract by intestinal bacteria. The products of this fermentation are mainly gases and short-chain organic acids, which we can include lactic acid, acetic acid, butyric acid, etc. Gases are mainly responsible for flatulence or colic. Organic acids, on the other hand, have an irritating effect on the intestinal mucosa. One of the symptoms of undigested lactose can be diarrhoea, which is caused by increased osmotic pressure in the small intestine due to undigested lactose. Research has shown that the highest amount of lactase is found in the glycocalyx of the toothbrush, which is closest to the lumen of the small intestine. In contrast, the highest activity of this enzyme is recorded at the top of the intestinal villi (Hutyra & Iwańczak, 2009). Congenital lactase deficiency is a metabolic error and although it is very rare, a dairy-free diet is recommended throughout life if a person has alactasia. Primary lactase deficiency is now a very common intolerance. The primary symptoms that lactose intolerance causes are nausea and vomiting, diarrhoea, bloating, and abdominal pain (Sawaia, 2018).

Lactose intolerance may even affect about 37% of the adult population in Poland (Zatwarnicki, 2014) and about 40% of the world population (Ozdemir, *et al.* 2018).

Currently, there are various types of lactase-containing products available on the market that can be used with a meal. However, it is important to note that individuals whose body indicates lactose intolerance do not have to strictly avoid it, but only limit it (McCray, 2003).

Although the proportion of people with lactase deficiency varies from country to country or continent to continent – in Southeast Asia it is approximately 98-100% of the adult population and in the Netherlands only 1% of adults (Silanikove, Leitner & Merin, 2015) – the demand for lactose-free products is proportionally distributed.

Lactose, a milk sugar, is the primary carbohydrate of milk of all mammals is one of the most important components of milk and milk is the only source of it in nature. In different species of mammalian milk, the percentage of lactose in the total composition is distributed as follows: female milk – 6.8%, cow milk – 4.6%, goat milk – 4.6%, sheep milk – 4.5%, buffalo milk – 4.5% (Zatwarnicki, 2014).

One of the main characteristics it has is that it helps to absorb into the body a number of minerals and vitamins, such as zinc and magnesium, which are important for the proper development of strong and healthy bones. It also has a positive effect on the regeneration of intestinal epithelial cells and intestinal motility due to its probiotic properties (Holsinger & Kligerman, 1991).

Lactose is an ingredient that can be problematic when making ice cream, due to its low solubility level compared to other disaccharides. One of the problems that can occur in supersaturated solutions is excessive crystallization of lactose, the formation of lactose crystals depends on the freezing time of the ice cream mixture. During longer and slower freezing times, the lactose crystals are much larger, affecting a gritty or rough mouthfeel, called sandyness (Skryplonek, *et al.* 2019). The amount of milk sugar can be reduced by hydrolysing lactose to glucose and galactose (Novalin, Neuhaus & Kulbe, 2005). Ice cream for which lactose has been hydrolysed has a higher sweetness than regular ice cream (Dekker, Koenders & Bruins, 2019; Palka, 2020).

Due to the increasing consumer demand for lactose-free products, manufacturers are choosing to use alternative milk substitutes, plant-based drinks (soy, coconut, almond, rice). In this case, soy beverage is considered the best substitute due to its very good properties, including its high protein content (Abudullah, Rehman & Zubair, 2003; FavaroTrindade, *et al.* 2001; Patil & Benerjee, 2017). Ice cream manufacturers in the USA have been introducing products based on soy beverage for many years to meet the expectations of discerning consumers (Davis, *et al.* 2009; Thompson, Chambers & Chambers, 2009). The list of products that have lactose in their composition includes ice cream, as milk is one of the main ingredients for making ice cream. A popular lactose-free product in the global frozen dessert market is sorbets, for which no milk is used. The lactose-free

ice cream market is the fastest growing segment in the dairy industry (Dekker, Koenders & Bruins, 2019).

In Poland, ice cream is further considered a seasonal dessert, mostly consumed during seasons such as spring and summer. In Europe, Sweden is considered the leading country in terms of demand for frozen desserts. Swedes consume on average 13.5 litres of ice cream every year (Palka, *et al.* 2016). The tendency of consumers to purchase ice cream in the off-season is changing, and this change is influenced by factors such as changing consumer perception, regional diversification, new innovative products, more widely developed marketing and promotion in the off-season, a large product range, different consumer acceptances and preferences, and climate warming (Patil & Banerjee, 2017).

Ice cream generally contains milk or ingredients processed from milk and the like in its composition, for which reason a large percentage of the human population chooses not to consume it. Usually, consumers choosing to exclude milk from their diet for reasons such as religious beliefs, lactose intolerance, food allergies, dietary preferences (vegetarianism, veganism, etc.), other reasons related to life ideology (Soler, 2005). Producers, during the production of such ice cream, may decide to hydrolyse the lactose in the milk used to make the ice cream, or to use substitutes of plant origin.

The aim of this study was to assess consumer preferences for lactose-free ice cream and ice cream with reduced lactose content, in particular, and to assess respondents' reservations towards this ice cream.

Research material and methods

The study involved 155 randomly selected individuals. The survey group consisted of 109 women, i.e. 70% of the respondents, and 46 men. The survey was conducted via a website in 2020. The research tool was an original, anonymous questionnaire. The results obtained from the questionnaires were analysed using Microsoft Excel v16.0.

Respondents in the 2130 age group constituted the largest percentage of respondents, as much as 60%, which may result from the greater online activity of people in this age group, resulting in more frequent participation in surveys conducted via this route (Table 1). In addition, these are the people most likely to consume ice cream and interested in news in this industry (Palka, 2019). Place of residence was chosen as a factor of variation. The percentage of urban residents among the respondents was 60%, while the percentage of those who chose "rural" as their place of residence – 40%.

Table 1. Characteristics of the research sample

Sex	female	70%
	male	30%
Age	< 20 years old	2%
	21–30 years old	60%
	31–50 years old	30%
	> 50 years old	8%
Place of residence	city	60%
	village	40%

Source: own study.

Consumers’ preferences – discussion of research results

The first question asked to respondents in the survey was: “How often do you consume frozen desserts?” (Figure 1).

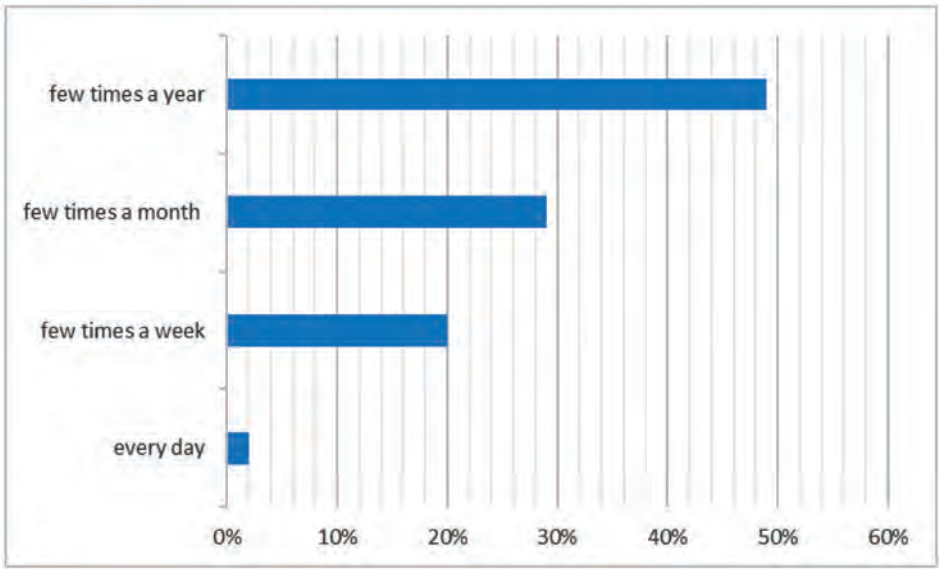


Figure 1. Frequency of ice cream consumption by surveyed consumers

Source: own study.

It was found that as many as 49% of the surveyed consumers declare consuming ice cream several times a year. The intensity of consumption of this type of product has not changed drastically over the years. This may be due to the high

seasonality of this type of product. This also indicates that consumers are more likely to consume these products in summer, when temperatures are higher. However, there is a growing tendency for interest in this type of product also in the off-season. However, it is very small. Poles are accustomed to tradition and treat ice cream as a dessert consumed in summer. Therefore, the level of demand for frozen desserts in other seasons may not increase soon. This more difficult availability may also be due to the low availability of frozen desserts outside the warm season (Palka, 2015).

It was found that most respondents (42%) most often chose vanilla ice cream. Respondents also had the opportunity to add their own answer. The total percentage of such answers was 12%. Among these were: cookie (1%), fruit (1%), mint (1%), blueberry (1%), toffee (1%), salted caramel (1%), coffee (1%), hazelnut (1%), coconut (1%), raspberry (1%), pistachio (1%), oreo (1%) (Figure 2).

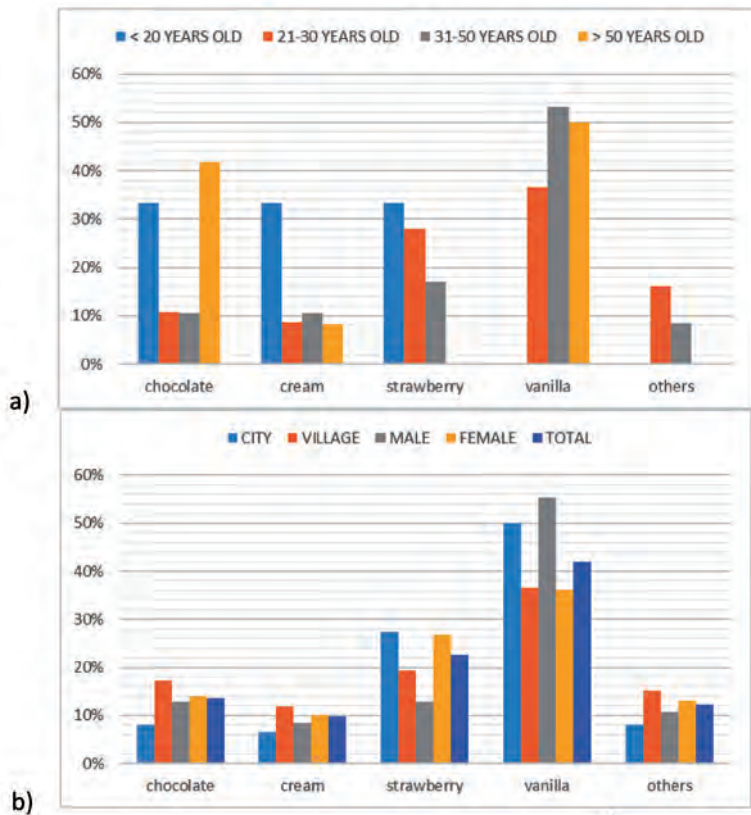


Figure 2. The respondents' taste preferences for ice cream: a) according to age, b) according to place of residence, sex and in total

Source: own study.

The taste preferences of the surveyed consumers have not changed significantly over the last few years. Consumers are still faithful to the traditional flavours such as vanilla, cream, chocolate and strawberry. This is confirmed by the survey results, as these four flavours were the most frequently chosen answers. Although their attention is increasingly drawn to innovative ice cream flavours proposed by manufacturers. Still consumers do not reach for typically new products. Those that are not available on the mass market. Polish consumers are devoted to tradition when it comes to the choice of frozen desserts. Currently, this trend is not changing much (Palka, 2015).

To the question asked: How often do you pay attention to the lactose content of frozen desserts? (Figure 3), most respondents (69%) marked the answer “not at all”. Only 3% of the respondents declared that they check the lactose content of frozen desserts very often. Consumers pay little or no attention to the lactose content of frozen desserts. Knowledge about the amount of lactose in a product may be necessary for a small group of consumers. To this group we can include: people with diagnosed lactose intolerance – whose percentage in Poland as well as in the world is not very high (it counts about 37% of the adult population in Poland (Zatwarnicki, 2014) and about 40% of the world population (Ozdemir, *et al.* 2018), as well as people who consciously remove lactose from their diet. The reasons for eliminating lactose from the diet in this case could be religion or a particular lifestyle as well as nutrition.

The study showed that 34% of the surveyed women pay attention to the lactose content of frozen desserts very often (4%), often (4%), and rarely (26%) (Figure 3). Women are more likely to shop for groceries than men. Therefore it is possible that they pay more attention to the composition of products. They are also more likely to check the content of ingredients they are trying to eliminate from their diet. In the case of male respondents, 15% declared that they often check the lactose content of frozen products, while 11% rarely do (Figure 3).

Regardless of age group, more than half of the respondents marked the answer “not at all” (Figure 3). This means that the consumers surveyed did not pay attention to the lactose content of the frozen desserts they bought. This may confirm that a small part of the population has problems with lactose digestion or is trying to limit it for various other reasons. In each age bracket of the surveyed population, only ¼ of the respondents could be identified as checking the lactose content to some extent. 8% of respondents aged over 50 marked the answer “often”. This may be due to the disappearance of the enzyme lactase with age, which leads to a reduced ability to digest lactose. Therefore, the older age group in which the activity of this enzyme is decreasing may pay more attention to the composition of products and their lactose content. By doing so, they are able to eliminate the reason for their reduced well-being or health.

Other factors may also influence consumers to pay more attention to the lactose content of frozen desserts. These may include culture, lifestyle or nutrition. So-called ‘healthy lifestyles’ or ‘green lifestyles’ are becoming more widespread and popular, which may influence the amount of lactose consumed. Knowledge about lactose and products that contain it is possibly not very widespread yet. Therefore, consumers are less knowledgeable about products that contain lactose. Just over 1/3 of the respondents (Figure 4) answered “don’t know” to the question: Do they buy lactose-reduced frozen desserts.

A similar number of people answered “no” to this question, while 27% of respondents declared that they buy frozen desserts with reduced lactose content. It is likely that this part of the respondents purchases lactose-reduced frozen desserts because of their lactose intolerance. They may also be motivated by a diet that requires them to eliminate animal products.

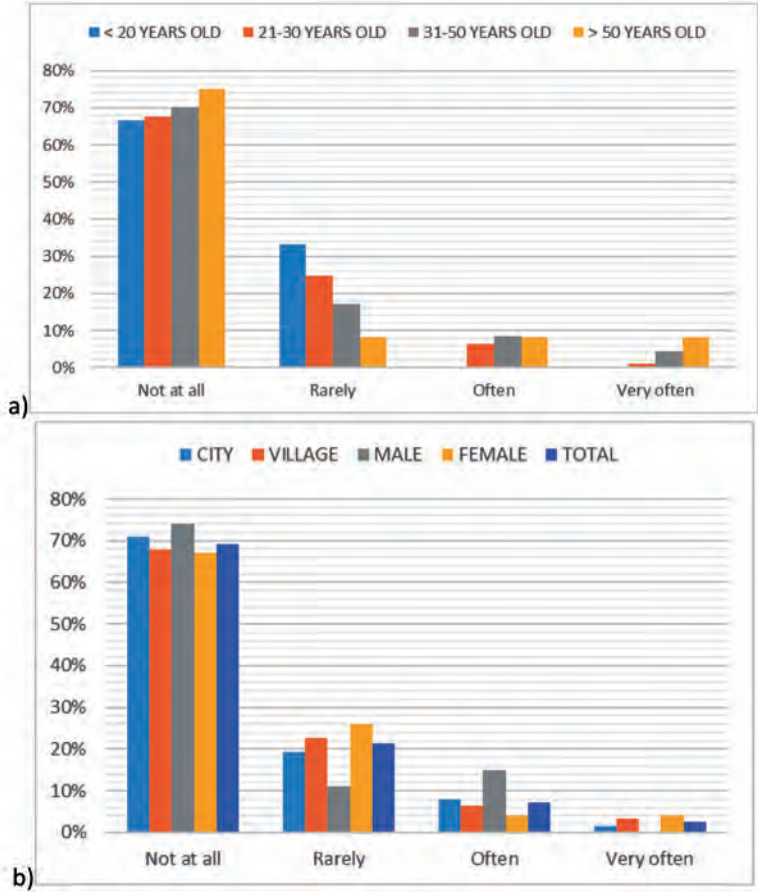


Figure 3. The frequency of checking the lactose content in frozen desserts: a) according to age, b) according to place of residence, sex and in total

Source: own study.

The gender of the respondents did not influence the number of “don’t know” answers (Figure 4) as similar percentages of female and male respondents chose this answer. This may be due to the lack of habit of reading labels and indications on packages. Lactose in products is mainly found in milk, so products which contain mammalian milk are also products containing lactose. The manufacturer also uses it to increase the viscosity of the product, which will make chewing it more pleasant, which is why it may be included in dairy-free products (Rychlik, Marszałek, 2013).

No difference was found with the answer “yes” (27%) in terms of place of residence. The answer “no ” was given by 39% of respondents from urban areas and 31% from rural areas. The answer “don’t know” was given by 42% of respondents living in the countryside and 34% in the city (Figure 4).

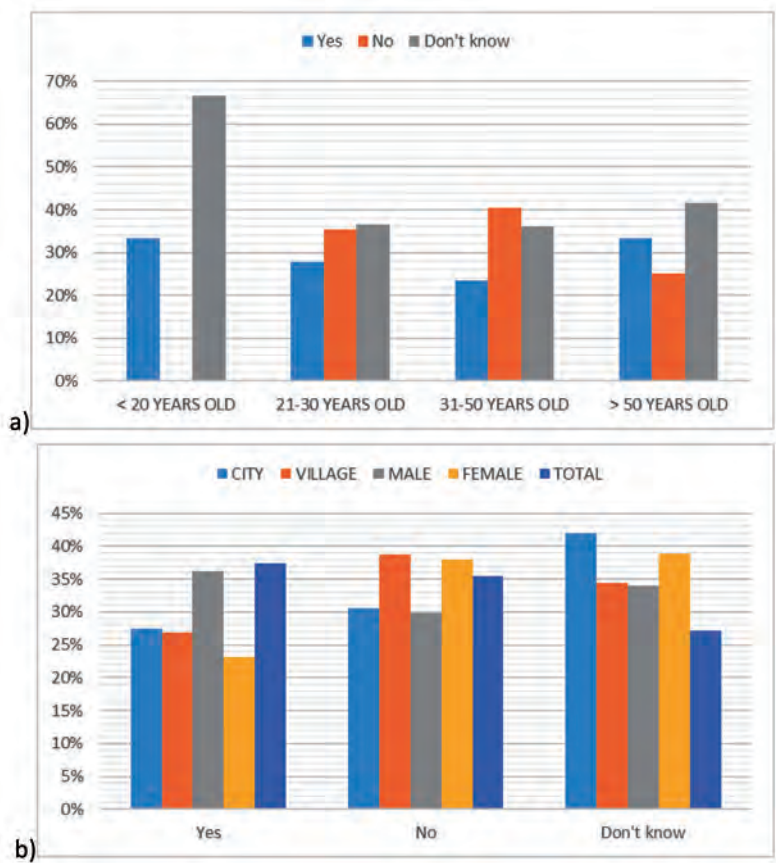


Figure 4. Buying frozen desserts with reduced lactose content by respondents: a) according to age, b) according to place of residence, sex and in total

Source: own study.

Based on these results, it can be concluded that city dwellers are more convinced that they do not buy frozen desserts with reduced lactose content than country dwellers, for whom almost half of them chose the 'don't know' answer. This may result from greater availability of such products in the city, or from greater knowledge of lactose among city dwellers.

Frozen desserts are a seasonal product, so also frozen desserts with reduced lactose content will be consumed more often in times of higher temperatures. 66% of respondents declared that they do not consume lactose-reduced frozen desserts at all. Only 1% of respondents consume them several times a week, 12% several times a month, and 21% several times a year (Figure 5). Frozen desserts with reduced lactose content are not very popular on the Polish market, so the surveyed consumers do not show much interest in them outside the summer season.

A total of 34% of the women surveyed declared consuming frozen desserts at different frequencies, including: 22% several times a year, 10% several times a month, and 1% several times a week (Figure 5). For men, 15% consume them several times a week and 17% several times a year (Figure 5). Women are more likely than men to consume lactose-reduced frozen desserts. This may be due to women paying more attention to product composition. Women are also more likely to follow diets that eliminate animal products, such as vegetarian or vegan diets.

Usually, age influences the diet, and as one gets older, one pays more attention to the products one eats. The amount of products excluded from the diet increases with age, as our body cannot digest everything in the same way. It was found that people in the age range up to 20 years are more likely to consume lactose-reduced frozen desserts (33% several times a month and 33% several times a year) (Figure 5). This may be due to the greater influence of information sources such as the Internet and social media on their knowledge of products and their ingredients.

Respondents living in rural areas (66%) declare they do not consume such products at all, the same is true for respondents living in cities (67%). Only 1% of urban and 2% of rural respondents answered "several times a week". Respondents living in cities consume such products less frequently than those living in villages (see Figure 5).

Food allergy or lactose intolerance problem affects consumers more and more often. However, consumers do not often give up frozen desserts. They rarely choose their substitutes or modified versions that would better affect their health and well-being. The frequency of consumption of lactose-reduced frozen desserts may also be influenced by their availability. They are not widely available products. They are difficult to obtain in smaller shops, but their availability in hypermarkets is not very common either. This type of dessert can be considered luxurious and difficult to access, and is associated with a higher price. This has a negative impact on the frequency of purchases of these products. Consumers will choose a cheaper substitute with similar taste qualities.

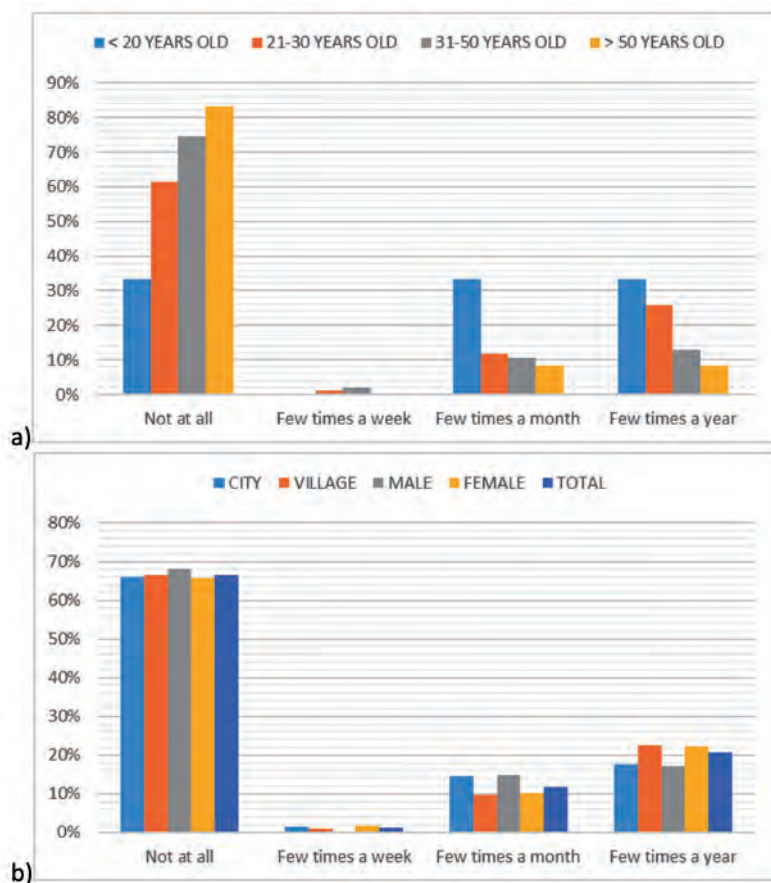


Figure 5. The frequency of purchasing lactose-reduced frozen desserts: a) according to age, b) according to place of residence, sex and in total

Source: own study.

About 1/3 of the respondents declared that they buy lactose-reduced frozen desserts for health reasons. 26% of respondents do not buy such products, 22% of respondents buy such products for their nutritional value. 14% of respondents said they buy these products because of their taste, while 5% of respondents buy lactose-reduced frozen desserts because of their vegetarian diet (Figure 6). Women are more likely to pay attention to the calorie content of the products, as well as to count them. 38% of women said they buy lactose-free frozen desserts because of the nutritional value. Men buy frozen desserts because of their taste, while for women taste is not a reason to buy this type of dessert.

67% of respondents in the under 20 age group buy lactose-reduced frozen desserts for their nutritional value, while 33% buy them for health reasons. In the 21–30 age bracket, 34% of respondents buy these desserts for health reasons

and only 4% buy them because of their vegetarian diet. Similar responses were received in the range from 31–50 years. Half of the respondents aged over 50 do not buy such frozen desserts (Figure 6).

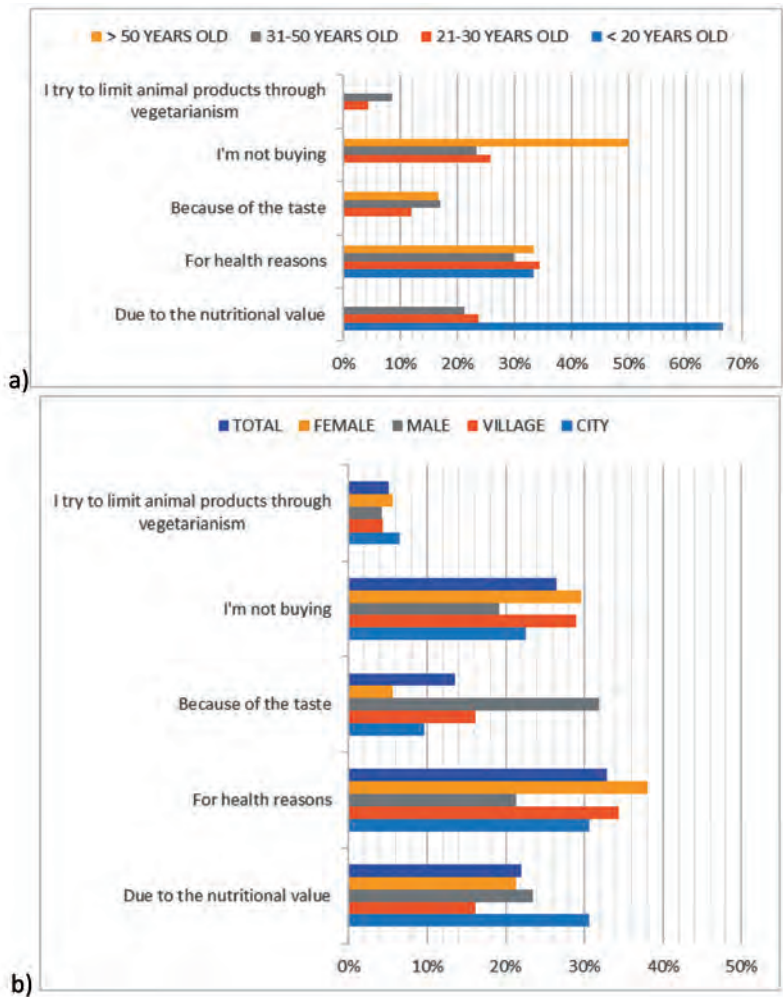


Figure 6. Reasons for buying lactose-reduced frozen desserts: a) according to age, b) according to place of residence, sex and in total

Source: own study.

Respondents living in rural areas most often consume such products because of their nutritional value (31%) and for health reasons (31%). 34% of respondents residing in the city consume frozen desserts for health reasons. Frozen desserts are largely considered a product consumed for pleasure (Kobyłko, 2013). Nutritional and health values are not the most important reason for purchasing this type of

product by the consumers surveyed. Fewer respondents declared consuming this type of frozen desserts for nutritional and health reasons.

They consumed them for pleasure and did not pay attention to their composition. People who follow diets such as vegan or vegan diets replace traditional ice cream with lactose-free ice cream precisely because they have given up animal products.

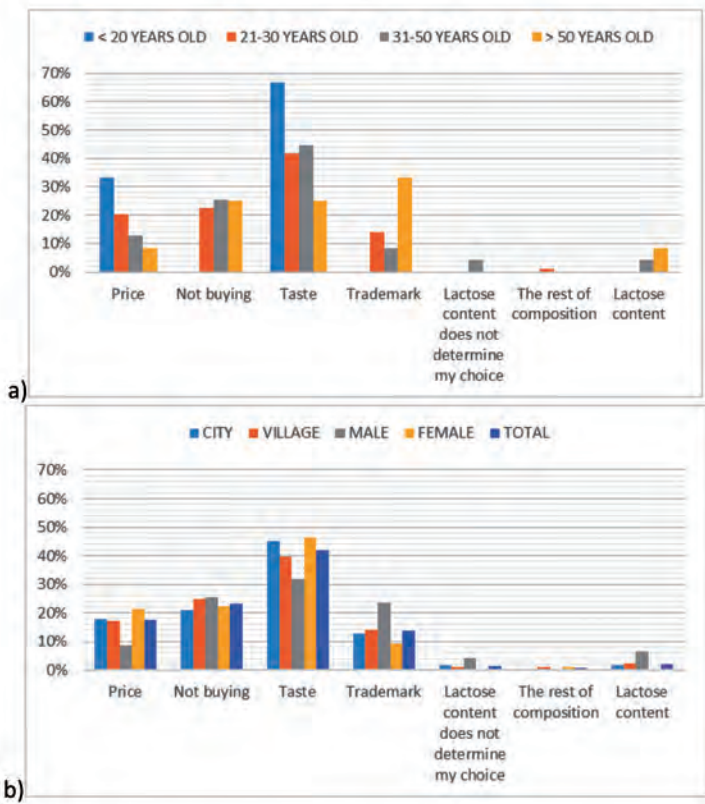


Figure 7. Determinants of the selection of desserts with a reduced lactose content: a) according to age, b) according to place of residence, sex and in total

Source: own study.

42% of respondents are guided by taste when buying lactose-reduced frozen desserts. Only 1% of respondents, on the other hand, are guided by the product composition when buying this type of frozen dessert. Also 1% of the respondents declared that lactose content does not guide their choice when purchasing (Figure 7). The choice of food products depends on consumer preferences. They are conditioned by many factors. Organoleptic properties, such as taste, are among the most important factors in choosing a frozen dessert with reduced lactose content. The taste of lactose-reduced desserts differs from ordinary frozen

desserts due to their different composition. They are characterised by a higher level of sweetness. Polish consumers still prefer 'traditional' frozen desserts. Guided by taste, they look for products similar to those they remember, but with a lower lactose content.

When buying frozen desserts, women are more often guided by taste (46%) and price (21%) than men. In contrast, the product brand influences men's purchasing decisions (23%) more often than women's (9%) (Figure 7). These differences may result from the frequency of making purchases. Women are more likely to manage their household budget and make purchases. For them, it is also more important that the price of the product is adequate to the taste and value of the product. Men pay more attention to brands which they associate with product quality (Zięba, 2010).

Most of the respondents chose the answer that the taste decides about the choice of the product, regardless of age. However, 33% of respondents aged 50 and above are guided by the brand when buying. Urban (40%) and rural (45%) consumers surveyed declared that 'taste' was the main factor in choosing lactose-reduced frozen desserts (Figure 7).

Taste is the most common factor influencing respondents' decisions to purchase frozen desserts. Frozen desserts are one of the forms of entertainment for the consumer, so they prefer to buy desserts that suit them.

35% of respondents forgo buying lactose-reduced frozen desserts because of their high price, and 32% because of their taste (Figure 8). Only 12% of respondents have no objections to this type of desserts. There is not much choice of frozen desserts with reduced lactose content on the market, which may result in a higher price of these products. Consumers accustomed to "traditional" flavours are not willing to try novelties when it comes to frozen desserts. They usually stay with buying frozen desserts that suit them in terms of sensory qualities (Palka, 2015).

Both men (38%) and women (34%) opt out because of the high price. Women (34%) also have reservations about these types of frozen desserts due to their taste qualities (Figure 8). Surveyed consumers in the age range up to 20 years declared that 'inadequate taste qualities' are the most common objections when buying this product. Respondents in the 21–30 and 31–50 age brackets are resigned to the high price. Those aged over 50 are less likely to give up frozen desserts (17%) because of their high price than the other age brackets (under 20 – 33%, 21–30 – 40%, 31–50 – 32%). This may be due to a greater need to buy frozen desserts with reduced lactose content.

Moreover, respondents over 50 years of age declared that they do not often consume frozen desserts with reduced lactose content. Probably because they buy them occasionally a few times a year, they can afford to buy a more expensive product. In contrast, surveyed people of this age are more likely to

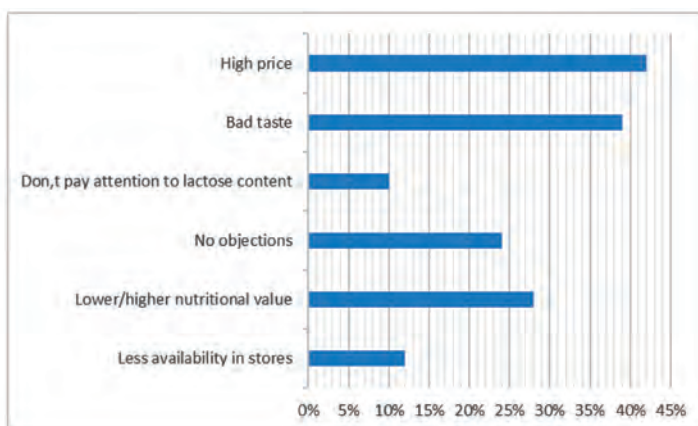


Figure 8. The most common objections to the purchase of lactose-reduced frozen desserts

Source: own study.

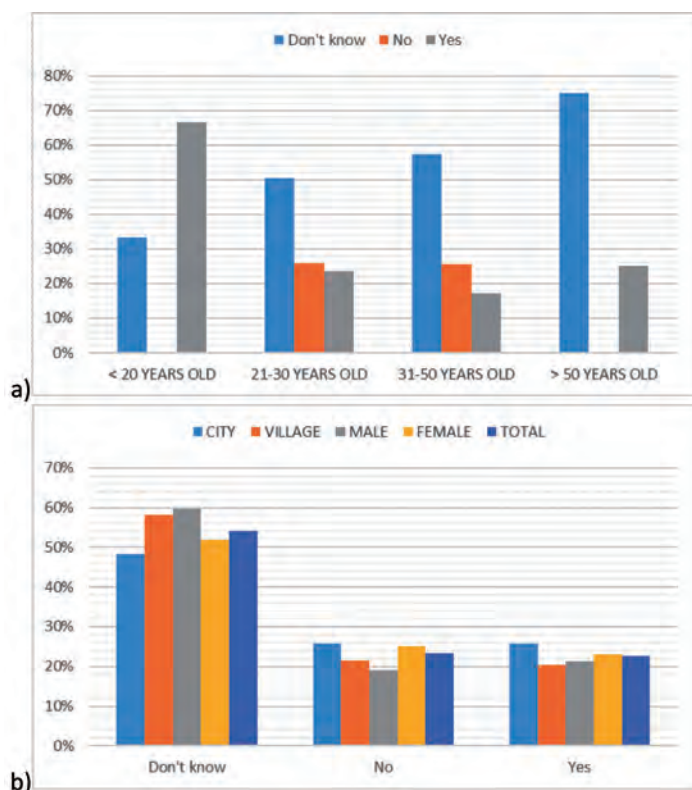


Figure 9. Declaration of the respondent's knowledge about the consumption of lactose-reduced frozen desserts among the respondent's friends: a) according to age, b) according to place of residence, sex and in total

Source: own study.

forgo them due to nutritional value or less availability in shops. They tend to shop in neighbourhood shops or hypermarkets. Frozen desserts with reduced lactose content are not a widely available product. The surveyed urban consumers (39%), as well as surveyed rural consumers (33%) declared that “price” and “taste” are the most common objections they have to this product (Figure 8). The price and taste of frozen desserts are more likely to influence consumers’ decisions.

Consumers surveyed are not very knowledgeable about lactose. More than half the respondents said they did not know if anyone in their environment consumed frozen desserts with reduced lactose content. When asked about people in their environment consuming lactose-reduced frozen desserts, 23% of the respondents answered “yes” as well as “no” (Figure 9).

Conclusions

In Poland, ice cream is still considered a seasonal product. Consumers mostly consume it in summer when the temperature is higher. There are many different manufacturers on the market who offer traditional as well as modern flavours of frozen desserts. The reasons why consumers may look for frozen desserts with altered or improved composition can be of various kinds: food diseases, allergies, food intolerances, preferences, or lifestyle and diet. Lactose intolerance is a fairly common food hypersensitivity in humans, which manifests itself to varying degrees. It is most common in adults, where the activity of the enzyme needed to digest lactose decreases with age. Therefore, the demand for products with reduced lactose content may become more desirable. Manufacturers are introducing substitutes for various dairy products with reduced lactose content. Frozen desserts with reduced lactose content are also available in shops. However, their availability is lower than “traditional” frozen desserts. Frozen desserts with reduced lactose content are not very popular and their share in the frozen dessert market is quite low. The surveyed consumers most frequently purchased and consumed frozen desserts several times a year (49%). However, they did not consume frozen desserts with reduced lactose content at all (66%), or only a few times a year (21%). The consumers surveyed treated them as a seasonal product, and showed little interest in frozen desserts with reduced lactose content. The lactose content of the products was not a decisive factor in the choice of consumers surveyed (2%). Consumers paid more attention to the taste (42%) or price (17%) of a given product than to its composition. Respondents over 50 years of age were more likely to pay attention to the lactose content of frozen desserts (8%). This could be due to the disappearance of the enzyme needed to digest lactose, which leads to lactose intolerance in the body. High price (35%), as well as inadequate taste (32%) were reasons for not buying frozen desserts with reduced lactose content. Since a high lactose content in ice cream may have an

adverse effect on organoleptic characteristics (including consistency) and melting, a recipe and/or technology for the production of lactose-free dairy ice cream with adequate taste qualities should be developed.

References

- Davis, C.G., Blayney, D.P., Yen, S.T., Cooper, J. (2009). An analysis of at-home demand for ice cream in the United States. *American Dairy Science Association*, 92(12), 6210–6216.
- Dekker, P.J.T., Koenders, D., Bruins, M.J. (2019). Lactose-Free Dairy Products: Market Developments, Production, Nutrition and Health Benefits. *Nutrients*, 11, 3–551.
- FavaroTrindade, C.S., Terzi, S.C., Trugo, L.C., Della Modesta, R.C., Couri, S. (2001). Development and sensory evaluation of soy milk-based yogurt. *Arch Lationam Nutr*, 51, 100–104.
- Fidler, E., Lisowska, A., Walkowiak, J. (2009). Nietolerancja laktozy – klasyfikacja i diagnostyka. *Pediatrica Polska*, 84(6), 562–566.
- Goryńska-Goldmann, E., Ratajczak, P. (2010). Świadomość żywieniowa a zachowania żywieniowe konsumentów. *Journal of Agribusiness and Rural Development*, 4(18), 41–48.
- Holsinger, V.H., Kligerman, A.E. (1991). Application of Lactose in Dairy Foods Containing Lactose. *Food Technol.* 45(1), 92, 94–95.
- Hutyra, T., Iwańczak, I. (2009). Nietolerancja laktozy: patofizjologia, objawy kliniczne, rozpoznanie i leczenie. *Polski Merkuriusz Lekarski*, 26(152), 148–152.
- Kobyłko, E. (2013). Uwarunkowania Technologiczne i techniczne produkcji lodów spożywczych. *Acta Sci. Pol., Techniza Agraria* 12(3–4), 27–37.
- McCray, S. (2003). Lactose intolerance: consideration for the clinician. *Pract. Gastroenterol*, 27(2), 21–42.
- Novalin, S., Neuhaus, W., Kulbe, K.D. (2005). A new innovative process to produce lactose-reduced skim milk. *Journal of Biotechnology*, 119(2), 212–218.
- Ozdemir, C., Arslaner, A., Ozdemir, S., Ugurlu, G. (2018). Ice-Cream Production from Lactose-Free UHT Milk. *Journal of Food Science and Engineering*, 8, 210–214.
- Palka, A. (2015). Zmiany w preferencjach konsumenckich na rynku lodów. *Handel wewnętrzny* 2(355), 308–319.
- Palka, A. (2017). Making purchase decision on ice cream market. *Marketing i Zarządzanie* 2(48), 53–62.
- Palka, A. (2019). Rynek lodów w Polsce – aktualne trendy rozwoju. In: M. Halagarda (ed.), *Konsument na rynku żywności – preferencje, opinie, trendy*, 43–51. Radom: Sieć Badawcza Łukasiewicz.
- Palka, A. (2020). The potential of ice cream made from goat's milk in Polish market – preliminary research. *Polish Journal of Commodity Science*, 4(65), 76–82.

Palka, A., Newerli-Guz, J., Wilczyńska, A., Rybowska, A. (2016). Innovations in Ice Cream Production in Baltic Sea Region. *Proceedings of The 11th European Conference on Innovation and Entrepreneurship*, Jyväskylä, Finland, Academic Conferences and Publishing International Limited Reading UK, 543–551.

Patil, A.G., Benerjee, S. (2017). Variants of ice cream and their health effects. *MOJ Food Process Technol*, 4(2), 58–64.

Rychlik, U., Marszałek, A. (2013). Nietolerancja laktozy – współczesny stan wiedzy. *Diagnostyka laboratoryjna*, 49(1), 71–73.

Sawaia, W. (2018). *Nietolerancja laktozy. Nietolerancja laktozy a stosowanie leków z laktozą. Praca pogłówna w ramach specjalizacji, Kierunek: farmacja apteczna*, Poznań. https://www.woia.pl/dat/attach/917_praca-specjalizacyjna---weronika-sawala.pdf.

Silanikove, N., Leitner, G., Merin, U. (2015). The Interrelationships between Lactose Intolerance and the Modern Dairy Industry: Global Perspective in Evolutional and Historical Backgrounds. *Nutrients*, 7(9), 7312–31.

Skryplonek, K., Henriques, M., Gomez, D., Viegas, J., Fonseca, C., Pereira, C., Dmyrów, I., Mituniewicz-Matek, A. (2019). Characteristic of lactose-free frozen yogurt with κ-carrageenan and corn starch as stabilizers, American dairy Science Association. *J. Dairy Sci.* 102(9), 7838–7848.

Soler, L. (2005). Development of Non-dairy Frozen Dessert Containing Soy Protein and Coconut Milk. *Agricultural Business*.

Szilagyi, A., Ishayek, N. (2018). Lactose Intolerance, Dairy Avoidance, and Treatment Options. *Nutrients*, 10(12), 1994.

Thompson, K.R., Chambers, D., Chambers, E. (2009). Sensory characteristics of ice cream produced in the U.S.A. and Italy. *Journal of Sensory Studies*, 24(3), 396–414.

Zatwarnicki, P. (2014). Nietolerancja laktozy – przyczyny, objawy, diagnostyka. *Pielęgniarstwo i Zdrowie Publiczne*, 4(3), 273–276.

Zięba, K. (2010). Czynniki kształtujące zachowania nabywcze młodych konsumentów. *Ekonomiczny Problem Usługi*, 54, 271–279.

INFLUENCE OF *SPIRULINA* ADDITION ON CONSUMER ACCEPTANCE AND FUNCTIONAL PROPERTIES OF YOGHURTS

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Abstract

Functional foods are of great interest to consumers because they have a positive impact on health and are an excellent source of bioactive ingredients. Fermented milk drinks are recognized as health promoting foods because they are particularly beneficial to the microbiota of the digestive system and support the immune system. Combining bioactive ingredients with a fermented product can give the consumer a double health benefit. The bioactive ingredient proposed for the production of the innovative yoghurt is *Spirulina Platensis*, (blue-green algae). Fermented products made with the addition of algae do not have a sweet taste and can be classified as dry products. The aim of the study was to produce, evaluate quality and consumer acceptance of fermented milk products such as yoghurts with *Spirulina*, added.

Keywords:

consumer acceptance, fermented milk drinks, yogurt, *Spirulina Platensis*

Introduction

The demand for probiotic functional foods is growing rapidly due to increased consumer awareness. Food manufacturers play an important role in supporting healthier eating habits by enriching and providing healthy foods. Today, fermented dairy products contribute to improved health and intestinal flora due to existing lactic acid bacteria. Fermented dairy products such as yoghurt, ajran, kefir, etc., are considered to be among the most popular worldwide (Shangpliang,

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et al. 2018; Turkmen, Akal & Özer, 2019). Fermented dairy drinks are considered healthy foods because they have a particularly positive effect on the microbiota of the digestive system and support the immune system. Probiotics are defined as live microorganisms that, when administered in adequate amounts, confer health benefits to the host (FAO/WHO, 2001).

Over the past few decades, considerable success has been achieved in the development of dairy products containing probiotic bacteria, such as fermented milk, ice cream, various types of cheese, baby food, milk powder, frozen dairy desserts, whey-based beverages, sour cream, buttermilk, normal and flavoured liquid milk (Mohammadi & Mortazavian, 2011). Probiotics provide several health benefits, mainly by maintaining normal intestinal microflora, protection against gastrointestinal pathogens (D'Aimmo, Modesto & Biavati 2007; Lourens-Hattingh & Viljoen, 2001), strengthening the immune system (Gilliland, 1990), lowering serum cholesterol and blood pressure, anti-cancer effects (Rasic, 2003), improving nutrient utilization and increasing the nutritional value of foods (Lourens-Hattingh & Viljoen, 2001). Probiotic consumption relieved human stress and anxiety symptoms possibly via modulating the neuroactive potential of the gut microbiota (Ma, *et al.* 2021). Probiotic foods must contain suitable probiotic organisms. The microorganisms that mainly provide balance in the gut are *Lactobacillus* and *Bifidobacterium*. Factors that negatively affect the interaction between gut microbes, such as stress and diet, lead to harmful health effects (Lourens-Hattingh & Viljoen, 2001). Probiotic foods should be safe and must contain adequate probiotic organisms in sufficient numbers at the time of consumption. Therefore, the probiotic strains selected should be suitable for large-scale industrial production, have the ability to survive and maintain their functionality during production. They must survive during food processing operations and also in the food products for which they are eventually formulated (Tripathi & Tripathi 2014). One of the most popular milk fermented product is yogurt. Yogurt is a dairy product that is pasteurized, fermented with bacteria mixture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, or *Lactobacillus acidophilus* that can break down the milk sugar (lactose) into lactic acid to obtain the acidity, smell, and taste which is typical. The use of *Streptococcus thermophilus* as starter culture is its ability to ferment lactose and lowers the pH of the product quickly, while *L. bulgaricus* is an important characteristic in yogurt that stimulates the growth of *Streptococcus thermophilus*, also produces exopolysaccharide which improves the texture and rheology of fermented milk products (Suzery, *et al.* 2018). Bio-yogurt is product who providing live cells of *Lactobacillus acidophilus* and *Bifidobacterium bifidum*. An adequate number of live cells, the “therapeutic minimum”, must be consumed regularly for the “probiotic” effect to be passed on to consumers. One of the factors determining the value of medicinal, prophylactic and dietary yogurts is the presence of live starter cultures throughout the declared shelf life (Lourens-Hattingh & Viljoen, 2001). According to the requirements of the FAO/WHO Codex

Alimentarius, the number of characteristic microflora of yogurt must be at least 10^7 cfu in 1 g of the product during the shelf life (Kycia & Krysinski 2014). Yoghurt consumption should be greater than 100 g per day (Lourens-Hattingh & Viljoen 2001). Yogurt provide several benefits for humans. Among them are better resistance to infections, stimulation of the immune system and better absorption of minerals and lactose (Hove, *et al.* 1999; de Caire, *et al.* 2000). Stanton, *et al.* (2005) found that the claimed health benefits of consuming fermented functional foods are either due to a probiotic effect (through the interaction of ingested live microorganisms with the host) or indirectly due to a biogenic effect (through the ingestion of microbial metabolites formed during the fermentation process). The taste and aroma of the food product may be altered by addition of probiotics due to production of different metabolic components such as acetic acid produced by *Bifidobacterium* spp. during fermentation and over storage period. The presence of the probiotic culture in food product, should not adversely affect product quality or sensory properties (Stanton, *et al.* 2005; Mohammadi & Mortazavian, 2011).

In general, a basic agent in preparation probiotic fermented milk is an absence of viability of probiotic through fermentation procedure and storage time (Mortazavian, *et al.* 2005; Nobakhti, *et al.* 2008). Several agents effect on viability of probiotics cultures in fermented milk such as titratable acidity, pH (Shah, 2000). As demonstrated in the Varga and Szigeti (2002) study, cyanobacteria such as *Spirulina Platensis*, were successfully added to prolong the life of probiotic bacteria in fermented dairy products.

Spirulina is the most nutritious, concentrated food that is known to mankind containing antioxidants, phytonutrients, probiotics, and nutraceuticals (Ruma Arora Soni, Sudhaka & Rana, 2017). *Spirulina* has an imposing nutrient composition which can be used for therapeutic uses. The United Nations world at food conference declared that *Spirulina* as the best food for future, and it is gaining popularity nowadays (Pulz & Gross, 2004; Ruma Arora Soni, Sudhaka & Rana, 2017).

Combining the properties of added *Spirulina* with a fermented product can provide a double health benefit to the consumer. The use of the health-promoting properties of *Spirulina* as an additive in fermented products may also contribute to increasing the range of products classified as functional foods. The aim of the study was to produce, evaluate quality and consumer acceptance of fermented milk products such as yoghurts with *Spirulina* added.

Characteristics of *Spirulina*

Spirulina Platensis, is a microscopic and filamentous cyanobacterium. It is a prokaryotic a blue-green alga that grows in clean, alkaline water. The name *Spirulina* comes from the word spiral and refers to its physical characteristics, which resemble a spring.

Spirulina has been proposed as a sustainable and environmentally friendly microalga useful for bioremediation, nitrification and carbon dioxide (CO₂) fixation (Singh, *et al.* 2016; Finamore, 2017). *Spirulina* does not need fertile land, has a rapid growth, and takes less energy input and less water per kilogram than soya and corn proteins and has been used as protein-rich animal feed for improving meat production and quality (Holman & Malau-Aduli, 2013) and has been proposed as a sustainable approach to prevent Protein Energy Malnutrition (PEM) and Protein Energy Wasting (PEW) in humans (Siva Kiran, Madhu & Satyanarayana, 2015). World Health Organization has described *Spirulina* as Mankind's best health product. FDA validated it as "One of the best protein source" (Ruma Arora Soni, Sudhaka & Rana, 2017). *Spirulina* has health-promoting properties, is rich in essential amino acids, vitamins and minerals, and exhibits antioxidant and anti-inflammatory effects (Chaiklahan, *et al.* 2011).

Spirulina Platensis powder is a dark green powder, have a mild seaweed taste and without decayed or smell (Celekli, Alaji Lalslibi & Bozkurt, 2018) *Spirulina platensis* is used for colouring food due to its phycocyanin content (Martelli, *et al.* 2014). These microalgae contain an abundance of nutritional and non-nutritional molecules that also provide benefits for brain health (Sorentii, *et al.* 2021).

In the European market, *Spirulina* is intended for human consumption, mainly as a functional food. *Spirulina platensis* is characterised by high carbonate and bicarbonate levels and pH values up to 11. The dried biomass of *S. platensis* typically contains 3 to 7% moisture, 55 to 60% protein, 6 to 8% lipids, 12 to 20% carbohydrates, 7 to 10% ash, 8 to 10% fibre, 1 to 1.5% chlorophyll a and a wide range of vitamins (Varga, Szigeti, Kovacs, Foldes & Buti, 2002). The proteins with the highest economic potential are biliproteins (e.g., c-phycocyanin and allophycocyanin), which are water-soluble blue pigments. The protein fraction can contain up to 20% phycocyanins (Cohen, 1997; Varga, *et al.* 2002). *Spirulina* is characterised by its high amino acid content. It contains per 100 g of product: glutamate 7.0–7.3 g leucine 5.9–8.4 g, sspartate 5.2–6.0 g, lysine 2.6–4.6 g, tyrosine 2.6–3.4 g, phenylalanine 2.6–4.1 g, methionine 1.3–2.7 g (Varga, *et al.* 2002). Selected mineral and vitamin compounds of dried *Spirulina* powder are presented in Table 1.

Tang and Suter (2011), report that commercially dried *Spirulina* powder (per 100 g) contains 373 kcal energy, 87.4 mg iron, 319 mg magnesium, 142 ug iodine and 162

g vitamin B12. It is important to be mindful that the nutrient content is influenced by how the algae is grown and how it is extracted (filtered) and dried (Ruma Arora Soni, Sudhaka & Rana, 2017). It should be noted that the cell wall of *Spirulina* is composed of proteins, carbohydrates and fat and not indigestible cellulose. Therefore, the bioavailability of nutrients from *Spirulina* may be more than from other food sources, especially plant food sources (Tang & Suter, 2011).

Table 1. Selected mineral and vitamins compounds in dried *Spirulina* powder (per 100 g)

Minerals	
Potassium	2.0–2.6 g
Sodium	1.5–2.2 g
Total phosphorus	1.3–2.2 g
Iron	273.2–787.0 mg
Magnesium	330
Calcium	120–900 mg
Vitamins	
B12	5.7–38.5 µg
B2	3.0–4.6 mg
B6	0.5–0.8 mg
Niacin (B3)	13–15 mg
Folic acid	0.05–9.92 mg
Carotenoids	0.3–2.6 g
Tocopherol	0.4–9.8 g

Source: own elaboration based on Finamore, *et al.* (2017).

There are studies recorded that *Spirulina* has several potential health-enhancing impacts: safeguards against renal failure diseases, inhibition of hypertension, decrease of high serum glucose values, the mitigations of hyperlipidemia and, increase growth-enhancing of intestinal *Lactobacillus* (de Caire, *et al.* 2000). As reported by Bhowmik, Dubey and Marea (2009) *Spirulina platensis* is able to inhibit the growth of some Gram-negative and Gram-positive bacteria. *Spirulina* presents hypolipidemic (Serban, Sahebkar & Dragan, 2016), hypoglycemic (Iyer Uma, Sophia & Mani Uliyar, 1999), and antihypertensive (Torres-Duran, *et al.* 2007). Studies in rats suggested that *Spirulina* increases the lipoprotein lipase activity (Iwata, Inayama & Kato, 1990) and the pancreatic secretion of insulin (Finamore, 2017). *Spirulina* contains many functional bioactive ingredients with antioxidant and anti-inflammatory activities, including phenolic phytochemicals (Chaiklahan, *et al.* 2011; Jensen, *et al.* 2015).

Spirulina showing such health-promoting properties can be used for food fortification and applied as an additive to various foods or consumed in dried form or as a microcapsule supplement. Furthermore, studies indicate its positive effect on the process of increasing the number of positive gut bacteria and bifidobacteria in fermented products (Celekli, *et al.* 2018; Varga, *et al.* 2002) Alizadeh Khaledabad, Ghasempour, Moghaddas Kia, Rezazad Bari and Zarrin (2020) reported that fortification of microalgae fermented products can increase probiotic viability and nutritional efficacy of also fermented vegan products (involving plant-based beverages).

Material and Methods

The study materials were yoghurts prepared under laboratory conditions using the thermostatic method from UHT milk with 3.2% fat content, and commercial natural yoghurt containing *Bifidobacterium* BB⁻⁵ and *Lactobacillus acidophilus* La⁻⁵ was used as a starter. *Spirulina* from Superfoods company from the local market was used as an algae additive. Sucrose or the sweetener xylitol and freshly squeezed lemon juice were used as flavour enhancers. The finally we made yogurth samples with: milk -100 ml, starter cultures came from commercial natural yoghurt (25%), addition of *Spirulina* was 1, 1,5; 2%, lemon juise 3 and 5%, sucrose (or xylitol 1%), (Tabel 2).

Table 2. Yoghurts with *Spirulina* and other flavor enhancing ingredients

Samples	Milk [ml]	Joghurt nat. starter [%]	<i>Spirulina</i> contens [%]	Lemon juise [%]	Saccharose [%]	Xilitol [%]
O – Yogurth – natural	100	25	–	–	–	-
A – Y + <i>Spirulina</i>	100	25	2.0	–	–	-
B – Y + <i>Spirulina</i> , lemon juice	100	25	2.0	5	–	–
C – Y + <i>Spirulina</i> , lemon juice, saccharose	100	25	2.0	5	1	–
D – Y + <i>Spirulina</i> , lemon juice, xylitol	100	25	2.0	5	–	1

Preparing of yoghurt

The yoghurts were prepared in 150 ml jars according to the following procedure: 2 g of *Spirulina* were weighed into the jars, 100 ml of UHT milk and 25 g of starter – natural yoghurt were added. Then lemon juice, sucrose or xylitol were added respectively. The content of the jars was mixed, closed and placed in the Yogurella

85 Yogurt Maker (Ariete) and thermostated at 40°C for 12 h. After finished fermentation yogurts were stored for min. 4 h at 4°C in refrigerated.

Thus prepared yoghurts were subjected to physicochemical, microbiological evaluation and to degree of consumer acceptance.

Physicochemical analyzes

Syneresis is the percentage of whey flowing out of yoghurt during storage. The degree of syneresis was determined using the centrifuge method. For this purpose, yoghurt samples of approx. 35 ml in volume were placed in centrifuge tubes graduated every 0.5 ml and centrifuged (MPW-352) at 2000 rpm for 10 minutes. The degree of syneresis was expressed as a percentage.

$$\text{degree of syneresis} = \frac{V_j - V_s}{V_j} \cdot 100\% \quad (1)$$

where:

V_j – volume of yoghurt taken for testing [cm³], V_s – volume of whey separated [cm³].

The active acidity of sample yoghurts was measured at 18 C with an HI 8521 pH-Meter and combined glass electrode (Hanna Instruments Deutschland GmbH, Karlsruhe, Germany) standardized with pH 4.00 and 7.00 standard buffer solutions (Merck).

The degree of syneresis and the measurement of active acidity were done on the second day after preparation and cooling of yoghurts. Measurements of each sample were made in triplicate and the results were averaged and subjected to statistical analysis. Significance of difference was set at $P < 0.05$ in all cases.

Microbiological analyzes

In order to determine the number of lactic fermentation bacteria in the obtained yoghurt samples, 10⁻⁸ dilutions of the yoghurt samples were prepared with *Spirulina*. From the prepared dilutions, cultures were made on a plate, poured with MRS agar (BIOMAXIMA S.A.), mixed gently and left to solidify, then placed in an incubator at 37°C and incubated for 48 hours. The cultures were performed in duplicate. After incubation, the colonies on the plates were counted and the averaged results are given in cfu/cm³.

Degree of consumer acceptance

Four coded trials were prepared to assess consumer acceptance of innovative yogurts with *Spirulina*. 33 people (aged 18–25 years) were evaluated Yogurth by organoleptic using a 9-point hedonic scale, where 1 – extremely dislike and 9 – extremely like. The characteristics evaluated were overall appearance, texture, color, smell and taste, and overall yogurt score. Participants in the organoleptic evaluation were then asked to complete a questionnaire regarding their evaluation and acceptance of fermented products and with *Spirulina*. The questionnaire consisted of 8 questions, which concerned the purchase, the choice factors, the frequency and the type of yoghurt purchase and answer if they would be interested in buying yogurt with *Spirulina*.

Results and discussions

Results of physicochemical and microbiological analysis

According to the results of the pH measurement (Table 3), yoghurts with *Spirulina* and lemon juice were characterised by a higher acidity of pH 3.81. On the other hand, the blank sample – yoghurt without and with *Spirulina* (A) was characterised by a similar acidity slightly higher than the above samples, pH was about 4.2. The active acidity of the products was characterised by values similar to the experiments of Wichrowska, Wojdyła (2014) and Lewandowicz, LeThanh-Blicharz & Śmigielska (2019) using market products containing the so-called mild cultures of *Lactobacillus acidophilus* and *Bifidobacteria bifidum*. However, the addition of *Spirulina* caused a slight increase in the active acidity of the tested samples. In a study by Beheshtipour, *et al.* (2012). found that the higher acidity of *Spirulina*-enriched samples was due to the positive effect of *Spirulina* on the microbiota of the samples, which was also observed in our study.

Table 3. Results of physicochemical and microbiological analysis on yogurt with Spiruline

Yoghurts sample	Syneresis [%]	pH in 1th day	Contents of yoghurt bacteria colonies [cfu/cm ³]
0 – natural	20.6 ^a	4.28 (+/- 0.03) ^a	4.6 x 10 ⁸
A + <i>Spirulina</i>	44.8 ^b	4.15 (+/- 0.01) ^a	3.2 x 10 ⁸
B + <i>Spirulina</i> , lemon juice	44.5 ^b	3.81 (+/- 0.02) ^b	2.5 x 10 ⁸
C+ <i>Spirulina</i> , lemon juice, sacharose	44.9 ^b	3.78 (+/- 0.02) ^b	2.9 x 10 ⁸
D + <i>Spirulina</i> , lemon juice, xylitol	45.7 ^b	3.77 (+/- 0.03) ^b	2.8 x 10 ⁸

± standard deviation. a, b – different letters in the same column indicate significant differences ($p < 0.05$)
Source: Authors' own study.

The syneresis results of yoghurts with and without *Spirulina* differ by 24%. In contrast, laboratory natural yoghurts in our other studies also showed a syneresis of 23% (Śmigielska, 2016). Such syneresis also occurs when fruit pulp is added to yoghurt without the use of added pectins, stabilisers or enzymes (Zaręba & Ziarno, 2018). Increased syneresis can also be caused by 5% addition of lemon juice. This can be prevented by the addition of starch or milk powder.

The live bacterial cell content indicates that the addition of *Spirulina* did not cause a large increase in the number of lactic acid bacteria. These results are not similar to those obtained by Varga, *et al.* 2002, where the addition of *Spirulina* was shown to increase the cell count of live bacterial cultures. In the study by Varga, *et al.* (2002), a different yoghurt production procedure was used. First, yoghurt was obtained and then a milk solution with *Spirulina* was added and no flavour additives (which also affect the active acidity of the product) were used. In Varga, *et al.* study (2002) an increase in the number of bacteria, especially *Streptococcus thermophilus*, was found between the samples with *Spirulina* and the control. Nevertheless, the number of live cultures in our study was within the required standard, i.e. CFU count > 10⁷. In a study. Patel, *et al.* (2019), similar results were obtained in the amount of bifidobacteria producing yogurts with 7% *Spirulina* added, but not the same procedure. The samples with *Spirulina* did not produce a clear, thick yoghurt curd in the samples with lemon juice and sweeteners. Which may have influenced the organoleptic evaluation, especially the texture discriminant.

Results of consumer acceptance yoghurts with *Spirulina*

There are no fermented products with algae on the Polish market. Although studies in other countries indicate the probiotic effects of *Spirulina* and the growth of bifidobacteria in fermented products. The taste and aroma of a food product may be altered when probiotics are added due to the production of various metabolic components such as acetic acid produced by Bifidobacterium spp. during fermentation and during storage. Therefore, the presence of a probiotic culture in a food product should not adversely affect product quality or sensory properties (Mohammadi, Mortazavian, 2011; Stanton, *et al.* 2003). An attempt was made to produce yoghurts with the addition of *Spirulina* and with taste and aroma enhancing substances. The products so produced were subjected to consumer organoleptic evaluation.

A total 33 people took part in the survey, varying in terms of gender, age, education and place of residence. Women predominated among the consumers (80%) and people aged 18–25 years. In terms of education, the majority of respondents had a university degree (51,5%) and secondary education (48,5%). There was an even split between people living in big cities and those living in villages.

All persons performed an organoleptic evaluation of the four yoghurt samples produced. Using a 9-point hedonic scale (where 1 – extremely dislike and 9 – extremely like), consumers rated attributes such as texture, colour, smell and taste, as well as sensory evaluation of the yoghurts as a whole. The consumer analysis showed that in terms of overall appearance, texture and colour, sample A, i.e. the sample containing only *Spirulina*, obtained the highest consumer acceptance. However, the same sample obtained the lowest acceptance in terms of taste. This indicates that the addition of sour lemon juice not only changes the consistency and colour of the *Spirulina* yoghurt, but also has a strong influence on consumer acceptance. The other samples B,C and D did not differ significantly in the evaluation in terms of the evaluated characteristics. The addition of lemon juice and sugar as flavour additives (sample C) was rated best by consumers especially in terms of taste. Yoghurt C also received the highest rating in the overall assessment (4.3). The addition of sugar to yoghurts was better accepted than xylitol. Yogurts produced by other researchers had lower *Spirulina* addition (Bhowmik, Dubey, Mehra, 2009; Varga, *et al.* 2002) which may have significantly influenced the colour evaluation of *Spirulina*-enriched yogurts. Taste and smell of yoghurts with sweeteners and lemon juice – scored more than yoghurts without these additives. The introduction of flavour enhancing additives resulted in lower consistency scores. Various studies have reported that the chemical properties in terms of pH and acid production in fermented dairy products can be improved by combining with prebiotics such as starch, glucose, inulin, calcium, fibre and β -glucan. This is the reason for the nutritional benefits of prebiotics in promoting probiotic growth and increasing lactic acid production through fermentation and storage time (Celekli, *et al.* 2018). Perhaps the use of starch or inulin can also improve the texture of yogurts in consumer acceptance. The evaluation of consumer acceptance of yoghurt with *Spirulina* in terms of texture and the results of the syneresis analysis conducted in this study also suggest the addition of thickeners to the final product. The results of the consumer acceptance of yogurt with *Spirulina* are shown in Figure 1.

After the organoleptic evaluation of the yoghurts, consumers completed a questionnaire on consumer acceptance of the yoghurts analyzed. The questionnaire consisted of 8 questions, which concerned the purchase, the choice factors, the frequency and the type of yoghurt purchase and whether they would be interested in buying such a product.

To question 1: which fermented milk beverages do you prefer to consume? respondents indicated that they most often consume yogurt (86.4%). The next most popular fermented milk drink was kefir (37.9%). According to a study by Krasnowska and Selejda (2008), yogurt was also the most frequently consumed fermented milk drink, followed by kefir. The study discussed here shows that 31.8% of consumers willingly consume buttermilk and 22.7% consume skyr. Only

6% of the consumers are keen to consume sour milk, ajran and acidophilic milk. None of the consumers gave the answer – I do not consume at all.

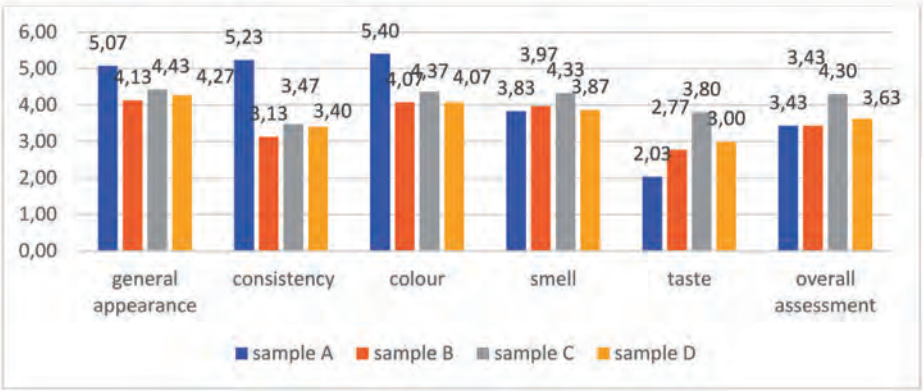


Figure 1. Consumer acceptance yoghurt with *Spirulina* and addiitive flavourings

* Sample A, B, C, D – test description as in Table 3

Source: Authors’ own study.

The results of the questionnaire on the frequency of consumption of beverages are shown in Figure 2. Only 4.5% of the respondents answered that they consume such products daily. A significant proportion, 62.1%, said they consume them several times a week, while 33.3% of respondents said they consume them once a week or less.

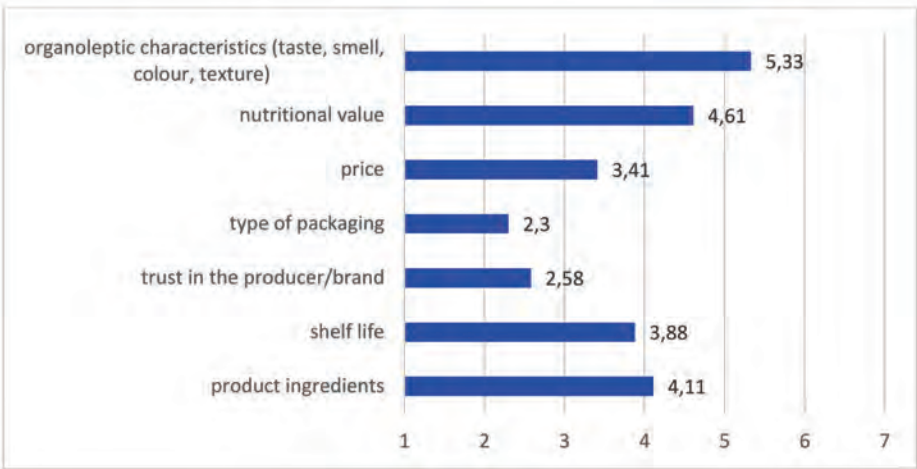


Figure 2. Factors Affecting the Purchase of fermented milk beverages

(rank from 1 to 7, where 1 is the least influence and 7 the most influence)

The analysis of the answers to the question “what has the greatest and the least influence on purchasing fermented milk beverages” shows that according to the respondents, organoleptic features such as flavour, aroma, colour and texture have the greatest influence on their purchasing decisions. In second place, respondents placed nutritional value, which is confirmed by research (Kudełka & Marzec, 2004). In these consumer preference research shows that product ingredients are another important factor, which may be related to consumers’ growing awareness of food. In a study by Janiak, Orzechowska-Przybyła & Lesiów (2016) on the choice of organic food, the composition of the product was also mentioned by a majority of respondents as the most important determinant of product choice. According to respondents, the type of packaging and trust in the producer and brand have the least influence when purchasing fermented milk drinks.

The yoghurts available on the Polish market are natural yoghurts – with a neutral – milk flavor and sweet with addition fruit. Recently, yoghurts with the addition of vegetable pulp have also appeared but this yoghurts is sweet. The addition of algae may affect the final flavor of a product that does not contain sugar. These Yogurt will be belongs to savory taste products. The survey showed that respondents are most likely to use natural yogurts with probiotics (42.4% of consuments), followed by flavoured drinking yogurts (34.8%) and flavoured yogurts with probiotics (33.3%). A similar quantitative choice (30.3%) was made for natural Greek yoghurts. Flavoured yoghurts and natural yoghurts of the skyr type (a recent novelty on the Polish market) were indicated by a total of 27.3% of respondents (Figure 3). In one of the in Polish supermarket chains, consumers were offered fruit and vegetable yoghurts without added glucose-fructose syrup. However, sugar is mentioned in the composition of such products, in second place.

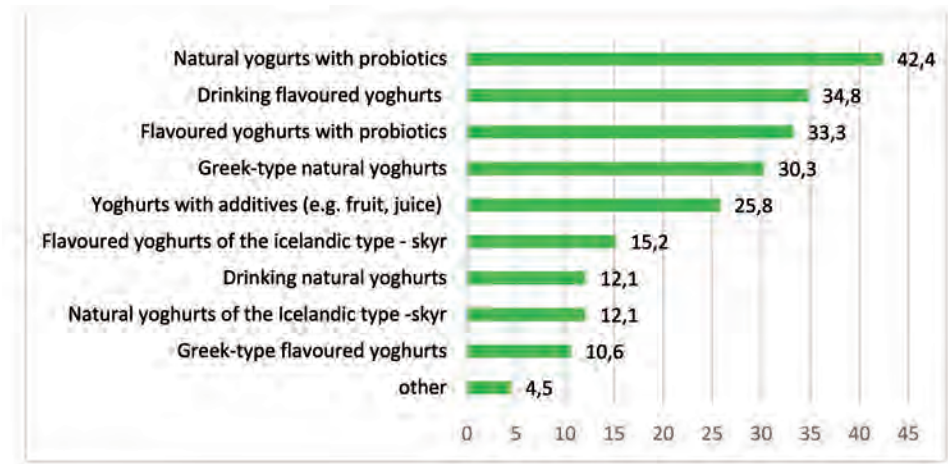


Figure 3. Yoghurts most frequently chosen by respondents [%]

Source: Authors’ own study.

Analysing the answers obtained, it can be assumed that consumers prefer yoghurts that are not sweet – savoury taste as the largest percentage of them chose natural yoghurts. The analysis of yoghurt consumption frequency among respondents showed that only 7.6% consume yoghurt daily while the majority of respondents (43.9%) consume yoghurt 1–2 times a week. The last questions of the survey concerned the consumption of yoghurts savoury flavour – e.g. vegetable yoghurts. Respondents admitted (86%) that they had never eaten such yoghurt. Respondents admitted (86%) that they had never eaten such yoghurt. Asked if you would be interested in buying savoury tasting yoghurt with added sea algae such as *Spirulina* or chlorella? 63.6% of the respondents of the consumer acceptance survey said they would be interested in buying such yoghurt, 36.4% said they would not.

Conclusion

Due to the high content of nutrients, *Spirulina* is a highly concentrated substance classified as functional food. Its addition to the daily diet may positively affect the metabolic processes of the human body and for the growth of positive gut bacteria. It can be used as an enrichment in yoghurts. Combining bioactive ingredients (*Spirulina*) with a fermented product can give the consumer a double health benefit.

Laboratory analyses that both types of yoghurt tested showed adequate acidity and yoghurt bacteria culture content. However, a large whey leakage – syneresis – was observed in the samples. The active acidity (pH) of yoghurts with added algae slightly increase (pH 3.77–4.15) than that of natural yoghurts without additives (pH 4.28). Due to the addition of bioactive ingredients, the yogurts had a liquid consistency and may require thickeners for full consumer acceptance. They can also be offered as drinkable yoghurts.

Conducted surveys among consumers showed that consumers quite often choose and consume yoghurt, 62% consume it several times a week. The organoleptic characteristics smell, aroma, colour and consistency have the greatest influence on the product choice of purchasing decisions. Natural fermented dairy drinks with probiotics are the most frequently chosen. 63.6% of respondents are interested in buying yogurt with a savoury taste. Organoleptic acceptance of yogurt with *Spirulina* test show that taste had the biggest differences in acceptability, while according to the overall assessment yoghurt C with *Spirulina* and lemon juice and sucrose received the highest rating. Due to the addition of bioactive ingredients, the yogurts had a liquid consistency and may require thickeners for full consumer acceptance. They can also be offered as drinkable yoghurts.

References

- Alizadeh Khaledabad, M., Ghasempour, Z., Moghaddas Kia, E., Rezazad Bari, M., Zarrin, R. (2020). Probiotic yoghurt functionalised with microalgae and Zedo gum: chemical, microbiological, rheological and sensory characteristics. *International Journal of Dairy Technology*, 73(1), 67–75.
- Beheshtipour, H., Mortazavian, A.M., Haratian, P., Darani, K.K. (2012). Effects of *Chlorella vulgaris* and *Arthrospira platensis* addition on viability of probiotic bacteria in yogurt and its biochemical properties. *European Food Research and Technology*, 235, (4), 719–728.
- Bhowmik, D., Dubey, J., Mehra, S. (2009). Probiotic efficiency of *Spirulina platensis* – stimulating growth of lactic acid bacteria. *World Journal of Dairy & Food Sciences*, 4, 2, 160–163.
- Cohen, Z. (1997). The chemicals of *Spirulina*. In: A. Vonshak (ed.), *Spirulina platensis, (Arthrospira): Physiology, Cell-biology and Biotechnology*, 175–204. Taylor and Francis Ltd., London, UK.
- Celekli, A., Alaji Lalslibi, Z., Bozkurt, H. (2018). Use of *Spirulina* in Probiotic Fermented Milk Products. *International Journal of Advances in Science Engineering and Technology*, 6, 3, 2321–9009, <http://iraj.in>.
- Chaiklahan, R., Chirasuwan, N., Loha, V., Tia, S., Bunnag, B. (2011). Separation and purification of phycocyanin from *Spirulina* sp. using a membrane process. *Bioresour. Technol.*, 102, 14, 7159–7164.
- D'Aimmo, M.R., Modesto, M., Biavati, B. (2007). Antibiotic resistance of lactic acid bacteria and *Bifidobacterium* spp. Isolated from dairy and pharmaceutical products. *International Journal of Food Microbiology*, 115 (1), 35–42.
- de Caire, G.Z., Parada, J.L., Zaccaro, M.C., Storni de Cano, M.M. (2000). Effect of *Spirulina platensis* biomass on the growth of lactic acid bacteria in milk. *World Journal of Microbiology and Biotechnology* 16, 563–565 <https://doi.org/10.1023/A:1008928930174>
- FAO/WHO, 2001, Evaluation of health and nutritional properties of probiotics in food including powder milk with live lactic acid bacteria, <https://www.fao.org/3/y6398e/y6398e.pdf>.
- Finamore, A., Palmery, M., Bensehaila, S., Peluso, I. (2017). Antioxidant, Immunomodulating, and Microbial-Modulating Activities of the Sustainable and Ecofriendly *Spirulina*. *Oxidative medicine and cellular longevity*, 3247528, <https://doi.org/10.1155/2017/3247528>,
- Gilliland, S.E. (1990). Health and nutritional benefits from lactic acid bacteria. *FEMS Microbiology Letters*, 87, 1–2, 175–188.
- Holman, B.W.B., Malau-Aduli, A.E.O. (2013). *Spirulina* as a livestock supplement and animal feed. *Journal of Animal Physiology and Animal Nutrition*, 97, 4, 615–623.
- Hove, H., Norgaard, H., Mortensen, P.B. (1999). Bakterie kwasu mlekowego a ludzki przewód pokarmowy. *European Journal Clinical Nutrition*, 53, 339–350, <https://www.researchgate.net/publication/344036599>,

Iwata, K., Inayama, T., Kato, T. (1990). Effects of *Spirulina platensis* on plasma lipoprotein lipase activity in fructose-induced hyperlipidemic rats. *Journal of Nutritional Science and Vitaminology*, 36, 2, 165–171. doi: 10.3177/jnsv.36.165.

Iyer Uma, M., Sophia, A., Mani Uliyar, V. (1999). Glycemic and lipemic responses of selected *Spirulina* supplemented rice-based recipes in normal subjects. *International Journal of Diabetes in Developing Countries*, 19, 17–22.

Janiak, E., Orzechowska-Przybyła, K., Lesiów, T. (2016). Analiza wiedzy i preferencji konsumentów w zakresie żywności ekologicznej. *Engineering Sciences and Technologies* 1, 20, 43–58. DOI: 10.15611/nit.2016.1.04.

Jensen, G.S., Attridge, V.L., Beaman, J.L., Guthrie, J., Ehmann, A., Benson, K.F. (2015). Antioxidant and anti-inflammatory properties of an aqueous cyanophyta extract derived from *Arthrospira platensis*: contribution to bioactivities by the non-phycoerythrin aqueous fraction. *Journal of Medicinal Food*, 18, 5, 535–541.

Krasnowska, G., Salejda, A., (2008). in Polish, Czynniki wpływające na wybór mlecznych napojów fermentowanych przez studentów Wrocławia. *ŻYWNOSĆ. Nauka. Technologia. Jakość*, 3, 58, 33–46.

Kudełka W., Marzec, M. (2004). Preferencje studentów dotyczące spożycia mlecznych napojów fermentowanych. *ŻYWNOSĆ. Nauka. Technologia. Jakość*, 3(40), 63–76.

Kycia, K., Krysiński, C. (2014). Microbiological and hygienic quality of commercial goat milk yoghurts in context of their therapeutic properties. *Probl. Hig. Epidemiol.*, 95, 1, 186–191.

Lewandowicz, J., LeThanh-Blicharz, J., Śmigielska H. (2019). Influence of origin of inuline on the quality of natural yoghurt produced by thermostat method. In: H. Śmigielska (ed.), *Current Trends in Quality Sciences – Quality design of foods product*. Poznań: Faculty of Commodity Science, Poznań University of Economics and Business, 78–88.

Lourens-Hattingh, A., Viljoen, B.C. (2001). Review Yogurt as probiotic carrier food. *International Dairy Journal*, 11, 1–17.

Martelli, G., Folli, C., Visai, L., Daglia, M., Ferrari, D. (2014). Thermal stability improvement of blue colorant C-Phycocyanin from *Spirulina platensis* for food industry applications. *Process Biochemistry*, 49, 1, 154–159.

Ma, T., Jin, H., Kwok, L-Y., Sun, Z., Liong, M-T., Zhang, H. (2021). Probiotic consumption relieved human stress and anxiety symptoms possibly via modulating the neuroactive potential of the gut microbiota. *Neurobiology of Stress*, pre-proof, doi: <https://doi.org/10.1016/j.ynstr.2021.100294>.

Mohammadi, R., Mortazavian, A.M. (2011). Technological aspects of prebiotics in probiotic fermented milks. *Food Reviews International*, 27, 192–212.

Mortazavian, A.M., Ehsani, M.R., Mousavi, S.M., Reinheimer, J., Emamdjomeh, Z., Sohrabvandi, S. (2005). Preliminary investigation on the combined effect of heat treatment and incubation temperature on the viability of the probiotic microorganisms in freshly made yoghurt. *Int. J. Dairy Technol.*, 59, 8–11.

Nobakht, A.R, Ehsani, M.R, Mousav,S.M, Mortazavian, A.M. (2008). Influence of lactulose and Hi-maize addition on viability of probiotic microorganisms in freshly made symbiotic fermented milk drink. *Milchwissenschaft*, 63, 427–429.

Patel, P., Jethani, H., Radha, C., Vijayendra, S., Mudliar, S.N., Sarada, R., Chauhan, V.S. (2019). Development of a carotenoid enriched probiotic yogurt from fresh biomass of *Spirulina* and its characterization. *Journal of food science and technology*, 56(8), 3721–3731, <https://doi.org/10.1007/s13197-019-03844-0>.

Pulz, M.O., Gross, W. (2004). Valuable products from biotechnology of microalgae. *Applied, Microbiology Biotechnology*, 6, 635–648.

Rasic, J.L., (2003). Microflora of the intestine probiotics, In: B. Caballero, L. Trugo, P. Finglas (eds.), *Encyclopedia of food sciences and nutrition*. Oxford: Academic Press, 3911–3916.

Ruma Arora Soni., Sudhaka, K., Rana, R.S. (2017). *Spirulina* – From growth to nutritional product: A review, *Trends in Food Science & Technology*, 69, Part A, 157–171, <https://doi.org/10.1016/j.tifs.2017.09.010>.

Serban, M.-C., Sahebkar, A., Dragan, S. (2016). A systematic review and meta-analysis of the impact of *Spirulina* supplementation on plasma lipid concentrations. *Clinical Nutrition*, 35, 4, 842–851. doi: 10.1016/j.clnu.2015.09.007.

Shah, N.P. (2000). Probiotic bacteria: enumeration and survival in dairy foods. *J Dairy Sci*, 83, 894–907.

Shangpliang, H.N.J, Keisam, R., Rai, S., Jeyaram, K., Tamang, J.P. (2018). Bacterial community in naturally fermented milk products of Arunachal Pradesh and Sikkim of India analysed by high-throughput amplicon sequencing. *Sci. Rep.*, 8, 1532.

Singh, S.K., Rahman, A., Dixit, K., Nath, A., Sundaram, S. (2016). Evaluation of promising algal strains for sustainable exploitation coupled with CO₂ fixation. *Environmental Technology*, 37, 5, 613–622.

Śmigielska H. (2016). *Innowacyjne produkty spożywcze na rynku żywności funkcjonalnej zawierające wzbogacaną skrobię*. Poznań: Wydawnictwo UEP, 251.

Sorrenti, V., Castagna, D.A., Fortinguerra, S., Buriani, A., Scapagnini, G., Willcox, D.C., (2021). *Spirulina* Microalgae and Brain Health: A Scoping Review of Experimental and Clinical Evidence. *Mar. Drugs*, 19, 293. <https://doi.org/10.3390/md19060293>.

Stanton, C., Ross, R.P., Fitzgerald, G.F., Van Sinderen, D. (2005). Fermented functional foods based on probiotics and their biogenic metabolites. *Curr Opin Biotechnol*, 16 (2), 198–203.

Sudhakar, K., Rana, R.S. (2017). *Spirulina* – From growth to nutritional product: A review. *Trends in Food Science & Technology*, 69, A, 157–171.

- Suzery, M., Hadiyanto H., Sutanto, H., Widiastuti, Y., Judiono J. (2018). Improvement the Yoghurt Nutritional Value, Organoleptic Properties and Preferences by *Spirulina (Spirulina platensis)* Supplementation The 12th Joint Conference on Chemistry. *IOP Conf. Series: Materials Science and Engineering*, 349 012040, doi: 10.1088/1757-899X/349/1/012040.
- Tang, G., Suter, P.M. (2011). Vitamin A, Nutrition, and Health Values of Algae: *Spirulina*, *Chlorella*, and *Dunaliella*. *Journal of Pharmacy and Nutrition Sciences*, 1, 111–118.
- Torres-Duran, P.V., Ferreira-Hermosillo, A., Juarez-Oropeza, M.A. (2007). Antihyperlipemic and antihypertensive effects of *Spirulina maxima* in an open sample of mexican population: a preliminary report. *Lipids in Health and Disease*, 6, 33. doi: 10.1186/1476-511x-6-33.
- Tripathi M.K., Giri S.K. (2014). Probiotic functional foods: Survival of probiotics during processing and storage. *Journal of Functional Foods*, 9, 225–241.
- Turkmen, N., Akal C., Özer B. (2019). Probiotic dairy-based beverages: a review. *J. Funct. Foods*, 53, 62–75.
- Varga, L., Szigeti, J. (1998). Microbial changes in natural and algal yoghurts during storage. *Acta Aliment Hung*, 27, 2, 127–35
- Varga, L., Szigeti, J., Kovacs, R., Foldes, T., Buti, S., (2002). Influence of a *Spirulina platensis* Biomass on the Microflora of Fermented ABT Milks During Storage R1. *American Dairy Science Association, J. Dairy Sci.*, 85, 5, 1031–1038.
- Wichrowska, D., Wojdyła, T. (2014). Ocena sensoryczna i fizykochemiczna wybranych jogurtów naturalnych i ekologicznych. *Inż. Ap. Chem.*, 53, 6, 421–423.
- Zaręba, D., Ziarno, M. (2018). Stabilizatory: Systemy stabilizujące mleczne napoje fermentowane. *Forum Mleczarskie Biznes* 1(31), <https://www.forummleczarskie.pl/raporty/856,systemy-stabilizujace-mleczne-napoje>.

ASSESSMENT OF CONSUMPTION, PREFERENCES AND CONSUMERS AWARENESS IN RELATION TO HOME-MADE PRODUCED ALCOHOLIC BEVERAGES

Karolina Doba¹, Jacek Stefanowicz, Wojciech Zmudziński¹

Abstract

The alcoholic beverages market in Poland is constantly developing. Consumers are open to new types of beers and wines. A wide range of products is also provided by home production of alcoholic beverages, which is constantly popular in our country. The main purpose of the research was to analyse the topics of home alcohol consumption and production in Poland. The knowledge of legal regulations regarding home alcohol production was also examined. First of all, checking the understanding of the term “production for own needs”. The aim of the survey was also to find out about the place and circumstances of alcohol consumption by consumers. The research method was the CAWI (Computer Assisted Web Interview) technique. A total of 600 respondents took part in the study. The most common home-made alcohols were wines (66%), tinctures (63%), beer (16%), cider/perry (14%), liqueur (12%) and mead (8%). About 27% of home-made alcohol production was at least once based on the production of distillate. Despite the fact that a large number of people are knowledgeable about the legal provisions in force in Poland regarding home production of alcohol for personal use, this knowledge is still insufficient.

Keywords:

alcohols beverages, home-made production, consumption, consumer preferences, legal regulations

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Introduction

Many types of home-made alcoholic beverages are popular in Poland. Based on a report prepared by the Nielsen Research Agency in 2018 the market value of individual types of alcoholic beverages can be compared (Nielsen Research Agency, 2018). As much as PLN 16.7 billion was spent in Poland on beer in 2018. Compared to 2017, beer sales increased by 7.1%. The vodka market, on which Poles spent over PLN 11 billion, was next. The highest increase was recorded among small alcoholic beverages. Small flavoured vodkas recorded an increase in sales by nearly 10%. Beer production in Poland increased by 0.9% in April 2021 year-on-year, and on a monthly basis it increased by 8.5%. However, the four months of 2021 brought a total decrease in beer production by 4.0% comparing same period of 2020. Beer production amounted to 11.87 million hectolitres. It is estimated that the spirits industry is facing a great challenge, both due to the coronavirus pandemic and the excise tax increase (Woźniak, 2020). One the other had the brewing industry for decades has been dominated by bottom fermentation beers, the so-called lagers (Wachełko, Szpot & Zawadzki, 2021).

Based on the data of the Republican Foundation report on the illegal spirits market from the end of 2017, almost 80% of illegal alcohol was spirits. It has been estimated that most of the illegal spirits are alcohol produced by decontamination of industrial denatured alcohol. Concentrations of hepatotoxic substances can be high in an illegally produced home-made alcohols (McKee, 2012; Rehm, Kanteres & Lachenmeier, 2010). Acetaldehyde, which is a product of ethanol metabolism is mainly responsible for these toxic effects. In addition, traces of chloroform was detected in 84% of the samples. Compounds that are present in illegally produced alcohol are: trans-anethol, 2-methyl-1-propanolol and asetic acid (Gökce, *et al.* 2016). Methanol can be found in home-made spirits. After consumption it is broken down by enzymes into toxic compounds – formaldehyde and formic acid. Although the toxic effects of methanol are reduced because ethanol contained in the product competes for the metabolic pathways, unfortunately cases of poisoning often occurs. Low product quality of alcoholic beverages impact health and may increase of occurring of alcohol-attributable diseases. On the other hand, it should also be noted that moderate regular alcohol consumption from legal sources has a cardioprotective effect (Cheiran, *et al.* 2019).

Currently, as in previous decades, Polish men drink more than women. According to studies performed by Wojtyniak, *et al.* (2002) education has a significant impact on drinking levels, but this impact differs for men and women. When standardized for age, male consumption tends to decline with increasing educational level, whereas women's consumption increases with education level. What is interesting, studies showed that women with university degrees drink more than women with any other level of education. According to research conducted by Popova,

et al. (2012) an average consumption in central and eastern Europe is high with a relatively large proportion of unrecorded consumption ranging from one litre in Czech Republic and Estonia to 10.5 litre in Ukraine. The proportion of heavy alcohol consumption (more than 40 g of pure alcohol per day) among men was the lowest in Bulgaria (25.8%) and the highest in Czech Republic (59.4%). Among women, the lowest proportion of heavy alcohol consumption was registered in Estonia (4.0%) and the highest in Hungary (16.0%). It should be noted that lockdowns and social distancing measures due to COVID-19 pandemic may cause increased consumption of alcoholic beverages, mainly because of the stress, insecurity and social isolation (Nicholls & Conroy, 2021). According to Gómez-Corona, *et al.* (2016b, 2017) people drink alcohol mainly for social reasons and psychological effects or an escape, which refer to avoidance and to a sensation seeking.

The main aim of the study was to analyse the issues of home alcohol production in Poland. The perception of home alcohol production, how many people undertake home production and what influences the decision about starting an alcohol production was researched. Analysing these factors in terms of their mutual correlation is crucial, because there may be many factors influencing the start of home alcohol production. Another important element of the study was to examine the knowledge of the legal provisions relating to home alcohol production. The aim of the research was also to determine the awareness and knowledge of consumers about production of alcohol for private use. The final goal of conducted research was to find out about the place and circumstances of alcohol consumption.

Study characteristics/methodology

The research method was the CAWI (Computer Assisted Web Interview) technique. The survey questionnaire was created via Google Form, which made it easy to reach a large number of people from various places in Poland. The online survey was described by giving a title containing information about the study of home alcohol production in Poland. It also contained a brief description of the purpose of the survey. The survey was completely anonymous. It took about 10–15 minutes to complete the questionnaire. A total of 600 people participated in the study. The survey was made available on Facebook, which made it possible to obtain answers from respondents with quite diverse socio-demographic data, as evidenced by the similar number of women and men, as well as the diversity of inhabitants of small, medium and large towns and the differences in education level and average earnings. The questionnaire consisted of 19 questions in total, including 5 questions describing the socio-demographic data of the respondents. People declaring alcohol consumption answered detailed questions about alcohol

consumption. Similarly, questions about home production were answered only by participants who declared home production of alcohol. A total of 600 participants took part in the survey. Due to the fact that the survey was made available on various Facebook groups, a research group that was demographically diverse in relation to the place of residence was obtained. The clear advantage of people aged 18–25 shows a great willingness to solve online surveys. People under 40 accounted for about 85% of the respondents. Among the respondents there were 6 people with a doctorate, and 37 people with primary or vocational education. The total number of people with non-university and secondary education does not exceed 8% of all respondents. Cities were inhabited by 66% of the respondents, most of which (30%) were cities with over 500,000 inhabitants. About 34% of participants inhabited rural areas. The average monthly earnings can certainly be considered the most diverse socio-demographic factor. People earning between 2,500 and 4,000 PLN were the most numerous group. The smallest number of respondents earn between 1500 and 2500 PLN.

Results and discussion

Figure 1 shows the frequency of alcohol use among 561 participants. 158 of respondents declared alcohol consumption several times a month; 129 people declared drinking alcohol several times a week and 117 participants of the conducted research was consuming alcohol once a week.

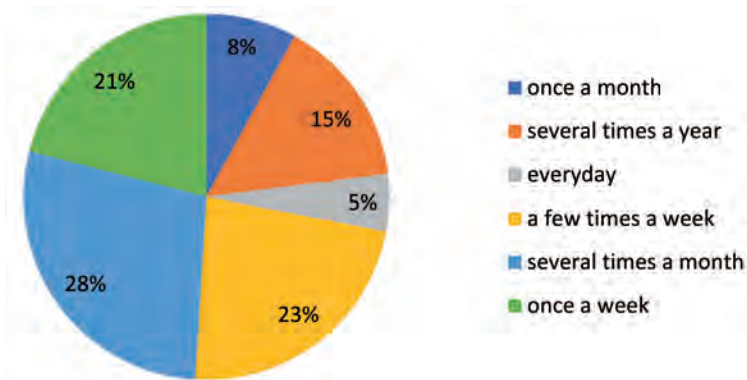


Figure 1. Frequency of alcohol consumption

Source: Authors' own study.

Difference between men and women can be seen on the basis of the declared frequency of alcohol consumption. Figure 2 shows the percentage of men who drink alcohol at least once a week and less than once a week. It is clear that

younger men drink much more than older men. It was found that men over 41 years of age declared less alcohol consumption. There is also a clear decline in men who declare drinking alcohol at least once a week among men over 50. On average about 62% of questioned women report alcohol consumption less than once a week.

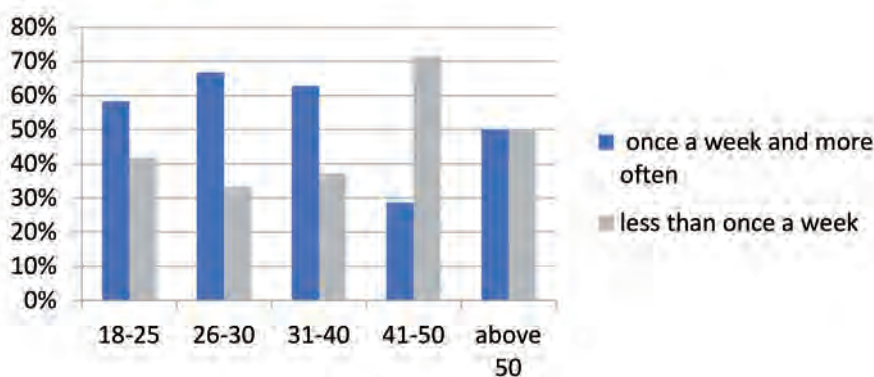


Figure 2. Comparison of men who drink infrequently and who drink often by age

Source: Authors’ own study.

Most women between age 41–50 declared frequent alcoholic beverages consumption, while in the same age group in men it was exactly the opposite. Among people aged 18–25 and 26–30, the declaration of women and men is quite the opposite. About 2/3 of women report drinking less than once a week, and 2/3 of men more than once a week (Figure 3).

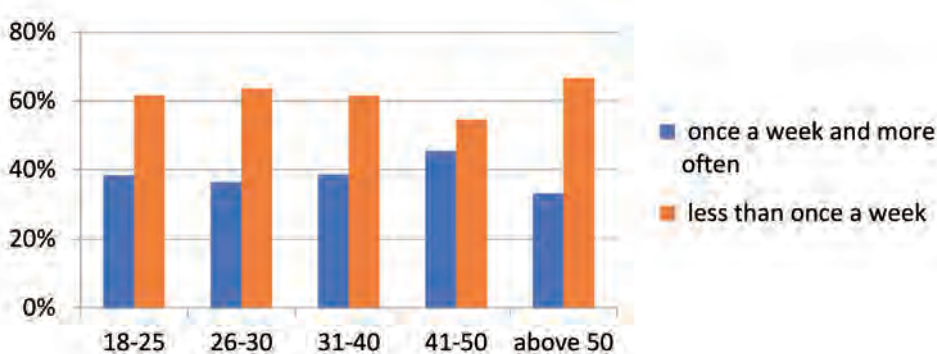


Figure 3. Comparison of women who drink infrequently and who drink often by age

Source: Authors’ own study.

The next question was about place of alcoholic beverages consumption – “Where do you most often drink alcohol?” The question allowed to give more than one answer, as well as to enter specific place of alcohol consumption. Several people reported alcohol consumption in the workplace (1.1% of respondents). About 91% of participants consume alcohol at home. Many of them chose outdoor locations more often than restaurants and clubs. Pubs account for 46% of the vote. This means that more than one in two people do not drink alcohol in pubs. There is still less interest in consumption of alcoholic beverages in pubs than in countries such as the United Kingdom, Germany or the Czech Republic, although it is definitely more than according to the Central Statistical Office’s data from 10 years ago (12% of alcohol consumption occurred in a pub or bar) (Central Statistical Office, 2010). It is also worth noting that the survey was conducted before the start of the COVID-19 coronavirus pandemic, which certainly affect greatly the more frequent selection of outdoor locations and homes in relation to pubs and restaurants.

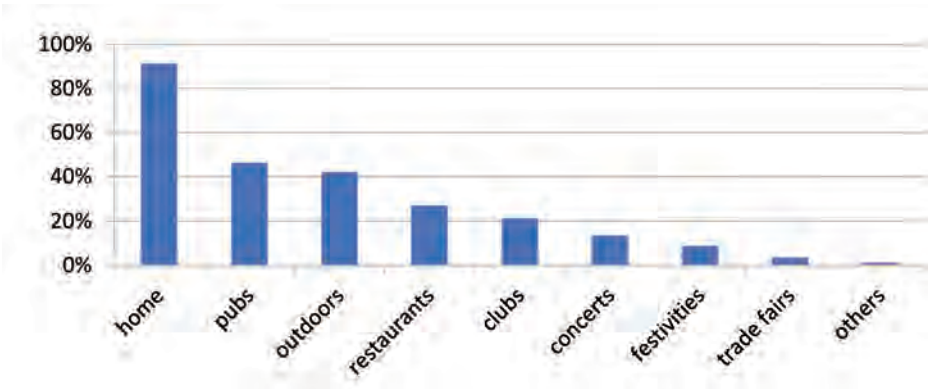


Figure 4. Place of alcohol consumption

Source: Authors’ own study.

Only 9% of people declared that they had never drunk homemade alcoholic beverages. Most, because almost half of the respondents (48%) declared consuming this type of alcoholic beverages several times a year. A large group of participants (28%) pick an answer “only a few times in their life”. Homemade alcoholic beverages was consumed by 15% of people more than a few times a month. 15% of respondents questioners was used to observe and analyze age as a factor related to the frequent consumption of home-produced alcohol. With the increase in age, a clear increase in the value of alcohol consumption can be observed, which for the range of 18–25 years was 17%, and for the range over 50 years – as much as 50%. This means that every second person over 50 and every third person aged from 31 to 45 regularly drink homemade alcoholic beverages.

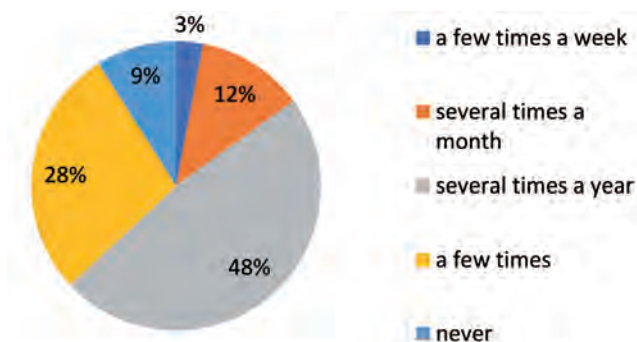


Figure 5. Frequency of consumption of home-made alcoholic beverages

Source: Authors' own study.

Over 70% of alcohol drinkers drank the tincture. This alcoholic beverage was preferred by women. The second alcohol, which definitely surpasses the others compared to all the respondents, was wine, however men more often than wine used all kinds of distillates. This is exactly the opposite of women. 69.9% of women and 65.4% of men drank wine. However, only 37.2% of women and 69.2% of men drank the distillate. This difference clearly indicates a greater interest in strong-tasting alcohols by men, however many tinctures also have a very high alcohol content despite a smoother and lighter taste. A similar relationship is visible in the case of beer. It was men who drank home beer more often. Home beer consumption is declared by 22.9% of men, which is 10.3% more than women. Before beer, however, the fourth place was taken by liqueurs consumed by a very similar number of men and women, with a slight majority of women (19.7% of women and 18.8% of men). An interesting remark is a slightly higher percentage of men drinking cider and perry (13%) than women drinking beer (12.6%). Another alcoholic beverage drunk by responders was mead, which was also consumed more often by men. Mead was tasted by 11% of men and 8.6% of women. In total, 53.8% of the respondents declared that they consumed home-distilled alcohol. The simple conclusion is therefore that one in two people who ever drink alcohol has most likely tasted illegally distilled alcohol. although It cannot be 100% certain that the alcohol was illegal in all cases, because participants of the research could consume moonshine coming from a small legal and registered production.

The respondents who confirmed the production of alcoholic beverages in the past gave the specific details about types of alcohol they produced. 66% of respondents produced vine. Only 3% less participants produced the tincture. These are by far the most common types of alcohol produced at home. Every fourth home production (27%) was based at least once on the production of distillate. The next places were beer (16%), cider/perry (14%), liqueur (12%) and mead (8%). According to McKee (2012) homemade spirits are widely produced in many parts

of Europe. These products are varied and include samogon (Russia), slivovica (Slovakia), pálinka (Hungary), and rakia (Bulgaria and Turkey). Their composition, and hence toxicity, depends on what they are produced from and how carefully controlled the process of distillation is. Based on the analysis of disclosed illegal alcohol sales and research estimates, it was established that this illegal market is at the level of 14–33 million liters of alcoholic beverages. This poses a great risk to consumers (Gökce, *et al.* 2016).

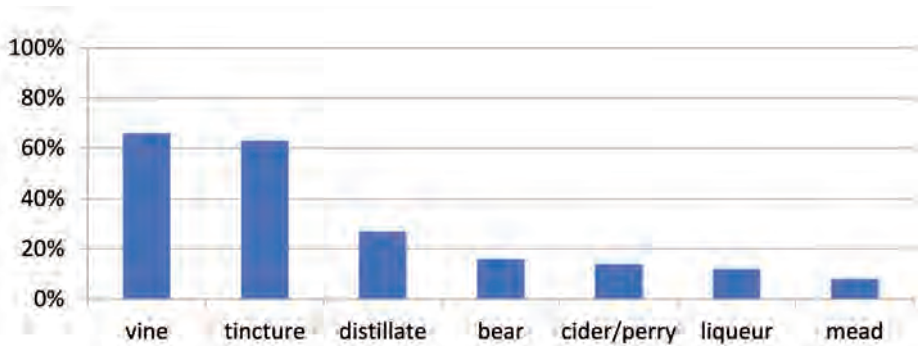


Figure 6. Home-made alcoholic beverages produced by participants of the survey

Source: Authors' own study.

One of the main aim of performed studies was to determine the awareness and knowledge of consumers about production of alcoholic beverages for private use. Anyone who wants to engage in the business of production or bottling of alcoholic beverages must obtain administrative permits. On the other hand, production of alcoholic beverages using home methods, and not intended for sale is allowed in principle and no permits are required. One exception is the production of spirits directly through distillation after alcoholic fermentation where a permit is required each time. Therefore, the next question was a question verifying the knowledge in regards of law on home-made alcoholic beverages production in Poland. Within the overview category of unrecorded products, three main categories can be distinguished: unrecorded legal alcohol products (e.g. homemade alcohol in jurisdictions where home production is legal, unrecorded illegal alcoholic products, coming from illegal production or from smuggling), surrogate alcohol not officially made for human consumption, but in many instances produced and distributed with clear intent for this exact purpose. The basic legal regulation regarding the production of ethyl alcohol is the Act of March 2, 2001 on the production of ethyl alcohol and the production of tobacco products (Journal of Laws 2001, No. 31, item 353, Article 12a). Polish law explicitly excludes the possibility of home production of all kinds of distillates. In the case of wines, ciders and other fermented alcoholic beverages, production for private consumption is possible. This is stated in the Act

of 12 May 2011 on the production and bottling of wine products, trade of these products and organization of the wine market (Journal of Laws of 2011, No. 120, item 690, Art. 1). The respondents could choose many answers, and their task was to correctly define what the phrase “producing alcohol for personal consumption” means. Among the four incorrect answers, two were true, i.e. “it cannot be sold” and “it can be consumed by the producer’s family and guests”. The vast majority of people voted for the correct answers 66.7% and 62.7% of the people chose the first and second correct answer. Every fourth person (26.4%) chose the most popular of the wrong answers, i.e. alcohol can be produced, but only to a certain amount. One in 10 people (10.9%) believed that homemade alcohol can only be consumed by the person who produced it. The least, 4.1% and 5.0%, respectively, chose the remaining incorrect answers. Despite the fact that a large number of people are knowledgeable about the legal provisions in force in Poland regarding home production of alcohol for personal use, this knowledge is still insufficient. Therefore it is necessary to take action to raise awareness of Polish consumers.

The factors prompting the respondents to start producing alcohol at home were also examined. Most people (67.4%) treated home production as experimenting and a desire to test their skills in this field. More than half of the people (53%) declared that they did it in order not to waste the raw materials they have. This is related to the answer to one of the previous questions, where the respondents answered that the raw materials usually come from their own crops. As many as 37.1% of people producing alcohol themselves believed that it is less harmful than alcohol bought in a store, and every fifth person (20.5%) believed that alcohol available in the store did not suit their tastes. Another answer in terms of the number of votes was the reluctance to pay excise duty (14.4%) and the reluctance to overly high alcohol prices in the store (12.9%). The production of alcohol was treated as a trend by 9.1% of the respondents. Some people (3.8%) plan to open their own alcohol production business in the future. 2.3% of people feared that the composition of alcohol available in the store is not beneficial, perhaps more harmful, containing unwanted additives. The same number of people treated alcohol production as a hobby.

Conclusions

It was found during the research that the most common home-made alcoholic beverages were wines (66%), tinctures (63%), beer (16%), cider/perry (14%), liqueur (12%) and mead (8%). About 27% of home-made alcohol production was at least once based on the production of distillate. It was found that about 91% of participants consume alcoholic beverages at home. Many of them chose outdoor locations more often than restaurants and clubs, because of COVID-19 outbreak. Despite the fact that a large part of people who knowledgeable about the legal

provisions in force in Poland regarding home production of alcohol for personal use, this knowledge is still very limited. The effectiveness of the prosecution and combating the phenomenon of illegal alcoholic beverages production is based on the appropriate scope of powers of the law enforcement agencies and actions undertaken jointly with other state institutions and social organizations. An important factor contributing to the prevention of this phenomenon is public education aimed at presenting the legal and social consequences of illegal spirits production. Home production of alcoholic beverages is interesting for both women and men. Consumers select the appropriate type of alcohol and most of people who are interested in this subject would like to ease the regulations on home alcohol production.

References

Act of 12 May 2011 on the production and bottling of wine products, trade of these products and organization of the wine market (in Polish).

Act of March 2 2001 on the production of ethyl alcohol and the production of tobacco products (in Polish).

Aquilani, B., Laureti T., Poponi S., Secondi, L. (2015). Beer choice and consumption determinants when craft beers are tasted: An exploratory study of consumer preferences. *Food Quality and Preference*, 41, 214–224.

Cheiran, K. P., Raimundo V. P., Manfroí, V., Anzanello, M.J., Kahmann, A., Rodrigues, E., Frazzon, J. (2019). Simultaneous identification of low-molecular weight phenolic and nitrogen compounds in craft beers by HPLC-ESI-MS/MS. *Food Chemistry*, 286, 113–122.

Gatrell, J., Reid, N., Steige, T.L. (2018). Branding spaces: Place, region, sustainability and the American craft beer industry. *Applied Geography*, 90, 360–370.

Gökce, H., Akcan, R., Celikel, A., Zeren, C., Ortanca, I., Demirkiran, S. (2016). Hepatotoxicity of illegal home-made alcohols. *Journal of Forensic and Legal Medicine*, 43, 85–89.

Gómez-Corona, C., Lelievre-Desmas, M., Escalona Buendía, H.B., Chollet, S., Valentin, D. (2016a). Craft beer representation amongst men in two different cultures. *Food Quality and Preference* 53, 19–28.

Gómez-Corona, C., Escalona-Buendía, H.B., García M., Chollet, S., Valentin, D. (2016b). Craft vs. industrial: Habits, attitudes and motivations towards beer consumption in Mexico. *Appetite*, 96, 358–367.

Gómez-Corona, C., Valentin, D., Escalona-Buendía, H.B., Chollet, S. (2017). The role of gender and product consumption in the mental representation of industrial and craft beers: An exploratory study with Mexican consumers. *Food Quality and Preference*, 60, 31–39.

<https://www.euromonitor.com/beer-in-poland/report>.

McKee, M. (2012). Illegally produced alcohol. *BMJ*, 344.

Nicholls, E., Conroy, D. (2021). Possibilities and pitfalls? Moderate drinking and alcohol abstinence at home since the COVID-19 lockdown. *International Journal of Drug Policy*, 88, in press.

Piacentini, K.C., Dagostim Savi, G., Olivo, G., Scussel, V.M. (2015). Quality and occurrence of deoxynivalenol and fumonisins in craft beer. *Food Control*, 50, 925–929.

Popova, S., Rehm, J., Patra, J., Zatonski, W. (2012). Comparing Alcohol Consumption in Central and Eastern Europe to Other European Countries. *Alcohol and Alcoholism*, 42(5), 465–473.

Rehm, J., Kanteres, F., Lachenmeier D. (2010). Unrecorded consumption, quality of alcohol and health consequences. *Drug and Alcohol Review*, 29, 426–436.

Wachefko O., Szpot, P., Zawadzki, M. (2021). The application of headspace gas chromatographic method for the determination of ethyl alcohol in craft beers, wines and soft drinks. *Food Chemistry*, 346, in press.

Wojtyniak, B., Moskalewicz, J., Stokwiszewski, J., Rabczenko, D. (2002). Gender-specific mortality associated with alcohol consumption in Poland in transition, Social Change and Gendered Drinking: A Symposium in Honour of Ludek Kubicka, 1779–1789.

Woźniak, B., <https://www.portalspozywczy.pl/alkohole-uzywki/wiadomosci/produkcja-wodki-wzrosla-w-lipcu-ale-po-7-miesiacach-2020-r-jest-spadek,188673.html> (in Polish).

EATING BEHAVIOUR AND ATTITUDES TOWARDS HEALTH BENEFITS OF FOOD AMONG WOMEN AGED 60+

Anna Platta¹, Karolina Śmigaj¹

Abstract

Attitudes towards food are good predictors of behaviour. If thoroughly explored, they play an important role in dietary education for different population groups.

The objective of the study was to assess nutritional behaviour and attitudes towards the health value of food and functional food exhibited by a group of women over the age of 60.

The study was carried out in 2020 among 102 women, living in Gdansk, while taking into account three variability factors: age, level of education and self-assessment of health. The empirical study was carried out by means of direct interviews and involved research tools such as Starzyńska's habitual dietary intake questionnaire, BSQFVF (Block Screening Questionnaire for Fruit/Vegetable/Fibre Intake), and the General Health Interest (GHI) scale.

The level of acceptance of innovations in food products depended on the socio-demographic characteristics of the consumers (women ≥ 60 years of age) such as age and level of education. The state of health of the female respondents aged 60+ did not significantly affect positive attitudes towards consuming food with health-promoting properties.

Keywords: eating behaviour, consumers, elderly women

Introductions

Attitudes towards food are good indicators of eating behaviour (Maison, 2004) and knowledge about the attitudes plays an important role in shaping healthy

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habits in different population groups (Babicz-Zielińska & Jeżewska-Zychowicz, 2015). This is particularly relevant for groups that are at a high risk of nutritional deficiencies. Consumers increasingly often have difficulties with maintaining good health regardless of their age. Poland and other countries around the world are ageing societies. Elderly people make up an increasingly large percentage of the population. It is this age group that is at the greatest risk of problems such as malnutrition, overweight or poorly balanced diets. There is a variety of foods on the market with specific properties that help to maintain good health or improve it (Łobaza & Kudełka, 2007). On the Polish market, the largest group of healthy food in terms of availability are: dairy products, juices and drinks enriched with vitamins and/or minerals, dietary fibre and inulin (Drywień, *et al.* 2018; Olędzka, 2007). In order to be beneficial to health, food products must provide sufficient amount of nutrients to meet the body's needs and reduce the risk of metabolic diseases (e.g. diabetes, atherosclerosis and obesity) (Piejko & Nowak, 2018). All these criteria are met by the so-called functional foods, which are becoming increasingly popular in various population groups, including seniors (Olejniczak, 2015).

The production of high-quality food with increased nutritional value and health-promoting properties has become an absolute requirement for manufacturers (Gutkowska, *et al.* 2015; Jeznach, *et al.* 2018; Nowak, Wawrzyniak & Wąsikowska, 2018). The aim of the study was to assess nutritional behaviour and attitudes towards the health value of food and functional food exhibited by a group of women over the age of 60.

Research material and methods

The study was conducted in October 2020 on a group of women aged between 60 and 90 years ($n = 102$). All the participants were residents of the city of Gdansk, and were selected on the basis of purposive sampling. Previous studies have shown that women tend to have more positive attitudes towards healthy food and lifestyle than men (Niewczas, 2013; Babicz-Zielińska & Jeżewska-Zychowicz, 2015). The analysis of the results was performed taking into account three factors differentiating the studied group of women: age, education level (primary, basic vocational, secondary, post-secondary, higher), and self-assessed state of health (Table 1). The largest group of the respondents were elderly women with secondary education, while elderly women with only primary education formed the smallest category (Table 1). As regards self-assessed state of health, the respondents could choose from 5 possible answers: 1 – very bad, 2 – bad, 3 – neither good nor bad, 4 – good, 5 – very good (Table 1). The vast majority of the respondents assessed their health as “neither good nor bad”. None of the surveyed women rated it as “very good” (Table 1).

The empirical research was conducted using a questionnaire, and was based on the direct interview methodology. The tools used included Starzyńska's habitual dietary intake questionnaire, BSQFVF (Block Screening Questionnaire for Fruit/Vegetable/Fibre Intake), and the General Health Interest (GHI) scale. In addition, the respondents were asked to indicate one of six listed factors which, in their opinion, would increase interest in functional food among elderly people: greater knowledge, greater awareness of its impact on health, taste, price, availability in smaller containers, greater popularity of such products in Poland.

Starzyńska's habitual dietary intake questionnaire (Gronowska-Senger, 2009) includes questions related to the number of meals consumed per day, the number of meals containing sources of animal protein (meat, fish, cold cuts, milk, cheese, eggs), the frequency of milk, cheese, vegetables or fruit consumption (also in raw form), as well as the consumption of wholemeal bread, groats and dry legumes. For each question, the respondent could obtain from 0 to 5 points, with a maximum score of 30 points. Based on the total number of points, the habitual dietary intake of women aged 60+ was rated as: good: no mistakes (28–30 points), satisfactory: mistakes that can be eliminated (21–27 points), below satisfactory: significant mistakes (12–20 points), and bad: significant mistakes that cannot be corrected (≤ 11 points).

Table 1. Characteristics of the examined group of women aged 60+

Socio-demographic characteristics of consumers	Number of indications [n]	Percentage [%]
age		
60–74	55	54
75–90	47	46
education level		
primary	10	9.8
basic vocational	21	20.6
secondary	37	<u>36.3</u>
post-secondary, higher	34	33.3
self-assessed health status		
very bad	2	2
bad	4	4
neither good nor bad	64	63
good	32	31

Source: own research.

The Block Screening Questionnaire for Fruit/Vegetable/Fibre Intake, BSQFVF (Thompson & Byers, 1994) was used to obtain data regarding the usual frequency of consumption of 9 food groups that are sources of dietary fibre. The respondents were asked how often they consume salads, pulses, potatoes, other vegetables, fruit and vegetable juices, fruit, coarse cereal products and wholemeal bread. The possible answers were: “less than once per month” (0 points), “1–2 times/month” (1 point), “2–3 times/month” (2 points), “3–4 times/week” (3 points), “5 and more times per week” (4 points). Fibre intake was assessed on a scale from 0 to 36 points. Having added up the points, fibre intake was assessed as very low (<20 points), insufficient (20–29 points) and sufficient (≥ 30 points), or as unacceptable (<20 points) and acceptable (≥ 20 points).

The respondents’ attitudes towards health and the health benefits of food were assessed using the General Health Interest (GHI) scale (Roininen & Tuorila, 1999). The GHI scale consists of 8 statements: 1. I care about healthy eating (positive attitude – P); 2. I try to keep my diet healthy and balanced (positive attitude – P); 3. I try to keep my diet low in fats (positive attitude – P); I make sure that my diet is rich in minerals and vitamins (positive attitude – P); I eat what I like and do not worry about a healthy diet (negative attitude N); 6. Health-related aspects of food do not influence my choices (negative attitude – N); 7. Health benefits of my snacks do not matter to me (negative attitude – N); 8. I do not pay attention to the cholesterol content of the products I consume (negative attitude – N). Each respondent evaluated her attitude to the above-mentioned statements using a 5-point Likert scale, with 1 indicating “I strongly disagree” and 5 indicating “I fully agree” (Ritchey, *et al.* 2003). In line with the methodology adopted, reverse scoring was applied to 4 of the 8 statements: 5, 6, 7 and 8. On the basis of the total sum of points, 3 attitudes of the respondents towards food were identified: negative (8–13 points), neutral (14–26 points) and positive (27–40 points).

To analyse the results, elements of descriptive statistics were used: number (n) and percentage of the study group (%).

Results and discussion

Evaluation of eating behaviour of women aged 60+ on the basis of an analysis of their habitual dietary intake, including dietary fibre intake – as an indicator of the level of consumption of health-promoting food products.

According to Muszalik, *et al.* (2003) health-promoting behaviour is significantly more common in people with higher education. The results of the research indicate that the level of education has an impact on the eating behaviour of women aged 60+. Respondents with higher education were more likely to score

higher in the habitual dietary intake questionnaire (Table 2) and their diets include more dietary fibre (Table 3).

The analysis of the habitual dietary intake of the respondents showed that as many as 51% of the surveyed women obtained less than 12 points. According to the adopted score interpretation, their diets were poor and the mistakes could not be corrected. In the case of women aged 60–74 years, for the most part (30%) their diets were assessed as bad, while the respondents aged 75–90 years were below satisfactory (24%) (Table 2). Such poor results were largely due to insufficient consumption of meals during the day (usually 3 meals). Possible reasons include: loss of appetite due to missing teeth and/or reduced salivary gland activity. In addition, the respondents consumed few meals rich in animal protein, such as: meat, fish, cold cuts, milk, cheese and eggs. Fruit and vegetables were consumed every day in two meals. The amount of wholemeal bread, groats and dry legumes consumed by the elderly women surveyed was very low.

Table 2. Evaluation of the habitual dietary intake taking into account age, education level and self-assessed state of health of women aged 60+ [%]

Assessment of factors		Evaluation of the habitual dietary intake taking			
		bad: significant mistakes that cannot be corrected (≤11 points)	below satisfactory: significant mistakes (12–20 points)	satisfactory: mistakes that can be eliminated (21–27 points)	good: no mistakes (28–30 points)
age	60-74	<u>30</u>	23	1	0
	75-90	21	<u>24</u>	2	0
	total	<u>51</u>	46	3	0
education level	primary, basic vocational	<u>21</u>	10	0	0
	secondary	<u>22</u>	15	0	0
	post-secondary, higher	9	<u>22</u>	3	0
self-assessed health status	very bad	0	<u>2</u>	0	0
	bad	<u>4</u>	0	0	0
	neither good nor bad	<u>32</u>	28	2	0
	good	15	<u>16</u>	1	0

Source: own research.

Table 3. Evaluation of the dietary fibre intake taking into account age, education level and self-assessed state of health of women aged 60+ [%]

Assessment of factors		Evaluation of the dietary fibre intake taking		
		very low (<20 points), unacceptable intake	insufficient (20–29 points), acceptable intake	sufficient (≥30 points), acceptable intake
age	60–74	<u>45</u>	9	0
	75–90	<u>35</u>	11	0
	total	<u>80</u>	20	0
education level	primary, basic vocational	<u>28</u>	2	0
	secondary	<u>31</u>	5	0
	post-secondary, higher	<u>21</u>	13	0
self-assessed health status	very bad	<u>1</u>	<u>1</u>	0
	bad	<u>4</u>	0	0
	neither good nor bad	<u>54</u>	9	0
	good	<u>22</u>	10	0

Source: own research.

The usual diet of women aged 60+ with primary and basic vocational (21%) and secondary education (22%) was very bad and beyond improvement. The respondents with post-secondary and higher education also made mistakes, but their mistakes could be rectified (22%) (Table 2). Education has a considerably impact on eating habits. Women who continued their education after secondary school declared greater knowledge in terms of proper nutrition and tried to eat more healthily than those with primary or secondary education.

The state of health of women aged 60+ also had an influence on their diets. The diets of women who assessed their state of health as “neither good nor bad” (31%) were bad, containing numerous mistakes beyond improvement (Table 2). Elderly women who declared themselves to be in “good” health tried to follow the principles of healthy eating.

The research conducted by Piejko & Nowak (2018) shows that elderly people rarely follow the dietary recommendations regarding the intake of dietary fibre. This was corroborated by the results of this research – it was found that the dietary fibre intake in the studied group of women aged 60+ was extremely low. The level of fibre intake in 80% of the respondents was at an unacceptable level. Fibre intake was very low for 45% of the respondents aged 60–74 years and 35% of those aged 75–90 years. Insufficient fibre intake was observed in 11% of the respondents aged 75–90 years (Table 3). Fruit, which is a rich source of fibre,

was rarely consumed by elderly women due to its tough texture and chewing difficulties experienced by the women. A possible reason for the low intake of fibre contained in legumes could be the bloating effect they cause.

Regardless of the level of education, the dietary fibre intake of the examined group of elderly women was very low. However, very low consumption of dietary fibre was more common in women with primary and basic vocational education (28%) and those with secondary education (31%). Insufficient fibre intake was most common for the respondents with post-secondary and higher education (13%) (Table 3). A correlation was observed between the level of education of the surveyed women and the increase in the level of fibre intake. The increase in fibre intake from an unacceptable (very low fibre intake) to an acceptable level (insufficient fibre intake) was positively correlated with the educational level of the respondents (Table 3).

The elderly women surveyed, regardless of their state of health, generally consumed very low amounts of fibre. The analysis of fibre intake showed that none of the respondents consumed sufficient quantities. 10% of all the respondents, who assessed their state of health as “good”, had insufficient fibre intake (Table 3). In addition, those respondents tended to pay more attention to ensure greater fibre intake in their daily diet as compared to those who assessed their state of health as “neither good nor bad” (Table 3).

Evaluation of elderly people’s attitudes towards the health benefits of food

The results of the research indicate that level of education has an impact on the attitude of women aged 60+ towards healthy eating and lifestyle. Respondents with higher education were more likely to demonstrate positive attitudes towards the health benefits of food (Table 4).

With the women’s age as a variable, no negative attitudes towards the health benefits of food were found (Table 4). Neutral and positive attitudes (63% and 37%, respectively) towards the health benefits of food prevailed among the women. Neutral attitudes were the most common both among respondents aged 60–74 years (37%) and those aged 75–90 years (25%). More women aged 75–90 (21%) than those aged 60–74 (17%) declared positive attitudes towards functional foods.

Among the respondents with primary and basic vocational education, the majority had neutral attitudes in this regard (23%) (Table 4). In the group of respondents with secondary education, neutral attitudes were also most common (26%). Positive attitudes towards the health benefits of food were found more often in the group of women with higher education (19%). The higher the level of education, the less frequent were neutral attitudes and the more frequent were positive attitudes

towards the health benefits of food. Elderly women with higher education were more open to discovering new foods with health-promoting benefits. Only 2% of elderly women (out of all the respondents) with a self-declared “very bad” state of health showed a positive attitude towards the health benefits of food. 43% of the respondents who assessed their state of health as “neither good nor bad” had a neutral attitude towards the health benefits of food. The percentage share of positive and neutral attitudes towards the health benefits of food among the respondents with self-declared “good health” was 50:50 (Table 4).

Table 4. Evaluation of attitudes of women aged 60+ towards health benefits of food, taking into account their age, level of education and self-assessed state of health [%]

Assessment of factors		Evaluation of attitudes of women towards health benefits of food		
		negative	ambivalent	positive
age	60–74	0	<u>37</u>	17
	75–90	0	<u>25</u>	21
	total	0	<u>63</u>	37
education level	primary, basic vocational	0	<u>23</u>	8
	secondary	0	<u>26</u>	11
	post-secondary, higher	0	15	<u>19</u>
self-assessed health status	very bad	0	0	<u>2</u>
	bad	0	<u>4</u>	0
	neither good nor bad	0	<u>43</u>	20
	good	<u>0</u>	<u>16</u>	<u>16</u>

Source: own research.

It was shown that positive attitudes of women aged 60+ towards the health benefits of food are influenced by age and educational level (Table 4). Neutral and positive attitudes towards the health benefits of food were prevalent among the elderly women surveyed (Table 4), which coincides with the results obtained by Kozirok, Baumgart & Babicz-Zielińska (2012) and Tańska, Babicz-Zielińska & Przysławski (2013), who observed a trend of greater interest in functional foods as the age of the respondents rose. The low level of food neophobia among women over 60 and their positive attitude towards new and unfamiliar foods with high nutritional value is a positive phenomenon that may have a significant impact on the popularisation of healthy diets among elderly people, both women and men (Platta, 2019; Platta & Pukszta, 2019). Further research is necessary in order to monitor changes in the eating and health-related behaviour of seniors due to a greater range of innovative food products.

Evaluation of factors which, in the opinion of women aged 60+, would increase interest in functional foods with health-promoting properties among elderly people

According to 27% of the respondents aged 60+, interest in functional food among elderly people could grow if more people knew about it. In the opinion of 23% of the respondents, better knowledge of the impact of functional food on human health could contribute to enhanced interest in functional food, while 17% of the respondents indicated more affordable prices as a key factor in this regard. Another factor mentioned (16% of the respondents) was greater popularity of such products in Poland. According to the women surveyed, what had the least impact on increasing interest in functional food was the availability of such products in smaller containers (Table 5). When analysing the responses in terms of different variables, the women aged 60–74 declared they would be interested in functional food if they were aware how it might benefit human health or if they knew more about it (17% and 15%, respectively). The respondents aged 75–90 declared, in turn, that they would pay attention to functional food when shopping for groceries if they knew more about it and if it was more affordable in terms of price (13% and 11% respectively).

Table 5. Factors that – in the opinion of women aged 60+ – could contribute to greater interest in functional food with health-promoting properties among elderly people [%]

Assessment of factors		Factors that could contribute to greater interest in functional food with health-promoting properties*					
		1	2	3	4	5	6
age	60–74	15	<u>17</u>	5	6	2	10
	75–90	<u>13</u>	<u>6</u>	7	11	4	6
	total	<u>27</u>	<u>23</u>	12	<u>17</u>	6	<u>16</u>
education level	primary, basic vocational	<u>11</u>	4	2	7	3	4
	secondary	8	<u>9</u>	6	6	2	6
	post-secondary, higher	9	<u>10</u>	4	4	1	6
self-assessed health status	very bad	1	0	1	0	0	0
	bad	2	1	0	0	0	1
	neither good nor bad	<u>16</u>	14	9	11	4	10
	good	<u>9</u>	8	2	6	2	5

*1. if I knew more about her; 2. if I knew well its effect on health; 3. if they were products that I like and/or like;4. if it was cheaper; 5. if it was packed in smaller packages; 6. if it was more popular in Poland.

Source: own research.

In the case of women aged 60+ with primary and basic vocational education, they responded that they would be more interested in buying functional food if they knew more about it (11%). According to the respondents with secondary (9%) and higher education (10%), a better knowledge of the impact of food with health-promoting properties on human health could make them more interested in it (Table 5).

It was found that the respondents who assessed their state of health as “neither good nor bad” or “good” declared that more knowledge about functional food would boost their interest in it (16% and 9%, respectively) (Table 5). The respondents with self-declared “neither good nor bad” state of health would pay more attention to healthy food if they knew about its impact on human health (14%) and if it was cheaper (11%) and more popular in Poland (10%). According to the women surveyed, what would have the least impact on increasing their interest in functional food was the taste of such products (9%) and its availability in smaller containers (4%) (Table 5).

The respondents with a self-declared “good” state of health would pay more attention to food beneficial to health if they were aware of its impact on human health (8%) and if it were less expensive (6%). The factor least likely to increase interest in functional food – according to the surveyed group of women aged 60+ – was its greater popularity in Poland (5%), taste (2%) and smaller containers (2%) (Table 5).

The analysis of the results obtained by Jędrusek-Golińska, *et al.* (2018), indicates that the factors which elderly people believe to have the greatest influence on the interest in health-promoting food include wider availability of information about such products, especially their effects on human health, and affordability. The above has been corroborated by the research presented in this paper. The surveyed group of women aged 60+ responded that their interest in health-promoting food would grow if there were more widespread knowledge about it, including its impact on human health, and if it were cheaper (Table 5).

Conclusions

1. The majority of the surveyed women aged 60+ had either neutral or positive attitudes towards the health benefits of food.
2. Women with higher education tended to have more positive attitudes towards food with health-promoting properties than women with secondary and primary or vocational education.
3. In the examined group of women aged 60+, the intake of dietary fibre was at an unacceptable level. Elderly women rarely consumed fruit, vegetables and pulses.

4. In the opinion of the respondents, the factors that could contribute to a growing interest in functional food with health-promoting properties among the elderly include: spreading knowledge about it, better awareness of its impact on human health, greater affordability and popularity of these kinds of products in Poland.

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References

- Babicz-Zielińska, E., Jeżewska-Zychowicz, M. (2015). Wpływ czynników środowiskowych na wybór i spożycie żywności. *Handel Wewnętrzny*, 2(355), 5–18.
- Drywień, M., Hamułka, J., Górnicka, M., Wawrzyniak, A., Frąckiewicz, J., Woźniak, A., Ciecierska, A. (2018). Spożycie produktów fermentowanych. Badania ankietowe kobiet. *Przemysł Spożywczy*, 2(72), 36–39. doi:10.15199/65.2018.2.5.
- Gronowska-Senger, A. (2009). Zarys oceny żywienia. Warszawa: Wydawnictwo SGGW.
- Gutkowska, K., Olewnik-Mikołajewska, A., Krośnicka, K., Piekut, M. (2015). Zachowania konsumentów wobec innowacyjnych produktów żywnościowych na przykładzie żywności funkcjonalnej. *Logistyka*, 2, 912–919.
- Jeznach, M., Kosicka-Gębska, M., Gębski, J., Kwiecińska, A. (2018). Czynniki skłaniające do nabycia żywności prozdrowotnej w świetle badań jakościowych. *Handel Wewnętrzny*, 4(375), 366–375.
- Jędrusek-Golińska, A., Szymandera-Buszk, K., Waszkowiak, K., Pieciewicz, M. (2018). Postrzeganie żywności prozdrowotnej przez osoby starsze w świetle badań. *Handel Wewnętrzny*, 4(375), 145–155.
- Koziorok, W., Baumgart, A., Babicz-Zielińska, E. (2012). Postawy i zachowania konsumentów wobec żywności prozdrowotnej. *Bromatologia i Chemia Toksykologiczna*, XLV, 1030–1034.
- Łobaza, D., Kudelka, W. (2007). Charakterystyka żywności funkcjonalnej. *Zeszyty Naukowe Akademii Ekonomicznej w Krakowie*, 743, 91–120.
- Maison, D. (2004). Utażone postawy konsumenckie. *Analiza możliwości wykorzystania metody IAT*. Gdańsk: Gdańskie Wydawnictwo Psychologiczne.
- Muszalik, M., Zielińska-Więczkowska, H., Kędziora-Kornatowska, K., Kornatowski, T. (2003). Ocena wybranych zachowań sprzyjających zdrowiu wśród osób starszych w oparciu o Inwentarz Zachowań Zdrowotnych Juczyńskiego w aspekcie czynników socjo-demograficznych. *Problemy Higieny i Epidemiologii*, 94, 509–513.
- Niewczas, M. (2013). Kryteria wyboru żywności. *Żywność. Nauka. Technologia. Jakość*, 6(91), 204–219.

Nowak, L., Wawrzyniak, A., Wąsikowska, B. (2018). Samoocena konsumentów a nowy produkt prozdrowotny z niestandardowym składnikiem. *Handel Wewnętrzny*, 2(373), 318–330.

Olejniczak, M. (2015). Ryzyko konsumenckie w procesie zakupu żywności funkcjonalnej. *Zeszyty Naukowe Wyższej Szkoły Bankowej we Wrocławiu*, Wrocław, 15(3), 417–424.

Olędzka, R. (2007). Nutraceutyki, żywność funkcjonalna – rola i bezpieczeństwo stosowania. *Bromatologia i Chemia Toksykologiczna*, 40(1), 1–8.

Piejko, L.J., Nowak, Z. (2018). Jakość diety i wybrane zachowania żywieniowe słuchaczy uniwersytetów trzeciego wieku w województwie śląskim. *Medycyna Ogólna i Nauki o Zdrowiu*, 24(1), 4.

Platta, A. (2019). Postawy i zachowania żywieniowe wybranej grupy osób starszych względem żywności nowej i nieznannej oraz produktów prozdrowotnych. *Intercathedra*, 3(40), 261–269. doi: 10.17306/J.INTERCATHEDRA.2019.00077.

Platta, A., Puksza, T. (2019). Elderly people's perception of new and convenience foods with health benefits. *Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu*, vol. XXI, 2, 235–245. doi: 10.5604 / 01.3001.0013.2228.

Ritchey, P.N., Frank, R.A., Hursti, U.K., Tuorila, H. (2003). Validation and crossnational comparison of the food neophobia scale (FNS) using confirmatory factor analysis. *Appetite*, 40, 163–173.

Roininen, K., Tuorila, H. (1999). Health and taste attitudes in the prediction of use frequency and choice between less healthy and more healthy snacks. *Food Quality and Preference*, 10, 357–365.

Tańska, M., Babicz-Zielińska, E., Przysławski, J. (2013). Postawy osób starszych wobec zdrowia i żywności o działaniu prozdrowotnym. *Problemy Higieny i Epidemiologii*, 94(4), 915–918.

Thompson, F.E., Byers, T. (1994). Dietary Assessment Resource Manual. *Journal of Nutrition*, 124, 2245–2317.

A HOLISTIC APPROACH TO FOOD INFORMATION AS AN ELEMENT OF MARKETING COMMUNICATION IN THE PRODUCTION AND TRADE OF FOOD

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Abstract

The food law strictly regulates the information that must be included in the labelling of foodstuffs. On the other hand, promotional and marketing information that is voluntarily placed on labels is rarely subject to specific legal conditions. Most often, in this respect, only a general prohibition of misleading consumers is in force, and producers and other entities involved in the process of developing communication often have a big problem in assessing when a given marketing slogan or other voluntary information about a product can be considered misleading, and when not. Holistic communication management for food business managers is a difficult area of strategic management of a company.

The aim of the work is to review and analyse the current state of knowledge on the holistic approach to food information as an element of marketing communication in the production and trade of food, in particular to food labelling. To achieve the purpose of the study, the method of analysis and synthesis was used, carried out on the basis of data from the literature review, data from the Rapid Alert System for Food and Feed (RASFF) portal and reports of Inspectorate of Agricultural and Food Quality Inspection (IJHARS), legal requirements, guidelines from standards and good management practices.

Keywords:

consumer safety, marketing communication, food quality, food labelling, food production and trade

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Introduction

The changing conditions of the functioning of enterprises on the food market in the 21st century necessitate the use of complex adaptation mechanisms that take into account the evolution of consumers' nutritional needs, increasing market competition, market communication processes, modern methods of communication and the expansion of new information technologies. The continuous process of adjusting the offer to consumers' expectations requires changes in the approach of managers from food companies, as well as organizational and management changes and modification of adopted strategies and creation of new policies. At the same time, the specificity of food production should be taken into account in terms of technical and technological requirements, quality assurance systems, requirements of distribution channels and finally aspects related to economic profitability and consumer acceptance.

Food safety through its impact on human health and life is crucial for public health protection, and thus is one of the pillars of the European food policy. Concern for the safety of the final product should start with the production of the raw material, feed quality, animal welfare, through the production technology and food trade.

Comprehensive management of marketing communication of companies participating in the food chain is becoming an increasingly important issue and challenge in the food industry. Reliable information is perceived by food enterprises as one of the most important elements of the company's strategic management system, being a part of the food quality and safety management system. The regulations make food enterprise responsible for the quality of the information provided and the correct labelling of food products. Infringements related to erroneous, inadequate information can have serious consequences, primarily for the health of the consumer, but also for producers, e.g. in the form of penalties for infringements of the food law. Current legislation provides common definitions, principles, requirements and procedures for food labelling, which significantly reduces the risk of excessive misinformation. Information management in the enterprises is multi-stage and multi-faceted of a holistic nature.

The aim of the work is to review and analyse the current state of knowledge on the holistic approach to food information as an element of marketing communication in the production and trade of food, in particular to food labelling. To achieve the purpose of the study, the method of analysis and synthesis was used, carried out on the basis of data from the literature review, data from the Rapid Alert System for Food and Feed (RASFF) portal and reports of Inspectorate of Agricultural and Food Quality Inspection (IHARS), legal requirements, guidelines from standards and good management practices.

Marketing communication in the food market

Marketing communication, according to Kotler & Keller (2017), defines as “the ways in which companies try to inform and convince consumers and remind them – directly or indirectly – about the products and brands they offer. Currently, marketing communication is one of the most important areas of business activity. It is an essential element of strategic management. Marketing communication is used to achieve the strategic goals of enterprises, but also is based on dialogue and building relations between the entrepreneur and the consumer.

Influencing market participants, in particular current and potential participants of the B2B or B2C market in the food chain, is a very difficult area of management for managers from food industry. Among many tools and instruments of marketing communication, especially in the era of the development of self-service or online forms of food sales, the importance of packaging is growing as an element which is not only fulfilling protective or logistic functions, but above all as a source of information about food products. The basic communication goals of the packaging are: attracting the attention of consumers, increasing the “visibility” of the product, reminding about its existence and, as a result, persuading consumers to make an appropriate purchase decision. Packaging is also a key element in providing the consumer with reliable and understandable food information (Tul-Krzyszczuk, *et al.* 2016; Nestorowicz & Pilarczyk, 2014; Cyrek, 2015; Szymoniuk, 2006).

Proper selection of marketing instruments, in particular reliable communication resulting from concern for the consumer along with the implementation of appropriate conditions and actions, can be a source of organizational growth and achieving a sustainable competitive advantage, as well as it is in line with the optimization of production processes in Economy 4.0. Moreover, food businesses should not only technically comply with the legal requirements for labelling, but also they should assess consumer perception of the information on the packaging.

Food labelling as an aspect of marketing communication – law regulations

Achieving food safety is the food law imperative at global, European Union (EU) and national levels. The basic regulation defining the rules according to which the consumer obtains full and legal information on food is Regulation No. 1169/2011 of the European Parliament and of the Council (EU) of 25 October 2011 on the provision of food information to consumers. The regulation defines the term *food information* as “information concerning a food and made available to the final consumer by means of a label, other accompanying material, or any other means

including modern technology tools or verbal communication". The regulation applies to all market participants, regardless of their place in the food chain, including food delivered to mass caterers and catering services. Detailed rules for food labelling are set out in legislation at EU and national levels. Examples of such regulations are presented in Table 1.

The business entity responsible for providing the food information is the enterprise that places the food on the market under its name or business name. Its duty is to ensure the presence and accuracy of information on food which is placed on the market. Packaged food must be described on the product label. In the case of unpackaged food, the food information needs to be communicated to the food distributor in order to ensure direct access to it for consumers. The labelling of food must not:

- mislead the consumer in terms of the characteristics of the food, its name, type, features and properties, composition, quantity, durability, source, place of origin, preparation or production methods,
- attribute to the food properties that it does not have (this requirement also applies to advertising and presentation, method of setting and the environment in which they are displayed),
- suggest that the food has unique properties if all similar foods have the same characteristics,
- assign the properties of disease prevention or treatment to a food (subject to Article 24(4) and Article 33(4) of the Act of Food and Nutrition Safety).

According to the new requirements, labels must be legible, reliable, clear and easy to understand by the consumer. Mandatory food information must appear directly on the packaging or on a label attached to it, so that the consumer has direct access to the information. The mandatory data requirements for packaged foods are set out in article 9 of Regulation (EU) No. 1169/2011 and include the proper presentation of names, list of ingredients, information on ingredients or substances causing allergies or intolerances used in the production or preparation of food and still present in the finished product (even if their form has changed), amounts of specific ingredients, net weights, dates of minimum durability or shelf life dates, data identifying the entity responsible for communicating the food information. Entrepreneurs can voluntarily extend the scope of the food information they provide, but in such case they have to comply with specific legal requirements. Moreover, the regulation introduces detailed rules for the presentation of food information, as well as defines the minimum font size to be used in presenting information on the product label. Strict labelling requirements for food products are introduced to protect the consumer as the weaker side of the trade market.

Food choices and consumers' nutritional behaviours are increasingly discussed from the point of view of health promotion. They depend on how consumers

Table 1. Global, European Union and national food labelling regulations

Global regulations	Codex Alimentarius, International Food Standards
UE regulations	<ul style="list-style-type: none"> • Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety • Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for on the hygiene of foodstuffs • Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007 • Commission Regulation (EC) No 445/2007 of 23 April 2007 laying down certain detailed rules for the application of Council Regulation (EC) No 2991/94 laying down standards for spreadable fats and of Council Regulation (EEC) No 1898/87 on the protection of designations used in the marketing of milk and milk products • Regulation (EU) 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers • Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives • Commission Implementing Regulation (EU) No 1337/2013 of 13 December 2013 laying down rules for the application of Regulation (EU) No 1169/2011 of the European Parliament and of the Council as regards the indication of the country of origin or place of provenance for fresh, chilled and frozen meat of swine, sheep, goats and poultry
National regulations	<ul style="list-style-type: none"> • Act of 21 December 2000 on the commercial quality of agri-food products • From 13 December 2014, the Act of 7 November 2014 amending the Act on the commercial quality of agri-food products and the Act on food and nutrition safety • Act of August 25, 2006 on food and nutrition safety. • Regulation of the Minister of Agriculture and Rural Development of 23 December 2014 on the labelling of individual types of foodstuffs • Regulation of the Minister of Agriculture and Rural Development of 13 April 2004 on the detailed scope and method of marking certain groups and types of agri-food products with the identification code of a production batch • Regulation of the Minister of Agriculture and Rural Development of 3 October 2003 on detailed requirements for the commercial quality of honey • Regulation of the Minister of Agriculture and Rural Development of 30 September 2003 on detailed requirements for the commercial quality of fruit juices and nectars • Regulation of the Minister of Agriculture and Rural Development of 29 July 2003 on detailed requirements for the commercial quality of jams, preserves, jellies, marmalades, plum jam and sweetened chestnut puree • Regulation of the Minister of Agriculture and Rural Development of 4 November 2019 on graphic symbols that are used to label food and feed as free from genetically modified organisms • Regulation of the Minister of Agriculture and Rural Development on the pattern of a graphic symbol containing the information “Polish product” of 16 December 2016

perceive and understand health and nutrition claims. Hence, they need to be regulated to avoid the use of unjustified and potentially misleading information and to improve the choice of “healthy food”. Food labelling with nutritional and health claims is described in Regulation (EC) No. 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods. Health and nutrition claims are used to inform consumers about the composition of food products (e.g. “low salt content”) and hidden health benefits (e.g. “suitable for a heart-healthy diet”) (Bryła, 2020). Taking into account the above aspects regarding food safety and quality, the priority for the quality of food enriched with health-promoting ingredients is the proper maintenance of the declared and communicated characteristics and properties of food by both the producer and the consumer at the assumed level throughout the entire life cycle of the product.

Food labelling as an element of marketing communication – perception by entrepreneurs

The entry into force of Regulation (EU) No. 1169/2011 forced the changes in solutions previously applied in marketing communication on the food market. Food companies have had three years since its publication to adapt to the new rules with the exception of the implementation of the nutritional information, which applies from 13th December 2016. According to the data from official food safety controls, the application of legal regulations in this area is still a challenge for food companies. Sometimes it is an unintended activity of entrepreneurs resulting from the misinterpretation of legal regulations but it may also be a deliberate food fraud.

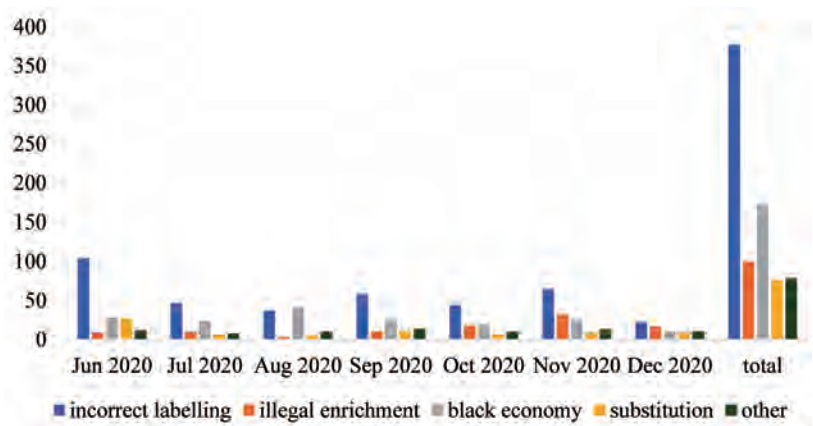


Figure 1. Food products frauds in the second half of 2020 registered in the RASFF system

Source: own study based on RASFF Portal.

According to RASFF reports, in the European Union in the second half of 2020 reports of counterfeit products with “incorrect labelling” dominated. In that period they accounted for 46.9% of all notifications (Figure 1).

In Poland the entity responsible for activities in the field of supervision over the commercial quality of agri-food products and control of the commercial quality of agri-food products in foreign trade is the Inspectorate of Agricultural and Food Quality Inspection (IJHARS). In 2016-2020, as a result of scheduled inspections of a batch of agri-food products, IJHARS determined the level of labelling irregularities from 20.3% (in 2019) to 25.1% (in 2017), in relation to all irregularities (Table 2).

Table 2. Share of irregularities in the labelling of batches of agri-food products inspected by IJHARS in 2016-2020

Year	Share of irregularities (%)	Change (%, previous year = 100)
2020	21.9	107
2019	20.3	84
2018	24.1	96
2017	25.1	117
2016	21.3	–

Source: own study based on IJHARS 2020, 2019, 2018, 2017.

The share of labelling irregularities in 2020, according to the stage of inspections, determined by IJHARS, was as follows: manufacturers – 21.8%, retail stores – 19.4%, catering outlets – 65.0%. The most frequent irregularities were related to the labelling of following product groups: wine (54.0%), ready-to-cook food (47.9%), dishes for children (46.6%), fish products (25.8%) and meat products (24.7%). The most common irregularities are presented in Table 3.

The name of the food is essential information that enables consumers to make conscious purchasing decisions. The name should reflect the nature of the product so that the consumer can easily see what the product is and compare it with similar products from other manufacturers. For some types of products, food regulations (national or EU) explicitly provide specific definitions. For most foodstuffs, however, such legal names are not provided and the producer has to deal with it on his own. The results of the judgments of the Supreme Administrative Court clearly show how important is the correct name of a food that corresponds to the facts and reflects the nature of the product.

After “ingredients”, the ingredients used in the production are listed according to the recipe in the order from the ingredient with the highest mass to the ingredient

Table 3. Selected irregularities in the labelling of batches of agri-food products inspected by IJHARS in 2020

Product group	Details of the irregularity
Wine	<ul style="list-style-type: none"> • no indication of the place of production • no indication of the product category and storage conditions • no information on the bottler • no indication or incorrect use of terms referring to areas geographically prohibited for wines
Ready-to-cook food	<ul style="list-style-type: none"> • incorrect product names (e.g. only fancy names used) • no information on the method of preservation used • not all raw materials used (including allergens) are listed in the ingredients list • irregularities in the ingredients list by not maintaining descending order • the use of misleading terms such as “old Polish cuisine”, “homemade” • the use of misleading terms such as “without the addition of...” e.g. preservatives • incorrect indication of information about the content of the ingredients highlighted in the labelling
Dishes for children	<ul style="list-style-type: none"> • no information on the thermal treatment applied • the use of misleading terms such as “does not contain preservatives and dyes”
Fish products	<ul style="list-style-type: none"> • smaller share of fish meat than declared on the product label • inaccuracies in the provision of the nutrition declaration
Meat products	<ul style="list-style-type: none"> • undeclared ingredients (raw meat, phosphates, starch) in ingredients list • inaccuracies in the provision of the nutrition declaration

Source: own study based on IJHARS 2020, 2019, 2018, 2017.

with the lowest mass. By bolding or underlining or other distinguishing way, the allergenic components (or the allergenic source from which the component is derived) are indicated in the list. Proper information about allergens occurring in foodstuffs is extremely important for the life and health of consumers, therefore the source of information for consumers about the presence of allergens in food is the appropriate labelling of the product. The mandatory allergen declaration applies only to ingredients that are intentionally included in a food product. Currently, the list of required declarations of the presence of substances or products causing allergies or intolerances includes 14 products (Annex II in Regulation (EU) No. 1169/2011 of the European Parliament and of the Council). Regulation (EU) No. 1169/2011 also requires food producers to inform about allergens present in packaged and unpackaged products (sold loose or served in restaurants or cafes). Unfortunately, the food law does not contain precise requirements regarding the presentation of information about the so-called hidden allergens contained in products that could potentially get in food products by cross-contamination. Moreover, the legislation does not define what amount of an allergenic substance

is to be considered a “trace amount”. Producers, who have been shifted the responsibility for reliable information to consumers about products, expect the legal regulations to specify the minimum amount of allergens in a product with which the product can be considered as allergen-free. Taking into account the increasing number of people with allergies or intolerance reactions to various food ingredients, as well as the possibility of causing an allergic reaction at a very low concentration of the allergen, food producers, out of concern for the welfare of consumers, more and more often decide to label food products with the words “may contain...” or “possible presence of...” (specifying the names of hidden allergens in accordance with Regulation (EU) No. 1169/2011). However, such terms should not be overused and applied by manufacturers to all finished products in order not to mislead consumers.

On the packaging, as information for the consumer indicating the durability of the product, the date must be given with the preceding phrase: „use by: day, month, year”, „best before: day, month, year” or „best before the end: month, year / only year”, depending on perishable products the consumption of which after a specified date may cause health problems, products whose shelf life in terms of their best quality does not exceed 3 months, or products whose shelf life in terms of their best quality exceeds 3 months and does not exceed 18 months. After the date indicated with the term „use by”, the food is considered unsafe for the health of the consumer in accordance with Art. 14 sections 2-5 of Regulation (EC) No 178/2002. The results of the study carried out by Ankiel and Samotyja in 2019 among food manufacturers (or companies introducing food products to the market) show that, according to the surveyed companies, the existing food labelling system in terms of its shelf life is too complicated. The individual consumer is faced with the dispersion of information, which may result in fear of consuming an expired product and ultimately wasting food. The surveyed companies indicate that in order to avoid the dispersion of information, a broad social educational campaign should be carried out, which should include both media activities, educational programs for students, as well as communication at the points of sale of products. The transparency and clarity of the labelling system can increase the understanding of the information provided on food labels and reduce the scale of food waste (Ankiel & Samotyja, 2019).

Consumers who want to choose products with appropriate nutritional quality increasingly look for information about the nutritional value of food on the labels. The declaration in labelling is (with some exceptions) the responsibility of the manufacturers. In addition to the obligatory elements, producers also have the option of indicating voluntary elements in the nutritional value, however, they are also subject to certain rules. The nutrient content declared in the labelling should be as close as possible to the actual ones, and the permissible deviations have been strictly defined and are subject to control by official food control authorities.

That is why it is so important that the nutritional value of products is not only correctly declared, but also determined in a correct and appropriate way.

Introducing foodstuffs to the market is associated with administrative and criminal liability (i.e. before official food control authorities and other state authorities) and civil liability (i.e. in relation to a consumer or business partner). Non-compliance with the regulations of food law in the field of labelling may have various legal qualifications – failures may be considered as improper commercial quality or adulteration. Depending on a given qualification various sanctions may occur – fines (from PLN 500 up to 10% of the income obtained in the previous year) or various supervisory measures (e.g. prohibition on the placing on the market). The amount of fines and the type of sanctions also depend on a given control inspection. It differs if the controlling body is the National Sanitary Inspectorate or when the procedure is carried out by the Inspectorate of Agricultural and Food Quality Inspection. Production losses related to product withdrawals from the market due to mislabelling are the least of the consequences for most food producers. Exposing consumers to a threat, loss of their trust, loss of image among consumers, undermining the reputation among business partners on the international or national arena, canceling business contracts, criminal liability are main risks of the food producers' environment.

Food labelling as an element of marketing communication – perception by consumers

Nowadays, consumers have access to a wide range of food products and purchase based on their knowledge about food, lifestyle, as well as financial factors. Information obtained through the media about food-related threats is also important.

Information about food is the means of communication between food companies and consumers. It is an important factor in consumers' purchasing decisions and in ensuring safety and providing consumers with reliable nutritional information. According to Petrovici, Fearne & Nayga (2012), health-related factors such as nutritional knowledge, situational factors, attitudes and behavioural factors are aspects that influence the use of information and nutrition claims. The research results presented by Kowalska (2018) indicate that some consumers do not realise the importance of individual information placed on the packaging of food products. Data analysis showed that consumers often buy products after reading the so-called marketing information that is only to assure the consumer about the high quality of the product (e.g. regarding the implementation of the HACCP system, which is an obligatory system in each entity in the food chain, or the non-obligatory ISO 22000 system). The results of the study showed also that

consumers do not read the basic information that is the source of knowledge about a given product: list of ingredients, shelf life.

The results of study presented by Moreira, *et al.* (2019) showed that consumers typically do not read food labels due to a lack of time and overload of information, and emphasise the need for public health entities to run information campaigns to show the importance and benefits of reading food labels. In addition, it has been observed that specific groups of consumers are more likely to analyse food labels, e.g. athletes, consumers with health problems, consumers who care about a healthy lifestyle. These groups of consumers also indicate the need to develop the necessary information that should be clearly visible and understood by consumers.

Bandara, *et al.* (2016) conducted a survey on the impact of information on food labels on consumer purchasing decisions. The results of the survey showed that some of the respondents tended to check the labels when making a purchase decision to assess the suitability of a food product for vegetarians, for religious reasons, to avoid food-related diseases or to check whether the food is organically grown or not. Complicated lifestyles, brand loyalty, and the intricate form of food labels were the main reasons why food labels were not verified. Promising answers of respondents on the existence of food labels were knowledge of shelf-life date, knowledge of the nutritional composition and the legal requirement.

Conclusions

Marketing communication is a form of social communication that should be considered from the perspective of the process of building relationships between food producers or distributors and consumers. Labelling has become a very important channel of communication with consumers, as it is an integral part of the product and consumer's perception of its quality. Labelling is an element of ensuring the safety of the food product. The purpose of labelling is to provide the consumer with reliable information about the characteristics and properties of a food product in a clear, precise and understandable way. The development of food information requires a holistic approach in enterprises involving many departments, including R&D, production, quality and marketing. It should be noted that enterprises operate in a competitive, social, economic and political environment. In order to operate efficiently, it is necessary to harmonise with its environment and adapt to internal and external conditions. Large enterprises are supported by law firms specialising in food law, while for smaller enterprises (including: gastronomy, mass catering) it becomes a challenge.

A holistic approach to providing food information can contribute to many positive effects such as consumer safety, added value for consumers and food companies, reduced costs by reducing errors, improving processes and products, and increasing productivity.

References

Act of 21 December 2000 on the commercial quality of agri-food products.

Act of August 25, 2006 on food and nutrition safety.

Ankiel, M., Samotyja, U. (2019). Ocena systemu znakowania terminami trwałości w opinii producentów żywności. *Current Trends in Quality Science Product Management – Quality, Safety and Environmental Focus*, 16–26.

Bryła, P. (2020). *Oświadczenia zdrowotne i żywieniowe na rynku produktów żywnościowych*. Łódź: Wydawnictwo Uniwersytetu Łódzkiego.

Bandara, B.E.S, De Silva, D.A.M., Maduwanthi, B.C.H., Warunasinghe, W.A.A.I. (2016). Impact of food labeling information on consumer purchasing decision: with special reference to faculty of Agricultural Sciences. *Procedia Food Science*, 6, 309–313.

Codex Alimentarius, International Food Standards. (2008), CXS 118-1979. Codex for foods for special dietary use for persons intolerant to gluten. Rome: FAO/WHO Codex Alimentarius Commission.

Commission Implementing Regulation (EU) No 1337/2013 of 13 December 2013 laying down rules for the application of Regulation (EU) No 1169/2011 of the European Parliament and of the Council as regards the indication of the country of origin or place of provenance for fresh, chilled and frozen meat of swine, sheep, goats and poultry.

Commission Regulation (EC) No 445/2007 of 23 April 2007 laying down certain detailed rules for the application of Council Regulation (EC) No 2991/94 laying down standards for spreadable fats and of Council Regulation (EEC) No 1898/87 on the protection of designations used in the marketing of milk and milk products.

Cyrek, P. (2015). Opakowanie jako źródło informacji o produktach żywnościowych, *Zeszyty Naukowe Uniwersytet Szczecińskiego. Problemy zarządzania, finansów i marketingu*, 866, 9–21.

Inspectorate of Agricultural and Food Quality Inspection, <https://www.gov.pl/web/ijhars/sprawozdanie-roczne> [access: 12th July 2021].

Kowalska, A. (2018). Wiedza konsumentów na temat bezpieczeństwa żywności i stosowane przez nich sposoby ograniczania ryzyka zagrożenia. *Handel Wewnętrzny*, 2(373), 246–260.

Kotler, P., Keller, K.L. (2017). *Marketing*. Poznań: Rebis.

Moreira, M.J., Díez, J.G., de Almeida, J.M.M.M., Saraiva, C. (2019). Evaluation of food labelling usefulness for consumers. *International Journal of Consumer Studies*, 327–334.

Nestorowicz, R., Pilarczyk, B. (2014). Wyzwania wobec komunikacji marketingowej na rynku żywności ekologicznej w Polsce – w świetle badań konsumentów. *Marketing i Rynek*, 8, 583–589.

Petrovici D., Fearne, A., Nayga R.M. (2012). Nutritional knowledge, nutritional labels, and health claims on food: A study of supermarket shoppers in the South East of England. *British Food Journal*, 114, 768–783.

RASFF Portal, <https://ec.europa.eu/food/safety/rasff> [access: 12th July 2021].

Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety.

Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for on the hygiene of foodstuffs.

Regulation (EU) No 1308/2013 of the European Parliament and of the Council of 17 December 2013 establishing a common organisation of the markets in agricultural products and repealing Council Regulations (EEC) No 922/72, (EEC) No 234/79, (EC) No 1037/2001 and (EC) No 1234/2007.

Regulation (EU) No 1169/2011 of the European Parliament and of the Council of 25 October 2011 on the provision of food information to consumers.

Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives.

Regulation of the Minister of Agriculture and Rural Development of 23 December 2014 on the labelling of individual types of foodstuffs.

Regulation of the Minister of Agriculture and Rural Development of 13 April 2004 on the detailed scope and method of marking certain groups and types of agri-food products with the identification code of a production batch.

Regulation of the Minister of Agriculture and Rural Development of 3 October 2003 on detailed requirements for the commercial quality of honey.

Regulation of the Minister of Agriculture and Rural Development of 30 September 2003 on detailed requirements for the commercial quality of fruit juices and nectars.

Regulation of the Minister of Agriculture and Rural Development of 29 July 2003 on detailed requirements for the commercial quality of jams, preserves, jellies, marmalades, plum jam and sweetened chestnut puree.

Regulation of the Minister of Agriculture and Rural Development of 4 November 2019 on graphic symbols that are used to label food and feed as free from genetically modified organisms.

Regulation of the Minister of Agriculture and Rural Development on the pattern of a graphic symbol containing the information "Polish product" of 16 December 2016.

Szymoniuł, B. (red.) (2006). *Komunikacja marketingowa – instrumenty i metody*. Warszawa: PWE Polskie Wydawnictwo Ekonomiczne.

Tul-Krzyszczuk, A., Świątkowska, M., Jeznach, M., Przybyła A. (2016). Nowe sposoby komunikacji marketingowej w handlu detalicznym żywnością. *Studia i Prace WNEiZ US*, 43, 337–346.

WASTE SEGREGATION IN POLISH HOUSEHOLDS

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Abstract

Waste management covers a wide range of activities, from its generation to final utilization or landfill. In Poland, according to EU regulations, there are the law regulations considering waste segregation among residents as the main method of waste management and efficient way to reduction the amount of municipal waste landfill. Poland is obligated to achieve obligatory levels of recovery selected materials from waste. However, to make segregation process economic and environmental efficient, it must be easy and understandable to “waste producer” – consumer.

The purpose of the article is to present and analyze the results of research on the segregation of packaging waste by Polish consumers and to indicate the possibilities of more rational waste management at level of households including an environmental education of citizens. The research tool was a questionnaire survey and an in-depth questionnaire survey, which aimed to identify potential possibilities for improving the waste segregation system. The results of the survey show that over 84% of respondents declare waste segregation but more than half of them do not avoid mistakes during assigning waste to the appropriate container. The greatest number of errors concerning the segregation of packaging waste is due to identify the main material of packaging waste.

Keywords: waste segregation, waste management

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Introduction

Directive 2008/98/EC, which is in force in the Member States of the European Union and which is one of the key legal acts in the field of waste management, aims at reducing the generation of waste and using waste as a resource. Therefore waste should be selectively collected “at source”, i.e. at the consumer’s households, offices, schools (www.eur-lex.europa.eu/).

From of January 1, 2021, Polish households are obliged to selectively segregation waste, which contributes to saving energy, raw materials and the environment (Journal of Laws 2019, item 1579). Segregation is the key to solid waste management, especially when the continuous growth of consumerism creates more and more waste of different origin, especially packaging waste. In addition, the Regulation of the Minister of Environment of 29 December 2016 (Journal of Laws 2019, item 2028), sets out detailed rules for selective waste collection and the conditions for fulfilling this obligation. Five fractions of waste are collected in specially marked containers or bags of a specific color (Table 1).

Table 1. Waste types by fractions

Faction	Colour of container/ bag	Inscription on the container	Description of the fraction
Paper	Blue paper	Paper	paper waste including cardboard, paperboard packaging waste and cardboard packaging waste
Clear glass	White clear glass	White glass	clear glass
Coloured glass	Green coloured glass	Coloured glass	colored glass marked green with the inscription
Plastics and metals	Yellow metals and plastic	Metals and plastic	plastic waste, including plastic packaging waste, multi- material packaging waste and metals.
Biodegradable materials	Brown bio	Bio	biodegradable waste with particular emphasis on bio-waste

Source: Journal of Laws 2019, item 2028.

The mixed waste bin is to collect all waste that does not belong to the categories described above and does not include bulky waste, hazardous waste, electrical waste or construction waste. The color of the container for mixed waste is determined by the municipality – usually brown, black or gray.

Selective waste collection in Poland AD. 2019

Data from the Statistics Poland shows that in 2019, 4 million tons of waste were collected selectively, which is 31% of all waste generated. Compared to 2018, there has been an increase of 10% (Statistics Poland 2020). Undoubtedly, this increase is due to mandatory waste segregation (Figure 1).

In 2019, there was about 104 kg of generated waste per capita in Poland (115 kg per urban resident and 86 kg per rural resident). The structure of selectively collected waste has been changing over the years. In 2005, when only 3% of total waste was selectively collected, the dominant fractions were paper and cardboard and plastics accounting for 80% of selectively collected waste (Generowicz, 2017).

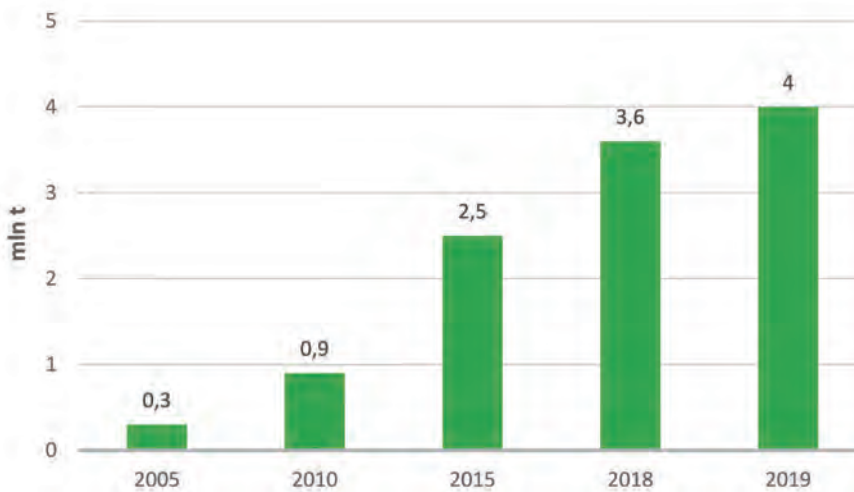


Figure 1. Selective collection of municipal waste in Poland

Source: Environmental Protection 2020 (Statistics Poland).

In recent years, biodegradable waste has been the most numerous fraction Table 2 shows the structure of selectively collected waste in households in 2018 and 2019. In 2019, only two municipalities in Poland achieved more than 90% of selective waste collection. A serious problem is the correct identification and segregation of waste, in particular paper, plastic and multi-material packaging waste (Krempa, *et al.* 2018).

According to the Act on Packaging and Packaging Waste Management, an entrepreneur introducing packaged products, producing packaging or importing packaging may voluntarily place on packaging markings indicating at least:

- the type of material from which the packaging is made,
- the reusability of the packaging (for reusable packaging),
- the recyclability of the packaging (for recyclable packaging).

Table 2. Structure of selectively collected waste in 2018 and 2019 (kg per capita)

Fraction	2018	2019
Paper	9	7
Glas	15	13
Plastics and metals	10	9
Bio	31	26
Bulky waste	16	14
Mixed	13	15

Source: Environmental Protection 2020 (Statistics Poland).

The label should be placed directly on the package or on a label affixed to it. In the case of smaller packaging, it is possible to attach such information on the leaflet. Moreover, the marking of materials should be visible, understandable and permanent (Journal of Laws 2021, item 888). In reference to the Act, the Minister of the Environment issued a Regulation on packaging labeling patterns. The information on the type of material from which the packaging was produced is most often in the form of a graphic sign. Most often it is a triangle, made up of arrow-shaped arms (stylized Mobius strip) with a digit in the middle. In turn, each digit indicates a different type of material (Journal of Laws 2014, item 1298). Table 3 contains examples of symbols and markings, found on packaging.

However, it should be emphasized that the addition of marks on the packaging of products in the Member States of the European Union is not mandatory, because it would constitute a barrier to the free movement of goods. Therefore, it is up to the entrepreneur's decision to use this type of labeling (Czarnecka-Komorowska & Wiszumirska, 2020).

Another problem is the robustness of the segregation process performed at the segregation site. One of the tools to control and discipline waste generators are waste identification systems. Several municipalities in Poland have introduced a pilot "system for the identification of municipal waste by barcodes in single-family dwellings" (<https://www.money.pl/>). Each bag of waste will be marked with a barcode individual for each household. In case of wrong waste selection, the company responsible for waste collection will be able to easily identify the "waste producer".

Table 3. Selected packaging label design

Name	Abbreviation	Graphic symbol
Polyethylene terephthalate	01-PET	A triangular recycling symbol with the number 01 in the center and the text PET below it.
High density polyethylene	02-HDPE	A triangular recycling symbol with the number 02 in the center and the text HDPE below it.
Low density polyethylene	04-LDPE	A triangular recycling symbol with the number 04 in the center and the text LDPE below it.
Polypropylene	05-PP	A triangular recycling symbol with the number 05 in the center and the text PP below it.
Paper	20-PAP	A triangular recycling symbol with the number 20 in the center and the text PAP below it.
Aluminium	41-ALU	A circular recycling symbol with the text alu inside.
Clear glass	70-GL	A triangular recycling symbol with the number 70 in the center and the text GL below it.
Multi-material packaging: paper and cardboard/aluminium	82-C/x	A triangular recycling symbol with the number 82 in the center and the text C/x below it.

Purpose and methodology of the study

The weakest side of selective waste collection is lack of consumer knowledge concerning correct selection of particular groups or particular wastes. The aim of this paper is to present and analyze the results of research on packaging waste segregation by consumers and to indicate the possibilities of more rational waste management in Poland in terms of environmental education of citizens. The research procedure was divided into two stages. The first was a questionnaire survey using an online survey questionnaire on a group of 600 people. The survey was performed in March and April 2021. Table 4 provides detailed information about the people who participated in the survey. In the second stage, an individual in-depth study was conducted using the zoom platform, in the form of a mini depth interview with 30 participants of the first stage of the study. This stage helped to rank the factors influencing the correct segregation of waste by consumers and to identify opportunities to increase the efficiency of the selective waste collection system.

Table 4. Sample structure of the questionnaire survey

Variable	Feature	Number of answers	Percentage
Gender	women	333	56
	men	267	45
Age	18–24	69	12
	25–34	113	19
	35–44	103	17
	45–55	105	18
	54–65	100	17
	over 65	110	18
Education	basic	100	17
	vocational/technical	116	19
	secondary	179	30
	higher	205	34
Place of leavin	village	239	40
	city	361	60
Number of persons in the household	1	142	24
	2	201	34
	3	101	17
	4	99	17
	5 and more	57	10
Waste collection fee per month (per person) {PLN}	les than 20	19	3
	21–25	81	14
	26–30	249	42
	31–35	171	29
	more than 35	14	2
	I don't know	66	11

Source: own survey.

Results

The survey indicated that just over a one-third of respondents (35%), evaluates the current waste management system positively. The vast majority rated it poorly or very poorly – 55% of respondents. Of those surveyed, respondents over the age of 55 were the most critical.

From the beginning of 2021, Polish citizens are obliged to selectively collect waste. According to the survey, 16% of respondents claim that they do not segregate waste. Most of them were over 55 years old, living in multi-family buildings or in villages. In turn, the main reasons for not segregating waste included:

- lack of space at home for waste separation (51%),
- lack of containers for segregation (21%),
- doubts about the effectiveness of the waste segregation system (12%),
- too low level of penalties for lack of segregation (5%).

Then respondents were asked about 21 wastes that were found difficult to allocate to the appropriate bin. The selection of suitable ones was based on a press article related to the segregation of “difficult” waste (www.wyborcza.pl). The results of the questionnaire survey indicated that a half (48%) of the respondents were able to allocate all waste to the proper container correctly. There is a greater problem with allocation for men (39% correct indications) than for women (57% correct indications). Moreover, people with higher education are better at choosing the right container than people with vocational or primary education. Figure 2 shows the percentage of correctly allocated waste to each bin.

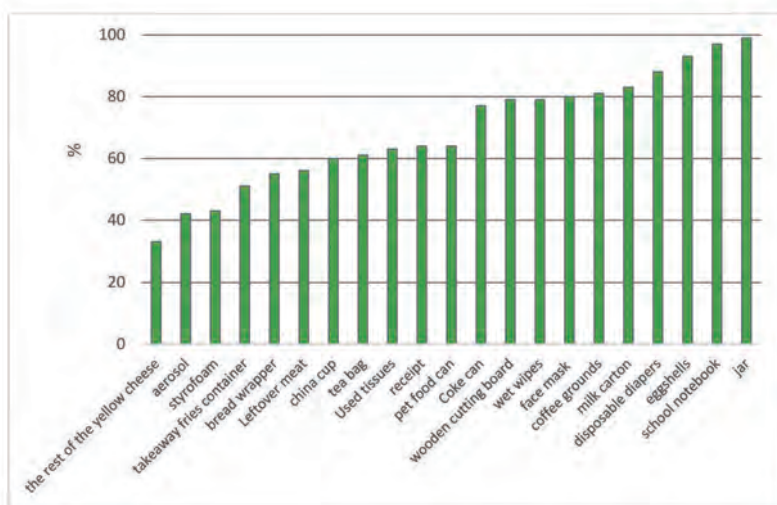


Figure 2. Percentage of correct consumer responses

Source: own survey.

The majority of respondents identified correctly the container for: a jar, a school notebook and eggshells. In contrast, the largest problem arose when asked about yellow cheese and aerosol deodorant. Almost 60% of the respondents would dispose of the leftover yellow heart in the bio-waste bin. In the case of aerosol, on the other hand, the majority of respondents indicated the mixed waste container (56%) as the one where the waste should go. The next waste analyzed is polystyrene packaging, which is considered by 50% of the respondents as a waste that should be placed in the mixed waste bin. Among the answers there were often mistakes concerning soiled waste. For example, a clean (not greasy) packet of French fries from a popular fast food chain or a new, not yet used hygienic tissue can go in the blue bag with paper waste. If, on the other hand, there is any contamination on the packaging, then it should be disposed of in the mixed waste bin. Another problematic waste is the cash register receipt, which should be placed in the mixed waste container, but 30% of the respondents declare that they put it into blue bag. The respondents also made mistakes when it comes to allocating metal packaging. This type of packaging should be placed in the yellow bag, however it is often placed in the container for mixed waste.

In the next question, the respondents were asked to state whether they look for information on this issue when they are not sure about the classification of waste to a given fraction. 63% of the respondents said they did not look for such information. 57% of respondents found the information on a leaflet, 33% on the Internet, and 10% on segregation bins.

Respondents were also asked if they had encountered signage on packaging while shopping that might make it easier to choose the right waste container. 13% of the respondents have seen such marking. However, when asked whether such markings are necessary and will make waste segregation more effective, 94% of the respondents answered in the affirmative.

The growing conviction of citizens to segregate waste, which is correlated with increasing efficiency of the process, from the consumer side is determined by many factors.

Using an individual in-depth study, the most important factors for making the decision to separate waste and their hierarchy were defined. Figure 3 summarizes the most important factors in the decision-making process.

In the main survey, the respondents were asked to rate the importance of the given factors on a point scale from 0 to 10, where 0 meant no influence of the factor and 10 for a very important factor. Based on the scores given by the survey participants, it was possible to rank the factors and indicate the most and least crucial ones.

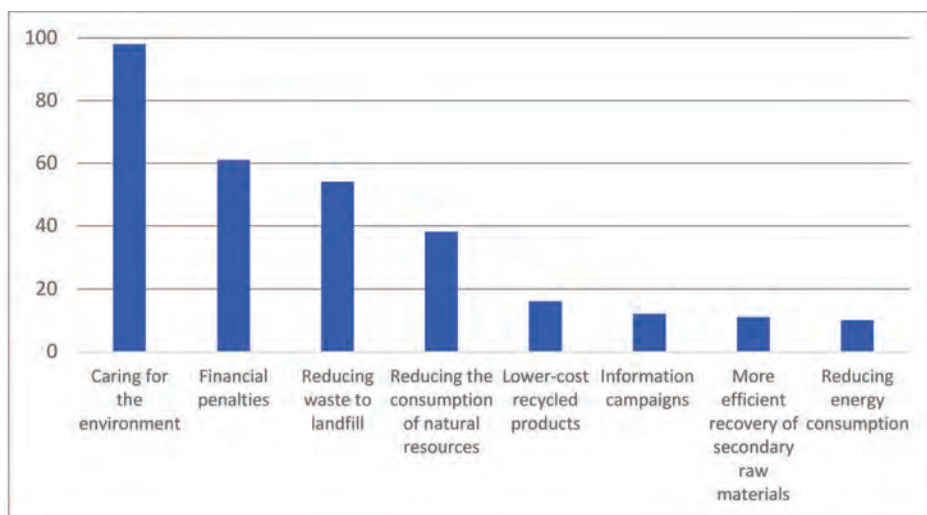


Figure 3. Point scores for factors that influence the decision to separate waste

Source: own survey.

Waste segregation is still a relevant problem for the selective waste collection system. The awareness and knowledge of the surveyed group of waste segregators is at high level, which is confirmed by the fact that the decision to segregate was definitely more influenced by environmental concerns than by financial factors. However, actions should be undertaken in order to make the society aware of the benefits resulting from waste segregation and recycling because, as can be seen from the analysis, the lowest indicators were given by the answers: more effective recovery of secondary raw materials, reduction of energy consumption and information campaigns.

Conclusion

The selective collection of municipal waste is undoubtedly the first integral element of a comprehensive waste management system. Without the development of a separate collection system, no further stages of waste management, i.e. recycling and processing, would be possible. It's proper solution often constitutes the key and first step of the whole system, and If it is neglected there wouldn't be possibility of subsequent stages. The results of the presented research show that the issue of proper segregation of municipal waste at the it's source has not been fully solved yet. The system's weak point remains proper waste segregation, which fundamentally affects it's effectiveness. Difficulties with correct identification and classification of individual wastes not only make it difficult for consumers

to choose, but also discourage them from conscientious segregation. Taking into account environmental concerns as the main motivation for waste segregation, it is necessary to intensify information campaigns and to make waste segregation rules more transparent. This task is assigned within the competence of both state and local authorities as well as packaging and product manufacturers.

References

Czarnecka-Komorowska, D., Wiszumirska K. (2020). Sustainable design of plastic packaging in circular economy, *Polimery*, T. 65, no. 1.

Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, <https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=celex:32008L0098>.

Generowicz, A., Iwanejko, R. (2017). Possibilities of conducting selective collection of municipal waste with partially uncertain market situation-technical basis and possibilities of segregation solutions. *Journal of Civil Engineering and Architecture*.

Journal of Laws 2014, item 1298, Regulation of the Minister of Environment of 9 December 2014 on specimen of packaging labeling, <http://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20140001298>.

Journal of Laws 2016, item 2028, Regulation of the Minister of Environment of 29 December 2016 of the detailed method of selective collection of selected waste fractions), <https://sip.lex.pl/akty-prawne/dzu-dziennik-ustaw/szczegolowy-sposob-selektywnego-zbierania-wybranych-frakcji-odpadow-18555891>.

Journal of Laws 2019, item 1579, Regulation of the Minister of Environment of 19 July 2019 amending the Act on Maintaining Cleanliness and Order in Municipalities and certain other acts, <https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20190001579>.

Journal of Laws 2021, item 888, Regulation of the Minister of Environment of 15 April 2021 on the announcement of the consolidated text of the Act on Maintaining Cleanliness and Order in Municipalities, <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20210000888/U/D20210888Lj.pdf>.

Krempa, M., Miazga, N., Garczyńska, M. Pączka, G. (2018). Waste management and biodiversity. *Polish Journal for Sustainable Development*, t. 22, cz. 1.

Ordinance of the Minister of Internal Affairs and Administration of 4 August 2020 amending the ordinance on offences for which municipal guards are authorised to impose fines by way of a penalty ticket, <https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=WDU20200001420>.

<https://www.money.pl/gospodarka/uczciwi-placa-za-sasiadow-kody-kreskowe-na-workach-moga-rozwiazac-problem-6596389211691904a.html>.

CONSUMER ATTITUDES AND IMPORTANCE OF PRODUCT DESIGN DURING SHOPPING FOR SELECTED NON-FOOD PRODUCTS CONSUMER STYLES BY DESIGN

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Abstract

Glass products are an everyday part of consumers' lives. There is evidence about the influence of the "container" on the perception of the drink, but influence of consumer decision making based on design is surveyed just by few authors. The aim of our research was to identify the importance of design of wine glasses in consumer decision-making and to specify consumer segments according to perception of design. Consumer survey using structured on-line questionnaire on social networks was applied. We surveyed 389 respondents living in Slovakia. Cluster analysis was used to create consumer segments reflecting the importance of design. Five consumer styles were identified, (1) design enthusiast, (2) thrifty design fan, (3) prudent consumer, (4) economical consumer, and (5) passive consumer. The largest consumer segment (51.2%) are design enthusiasts, who find product design very important and are willing to pay extra for a product they like. The results of the survey unhide consumer values and life-styles which allow proper customizing the offer, and easier targeting. The limitation of the research is the structure of the sample composed mainly of young people due to the data collection on social networks.

Keywords:

wine glasses, consumer decision-making, design, segmentation, consumer styles

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Introduction

The glass industry in Slovakia has a rich history and strong tradition which dates back to the 14th century. At present, the glass industry in Slovakia is mainly export-oriented, depending on foreign markets, especially Germany, France and the USA (Brezina & Donovalová, 2020). Thanks to their properties, glass products have become an everyday part of consumers' lives. Consumers choose from a wide range of products, which can take different forms and designs, including different volumes and shapes. For this reason, the design of glass products should become an integral part of marketing, which requires careful consideration in order to enhance sales (Stead, *et al.* 2014).

History of the glass industry

Glassmaking was the typical Slovak craft developed in mountain forest area with the sufficiency of wood and water – the most essential location factors of glassmaking. Because of mountainous character of the country, glassmaking was relatively equally deployed in different regions of Slovakia (Madziková, *et al.* 2015). The oldest written reports about glassworks in Slovakia are from 1350 from Sklené Teplice. From the 14th to the 20th century, more than 70 glassworks operated in Slovak territory. The development of glassmaking was conditioned by favorable natural environment and abundance of raw materials, such as water resources, beech wood, and quartz sand and the growing needs of the nobility, urban and later also the needs of rural population.

After 1918, there was a great decline in glassmaking, as well as the demise of major glassworks. The Slovak glassworks were not able to compete with the Czech ones, which were more technically advanced with developed transport system. Growth was recorded in glassworks focused on the luxury hollow glass, especially cut glass (Lednické Rovne, Katarínska Huta). During the Second World War, most of the glassworks got into a difficult situation. In 1948, the glassworks were nationalized, and administered in the joint companies. After 1989, the glass companies were privatized by domestic investors, (such as Rona Lednické Rovne, Slovglass Poltár), several ceased to exist. After the year 2000, foreign investments entered into the glass industry in Slovakia.

In 2001, Skloplast Trnava was bought by the American company Johns Manville, producing glass fibers mainly for automotive and construction industries. In 2002, the Swiss company Vetropack Holding took over the company Skloobal Nemšová and to this day it is the only manufacturer of glass containers for the food industry in Slovakia. In 2001, new glass plant RF, in Malacky was built, now part of Sisecam Automotive, focusing on car windows. These companies, together with RONA,

Lednické Rovne focusing on utility glass for hospitality sector and for domestic use, and Medical Glass Bratislava (formerly Technical Glass) producing glass packaging for the pharmaceutical industry, are the most important glass industry companies in Slovakia.

Impact of glass design on consumer behaviour

The design of glass products can influence consumer behavior when buying but also when using a particular product. Many authors deal with the influence of the glass design on consumer behavior. Zupan *et al.* (2017) state that due to the possible influence of glasses on the behavior and drinking of alcoholic beverages, design is a means of reducing the consumption of alcoholic beverages. There is ample evidence about the influence of the “container” on the perception of the drink, taste, aroma and quantity of the drink (Spence & Van Doorn, 2017; Spence & Wan, 2015). Beverages may taste different depending on the shape of the glass, for example wine may taste more fruity and intense when served in a curved container compared to a flat glass (Mirabito, *et al.* 2017). Clicerì (2018) found that satisfaction with the amount of beverage consumed is higher when served in a high narrow glass than when served in a short and wide glass. In his study, Cliff (2001) examined the perception of aroma intensity influenced by the type of the glass used. Wine glasses with a large glass diameter (opening the glass) cause a more intense aroma. This suggests that it is possible to choose a glass to maximize the perception of aroma.

We can state that the design of cups, specifically the shape of the cup, is an important element that influences consumer behavior. The effect is manifested especially in use, when it can affect the aroma and the taste of the drink, or the amount of drink consumed.

Methodology

The aim of our research is to identify the importance of design of wine glasses in consumer decision-making and to specify consumer segments according to perception of design. To achieve the goal, we used primary data obtained from the survey by means of the on-line questionnaire. The final sample consisted of 389 respondents living in Slovakia, who responded to the questionnaire.

We used cluster analysis in the PSPP program to create consumer profiles. We used K-Means cluster analysis, which creates clusters based on similarity averages. We have also assigned names to the segments.

The segments were created based on an evaluation of the factor glass design, based on the importance of the design and the willingness to pay extra for the product that the respondents like. Five consumer profiles were created (Table 1).

Table 1. Results of cluster analysis – segmentation

	Final Cluster Centers				
	Cluster				
	1	2	3	4	5
Glass design	3.70	5.83	7.86	9.11	9.43
Importance of design	5.67	7.31	3.48	9.25	9.29
Willignes to pay more	3.27	7.59	3.71	4.45	8.83

Source: own processing in PSPP program.

Number of Cases in each Cluster		
Cluster	1	28
	2	66
	3	21
	4	75
	5	199
Valid		389

Source: own processing in PSPP program.

Results

We surveyed which factors are the most important for respondents when buying wine glasses – design, place of production, method of production (manually or by machine), brand and price. We found out that respondents consider the *design* of the glass to be the most important factor when buying wine glasses. *Price* is the second most important factor for respondents. Respondents consider the manual method of production to be more important than the machine method of production. For most respondents (349; 89.7%), the design of wine glasses is important, while for women design is more important than for men. The importance of design for respondents is also reflected in the willingness of respondents (290; 74.6%) to pay extra for the wine glass they like.

Respondents also assessed the importance of selected elements of wine glass design – the shape of the glass, the color of the glass, the quality of processing, the thickness of the glass and the packaging of the glass. From the respondents’ point of view, the most important design element is the shape of the glass, followed by the color of the glass, the quality of workmanship, and the thickness of the glass. The packaging, in which the wine glasses are sold was identified by the respondents as the least important element.

Although the majority of respondents (258; 66.2%) consider hand-made wine glasses to be of good quality, this is not reflected in the respondents’ purchases. 159 (40.9%) respondents do not consider machine or hand-made way of production, and only 108 (27.8%) respondents would prefer hand-made wine glasses to machine production. Although respondents are not loyal to one brand and they claim that the brand is not important to them, awareness of the RONA brand has a positive effect on the perception of handmade glasses, country of origin, brand, quality of workmanship and many other factors when buying. We can state that those respondents who know the RONA brand also have higher demands when choosing wine glasses and apply the above factors in their decision-making.

Based on the cluster analysis, we created five consumer segments. The segments reflect respondents’ attitudes towards the design of wine glasses. Based on Graph 1, we can see the respondents’ attitude to the design and willingness to pay extra for the wine glass that the respondents like. The design is most important for the design enthusiast segment, which is also typical by the highest willingness to pay extra for the product.

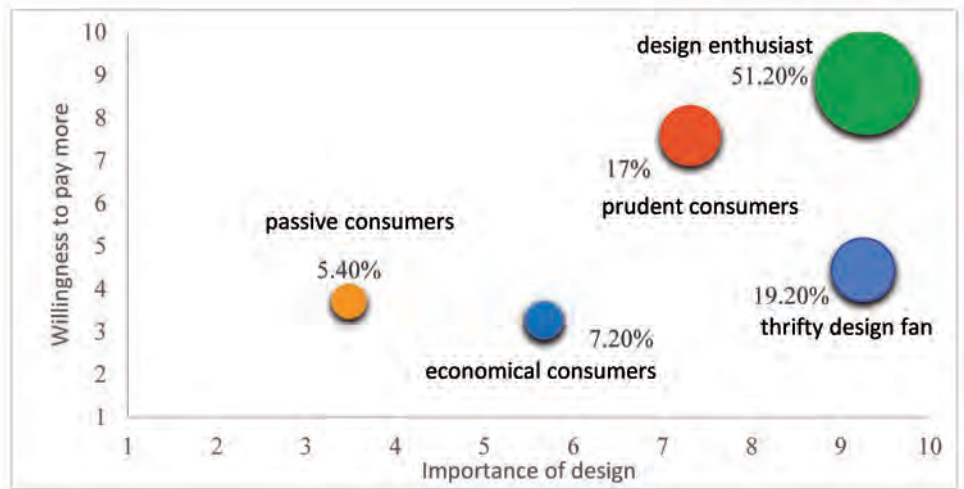


Figure 1. Consumer segments in relation to design of vine glasses

Source: own processing.

Consumer segments characteristic

Economical consumer

The consumer, who perceives price as the most important factor. His attitude to design is not expressed in clearly. Sometimes he/she appoints only medium importance to design, sometimes low, but he is not willing to pay extra for the product he likes. Economical consumer is not interested in the brand or the place of production. And he does not care how wine glasses are made. It also does not take into account the opinion of others.

Prudent consumer

The consumer perceives price as an important factor, but also shows some interest in design. The method of production is not important to him in his decision making, but he attributes more importance to manual production when asked about preferred way of production. He is looking for simplicity when choosing a wine glass. He also shows a willingness to pay extra for the product he likes, but he is not very interested in the opinion of others.

Passive consumer

A consumer for whom price is very important, but is interested in the design of the glass, particularly the shape and the color. He is not willing to pay extra for a product he likes. He takes into account friends' recommendations.

Thrifty design fan

A consumer who sees design as an important factor, but also takes price into account. He is not willing to pay extra for a product he likes. He appreciates manual production, but he does not decide based on the way of production. He prefers simplicity of wine glasses, as the decoration reminds him of the "old days". Before buying wine glasses, he has to see them in the store. When buying glasses, he considers the opinion of others only occasionally.

Design enthusiast

A consumer for whom design is very important and is willing to pay extra for a product he likes. Design enthusiast is interested in the place of production when making his decision. Sometimes he also looks for inspiration on the Internet, but he wants to see the product directly in the store before buying. Prefers manual production.

Conclusions

The aim of our research was to identify the importance of design of wine glasses in consumer decision-making and to specify consumer segments according to perception of design. Based on the research, we found that the design of the glass is very important for the respondents which is also reflected in the willingness of the respondents to pay extra for the product they like. During the survey, respondents did not consider the brand to be a significant factor in their purchase. However, we found the correlation between the awareness of brand and appointing higher significance to selected factors and elements such as the method of production, quality of processing, or place of production. We can state that the awareness of the brand contributes to increasing number of factors in decision making and sophistication of consumers.

The created segmentation reflects the relationship of respondents to the design of wine glasses, but also the relationship of respondents to the price of the product. Segmentation is applicable in business and production practice, whether in the development of new products, in the phase of their launch, but also in sales and marketing communications.

In further research, it is important to focus on other products, based on low, medium and high technologies to allow a better understanding of consumer behavior. Extending existing research and a larger sample of respondents would allow closer and more precise specification of consumer segments which may highlight the opportunities for investing in design in selected consumer and product segments.

Acknowledgement

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References

- Brezina, I., Donovalová, A. (2020). The State of the Glass Industry in Slovakia. *Desire. Design and Research in Business: Proceedings of the of the International Scientific Conference*, 6–17.
- Clicer, D. Petit, E., Garrel, C., Monteleone, E., Giboreau, A. (2018). Effect of glass shape on subjective and behavioral consumer responses in a real-life context of drinking consumption. *Food Quality and Preference*, 64, 187–191.

Cliff, M. (2001). Influence of Wine Glass Shape on Perceived Aroma and Colour Intensity in Wines. *Journal of Wine Research*, 12(1), 39–46.

Madziková, A., Kandráčová, V., Kulla, M., Nováková, S., et al. (2015). Development of Glassmaking and Changes in its Distribution in Slovakia. *Folia geographica*, 57(1), 52–78.

Mirabito, A.J., Oliphant, M.S., Doorn, G.H., Watson, S., Spence, C. (2017). Glass shape influences the flavour of beer. *Food Quality and Preference*, 62, 257–261.

Spence, Ch., Van Doorn, G. (2017). Does the shape of the drinking receptacle influence taste/flavour perception. *Beverages*, 3(3:33).

Spence, Ch., Wan, X. (2015). Beverage perception and consumption: The influence of the container on the perception of the contents. *Food Quality and Preference*, 39, 131–140.

Stead, M., Angus, K., Macdonald, L., & Bauld, L. (2014). Looking into the glass: glassware as an alcohol marketing tool, and the implications for policy. *Alcohol and alcoholism (Oxford, Oxfordshire)*, 49(3), 317–320, <https://doi.org/10.1093/alcalc/agt178>.

Zupan, Z., Evans, A., Couturier, D.L., Marteau, T. M. (2017). Wine glass size in England from 1700 to 2017: a measure of our time. *BMJ (Clinical research ed.)*, 359, j5623, <https://doi.org/10.1136/bmj.j5623>.

ACTIVE AND INTELLIGENT PACKAGING – AN OVERVIEW BASED ON PUBLICATIONS, PATENTS AND CONSUMERS’ OPINIONS

Ryszard Cierpiszewski¹

Abstract

In recent years, a rapid development of the packaging industry has been observed, and one of the directions of development is active and intelligent packaging. It is believed that the demand for such packaging is related to new consumer preferences, social changes and attempts to reduce food losses.

The definitions used in the literature regarding active and intelligent packaging, as well as legal acts enabling their introduction to the market has been discussed. On this basis, active and intelligent packaging has been characterized. The publication and patenting activity related to these techniques were also analysed.

The results of research on the knowledge of active and intelligent packaging among consumers and their tendency to purchase food in such packaging are also presented. Acceptance studies of active and intelligent packaging carried out in many countries indicate that consumers’ knowledge on this subject is low.

Another significant factor is the interest of companies in active and intelligent packaging. The results of a survey of senior executives show that intelligent packaging will be the subject of a significant investment.

Based on the analysis of the scientific literature, it was found that active and intelligent packaging show significant potential for further development.

Keywords:

active and intelligent packaging, patents, industry, consumer

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Introduction

In recent years, a rapid development of the packaging industry has been observed, and one of the directions are active and intelligent packaging. It is believed that the demand for such techniques is related to new consumer preferences, social changes and attempts to reduce food losses (WPO, 2009). There are many studies in the scientific literature devoted to such packaging techniques (Fang, *et al.* 2017; Realini & Marcos, 2014; Kaplana, *et al.* 2019). However, the knowledge of consumers in this area is low (Restuccia, 2010). The market offer of active and intelligent packaging is also relatively low.

The study aimed was to analyse the factors contributing to the development of active and intelligent packaging and the factors limiting their use.

Definitions of active and intelligent packaging

Many terms define active and intelligent packaging. Apart from the words 'active and intelligent packaging', the most common are 'smart packaging', 'interactive packaging' or 'innovative packaging'. Sometimes these terms are used without providing a definition or explanation of what the author meant when writing active packaging or intelligent packaging (Robertson, 2006).

Although the terms 'reactive packaging' and 'intelligent packaging' are used often interchangeably, there is a fundamental difference between them. In the scientific literature, active packaging is considered to be packaging in which additional components are intentionally incorporated into the material from which it is made, or incorporated inside the packaging, or attached to the outside of the packaging. The purpose of active packaging is to extend the shelf life of the products. In turn, the task of intelligent packaging is to monitor the properties of food products and inform the consumers about any changes. The aims of intelligent packaging is also improving the quality of the product by increasing the convenience of use, indicating attempts to open or prevent theft (Robertson, 2006).

The lack of official regulation on active and intelligent packaging in Europe resulted in less interest in those materials. Therefore the European Parliament and of the Council issued Regulation (EC) No 1935/2004 of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590 / EEC and 89/109 / EEC. On this basis, the European Commission issued Commission Regulation (EC) No. 450/2009 of May 29, 2009 on active and intelligent materials and articles intended to come into contact with food. The above regulations define these materials as follows:

“active materials and articles’ means materials and articles that are intended to extend the shelf-life or to maintain or improve the condition of packaged food; they are designed to deliberately incorporate components that would release or absorb substances into or from the packaged food or the environment surrounding the food;’

“intelligent materials and articles’ means materials and articles which monitor the condition of packaged food or the environment surrounding the food;’

Unfortunately, it may be difficult to classify a given package or material correctly, e.g. when oxygen is removed from the inside of the package, but the effect is unintended and small. In this case, the packaging is not classified as active packaging (European Commission, 2011).

Many authors extend the definition of intelligent packaging with additional functions. Very often such concepts are called smart packaging. Some authors define smart packaging as packaging having the properties of both active and intelligent packaging. Others, on the other hand, describe that smart packaging allows the product to be tracked throughout its life cycle and the environment inside or outside the packaging can be analysed and controlled in order to inform the producer, retailers or the consumer about the condition of the product at a given moment (Schaefer & Cheung, 2018). Such functions allow the use of packaging on the Internet of Things (Roberge, 2019). Many publications also consider data carriers as intelligent packaging. These include barcodes and RFID tags (Tichoniuk, Biegańska & Cierpiszewski, 2021). This lack of unambiguous definitions can create confusion.

Types of active and intelligent packaging and their commercial applications

Active packaging can be divided into three groups: absorbing systems, emitting systems and others. The first one removes unwanted substances from the atmosphere of the package. This group of active packaging includes: oxygen absorbers, carbon dioxide absorbers, etc.

The second system is based on the emission of substances from the packaging material to package atmosphere, e.g. CO₂. The third group includes systems that allow the consumer to take advantage of additional packaging functions, e.g. heating or cooling a can. Most often, however, active packaging is divided according to the type of emitted or adsorbed substance, e.g. oxygen absorbers, carbon dioxide absorbers and emitters, water absorbers, etc. (Dobrucka & Cierpiszewski, 2014). The examples of commercially available active packaging are listed in Table 1.

Table 1. Types of active packaging and their commercial applications

System	Product	Manufacturer
Oxygen scavenger	Ageless G, Amosorb®, ATCO®, Bioka Oxygen Cryovac®, Desi Pak®, Sorb-It®, Tri-Sorb®, Getter Pak®, 2-in-1 Label Cryovac®, OS2000 FreshPax®, Oxbar®,	Mitsubishi GasChemical, Japan Amosorb SolO2, ColorMatrix Group Inc., USA Laboratories STANDA Bioka Ltd., Kantvik, Finland OS Film Sealed Air Corporation, USA Enzyme-based, Bioka Ltd., Kantvik, Finland OS Film Sealed Air Corporation, USA Multisorb Technologies, Inc., USA Constar International Inc., Plymouth, USA
Carbon dioxide emitters	Ageless G, CO2® Fresh Pads, Freshpax, Freshlock, UltraZap® Xtenda Pak pads, Verifraise package,	Mitsubishi Gas Chemical, Japan CO2 Technologies, USA Multisorb Technologies, USA Multisorb Technologies, USA Paper Pak Industries, Canada SARL Codimer, France
Antimicrobial Packaging	Agilon™, Bioka, Biomaster®, Ethicap™, Irgaguard®, Microban, Microgarde™and Microsphere™, Sanico®,	Agion Technologies, USA Bioka Ltd., Finland Addmaster Ltd., UK Freund, Japan BASF, USA Microban Prod., UK Bernard Technologies, Toagosei, Japan Laboratories STANDA
Moisture Absorbers	Dri-Loc® MeatGuard	Sealed Air Corporation McAirlaid Inc.

Source: based on: Fuertes, *et al.* 2016; Fang, *et al.* 2017; Realini & Marcos, 2014.

Intelligent packaging

Intelligent packaging is often divided into three groups (Robertson, 2006): monitoring product quality, improving the comfort of use, protecting against theft, destruction, etc. The following devices are used: freshness indicators, temperature and time indicators (TTI), and gas indicators. The first of them, placed inside the packaging, react with compounds formed during the spoilage of the packaged food. After the reaction, the indicator changes the colour and informs the consumers about the change of food product quality. Examples of such indicators are fish freshness indicators (Tichoniuk, Radomska & Cierpiszewski, 2017) based on the reaction with volatile amines or kimchi freshness indicators based on the reaction with CO₂ (Hong & Park, 1999). TTI indicators are labels that allow the user to find out how long a food product has been exposed to

undesirable temperature (Taoukis, 2001). The third group of indicators are labels indicating the presence of gases, e.g. oxygen or carbon dioxide. If such gas appears or is removed from the packaging, it means that the packaging has been opened or damaged, or undesirable processes have occurred in the product (Mills, 2005). As you can see the above-mentioned indicators correspond to the definition proposed in the European Commission regulation. Another group of intelligent packaging improving the convenience of use is, for example, milk or beer packaging covered with thermochromic paint. A change in the colour of the paint indicates that the desired temperature for consumption of food has been reached (Tichoniuk, Biegańska & Cierpiszewski, 2021). This group also includes bar codes, QR codes, elements facilitating dosing, improving access to information, etc. (Pareek & Khunteta, 2014). The examples of commercially available intelligent packaging are listed in Table 2.

Table 2. Types of intelligent packaging and their commercial applications

System	Product	Manufacturer
Freshness indicator	Fresh Tag® Food Sentinel System Raflatac RipeSense SensorQ® Toxin Guard	COX Technologies SIRA Technologies Inc. VTT and UPM Raflatac RipeSense DSM NV nd Food Quality Sensor International Inc
Time temperature indicators (TTI)	3M Monitor Mark™ CheckPoint® Fresh-Check® FreshCode® Keep -it® OnVu™ VITSAB® Tempix® Timestrip® PLUS™	3M company VITSAB Temptime Corp. Varcode Ltd. Keep-it Technologies Freshpoint and Ciba VITSAB International AB Temptix AB Timestrip Plc
Gas indicator/ Integrity indicators	Ageless Eye® O2Sense Tell-Tab	Mitshubishi Gas Chemical FreshPoint Lab IMPAK
Radiofrequency identification tags RFID	CS8304 Easy2log® TempTRIP Integrity indicators	Convergence Systems Ltd. CAEN RFID Srl TempTRIP LLC Craemer Group GmbH

Source: based on: Fuertes, *et al.* 2016; Fang, *et al.* 2017; Realini & Marcos, 2014.

The third group of intelligent packaging that protects against theft, destruction and counterfeiting consists of many techniques. It is most often associated with RFID

tags, which allow the product to be traced from the producer to the consumer. However, it is important that RFID tags are inexpensive and high-performance. The combination of sensors with RFID tags provides them with additional functionality. Such sensors allow you to monitor temperature, humidity or detect substances emitted during food spoilage, and at the same time transmit the obtained results to the management system in real time (Bibi, *et al.* 2017).

The group of intelligent devices also includes appropriate inks, holographic signs, stickers indicating tampering with the contents of the package, printing microtext on the package, making embossing, etc. (O'Connor, 2006).

The above examples show the diversity of techniques classified as active and intelligent packaging. As a result, it is difficult to clearly indicate areas that will develop and which will be abandoned.

Active and intelligent packaging: research trends

In recent years, there has been a growing interest in active and intelligent packaging, reflected in the number of publications. The number of websites devoted to this subject is also growing on the Internet. Figure 1 shows the number of publications on active and intelligent packaging. A search conducted in the Elsevier database ScienceDirect in the period from 1980 to 2020.

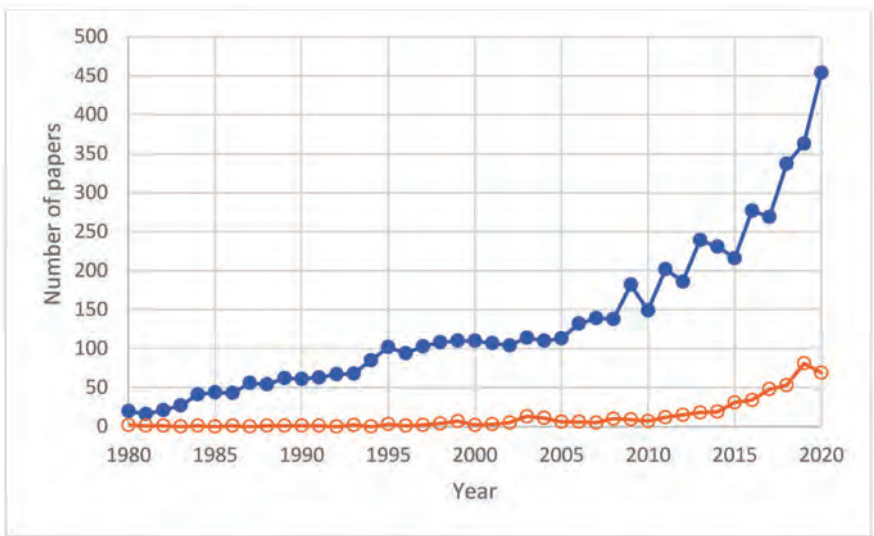


Figure 1. Number of publications in scientific journals on active and intelligent packaging (keywords;; ○ – intelligent packaging, ● – active packaging)

Source: own research based on the ScienceDirect database.

The presented in Figure 1 data show that the interest in active packaging is much greater compared to intelligent packaging. However, many of the solutions discussed in the articles are not referred to by the authors as active or intelligent packaging, even though they belong to this group. This is especially common in the case of intelligent packaging. Hence, the number of searched publications may be significantly underestimated

The second group of publications are patents that allow for the effective use of patented technologies and obtaining benefits from the resources put into research (Wrześniak, 2009). They can reflect the interest of enterprises in intelligent and active packaging. Figure 2 shows the number of patents in the field of active and intelligent packaging. The research was based on the Lens database. Comparing the obtained results with the data shown in Figure 1, one can notice a similar upward trend in the number of applications and granted patents after 2000 and similarly higher interest in active packaging.

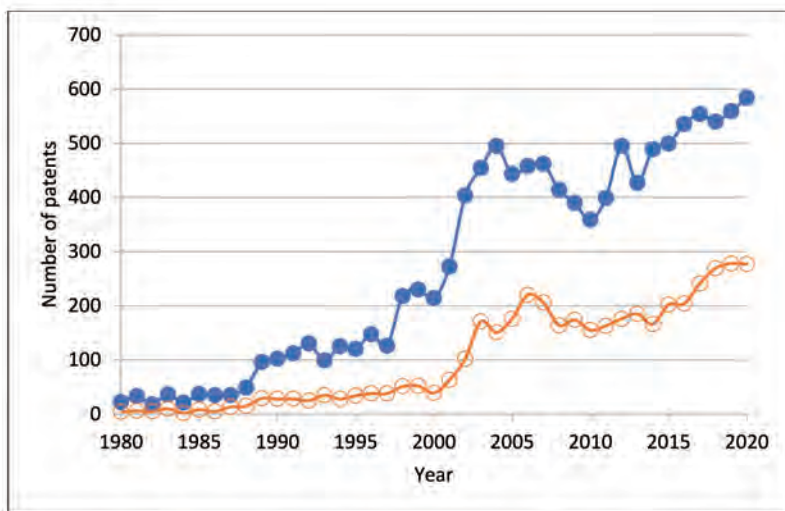


Figure 2. Number of patents on active and intelligent packaging (o – intelligent packaging, ● – active packaging)

Source: own research based on the ScienceDirect database.

Consumer attitudes towards active and intelligent packaging

Active and intelligent packaging has been in use for several decades in Japan and the USA. In Europe, on the other hand, such materials were blocked for many years by legal conditions and the lack of consumer knowledge (Restuccia, 2010). It is advantageous, however, that some studies indicate that customers are interested

in such packaging. They most often focused on individual materials (Aday & Yener, 2015). For example, Finnish consumers were open to the idea of using oxygen scavengers in food packaging, with the highest acceptance of oxygen scavengers in pizza packs (62%) and the least with fresh meat (29%) (Mikkola, 1997)

Research into freshness indicators in the USA shows that most respondents consider meat products and salads to be safe and fresh, but have reservations about freshness and are willing to pay extra for packaging with freshness indicators (Fortin, Goodwin & Thomsen, 2009). Belgian consumers are also willing to pay for the addition of the Fresh-Check® indicator. 75% of respondents saw the benefits of using this indicator, and 71% of them found it useful as food safety and quality tool (Fortin & Goodwin, 2008). On the other hand, studies in Ireland show that although consumers would be willing to extend the shelf life of the cheese, they were not willing to pay more for the use of elements facilitating this (O'Callaghan & Kerry, 2016). TTI acceptance studies carried out in France, Greece, Germany, and Finland show that consumers appreciate TTI technology and believe that its use may bring benefits (Pennanen, *et al.* 2015).

Research on the perception of active and intelligent packaging by consumers in Poland was carried out in various regions of the country (Ucherek, 2011; Popowicz & Lesiów, 2014; Pałkowska & Stenka, 2013; Barska & Wyrwa, 2016). They showed that the knowledge of active and intelligent packaging is low. Only 13-29% of respondents know the concept of active packaging, and the knowledge of intelligent packaging was confirmed by 4% to 38% of the respondents. On the other hand, almost 70% of the respondents positively answered the question about the willingness to purchase packaging with active devices. However, when their operation was explained 89% of respondents were ready to accept such packaging. However, if the purchase was associated with an increase in the price, the interest in the purchase will decrease (Barska & Wyrwa, 2016). Summing up, it can be said that the attitudes of consumers in different countries are similar, most often the knowledge about active and intelligent packaging is low, but after learning about the benefits they offer, the interest in these packaging grows significantly.

The Active and intelligent packaging market

The development of active and intelligent packaging is particularly influenced by how it is perceived by companies producing consumer goods. The results of a survey show that significant investments in intelligent packaging are planned. Their development is seen in three areas: inventory management, product integrity

protection, and user perception (Armstrong, *et al.* 2019). Computer simulations also show the benefits of using intelligent packaging in managing the inventory of perishable products. They show that in dynamic stochastic environments the use of cheap TTI indices can be very beneficial (Herobon, 2012).

The most important factor demonstrating interest in a product is value of the market. According to the Smithers Pira report (2018), the total value of the active and intelligent packaging market should reach USD 5.68 billion in 2018, including the active packaging market USD 4.62 billion, and the smart packaging market USD 1.06 billion. Total sales are estimated to grow an average of 5.9% annually and will reach \$ 7.56 billion in 2023. The market of intelligent packaging will grow faster by 12.9%, while active packaging only by 4%. However, it is difficult to consider these results as extremely optimistic because the growth for the entire packaging market was set at 6% (portalspozywczy.pl, 2018), and the value of the packaging market itself in 2018 was estimated at USD 876 billion (<https://wiki.com.pl>, 2020). Which means that active and intelligent packaging accounts for less than 1% of the packaging market.

Conclusions

Considering all the facts presented, it is obvious that the future of active and intelligent materials and articles is uncertain. Problems starts when you try to define them. Therefore, in most publications, there is a need to define what the author considers active and intelligent packaging.

The differences in definition are probably the reason for the discrepancy in the assessments of active and intelligent packaging markets provided in different studies. The high growth forecasts for the smart packaging market are related to the rapid development of printed electronics, activities in the cloud, and the Internet of Things, which techniques go beyond the definition formulated by the European Commission.

The development of the active and intelligent packaging market is proportional to the development of the entire packaging market. This does not indicate any particular interest in these techniques.

Many active and intelligent packaging described in the scientific literature work, but there are problems with the repeatability and uniqueness of the results obtained. This is probably why there are few active and intelligent packaging offers available on the market. Many of them were proposed a long time ago, and there seem to be relatively few new products.

It also points to the benefits of using active and intelligent packaging, which contribute to meeting the requirements of consumers. Unfortunately, most

consumers have not encountered or are not familiar with such solutions. The above reflections show that active and intelligent packaging can be considered interesting packaging development proposals, but their market success will depend on their popularization and technical development.

References

- Aday, M.S., Yener, U. (2015). Assessing consumers' adoption of active and intelligent packaging, *British Food Journal*, 117(1), 157–177, doi: 10.1108/BFJ-07-2013-0191.
- Armstrong, M., Fazio, F., Herrmann, D., Hetland, C. (2019). Capturing Brand value from the smart packaging revolution. *BXP Smart Packaging*, 3(4), A5-A12.
- Barska, J., Wyrwa, A. (2016). Consumer perception of active and intelligent food packaging. *Problems of Agricultural Economics*, 4(349) 138–159.
- Bibi, F., Guillaume, C., Gontard, N., Sorli, B. (2017). A review: RFID technology having sensing aptitudes for food industry and their contribution to tracking and monitoring of food products. *Trends in Food Science & Technology*, 62, 91–103, doi: org/10.1016/j.tifs.2017.01.013.
- Dobrucka, R., Cierpiszewski, R. (2014). Active and Intelligent Packaging Food – Research and Development – A Review. *Polish Journal of Food and Nutrition Sciences*, 64(1), 7–15.
- European Commission Final Report – Preparatory Study on Food Waste, (2010), https://ec.europa.eu/environment/eussd/pdf/bio_foodwaste_report.pdf [access year] = [12/03/2020].
- Fang, Z., Zhao, Y., Warner, R.D., Johnson S.K. (2017). Active and intelligent packaging in meat industry. *Trends in Food Science & Technology*, 61, 60–71, doi: org/10.1016/j.tifs.2017.01.002.
- Fortin, C., Goodwin, H.L. (2008). *Valuation of Temp-Time's Fresh-Check® Indicator on Perishable Food Products in Belgium*. 2008 Annual Meeting, February 2–6, Dallas, Texas from Southern Agricultural Economics Association, doi: 10.22004/ag.econ.6766.
- Fortin, C., Goodwin, H.L., Thomsen, M.R. (2009). Consumer Attitudes toward Freshness Indicators on Perishable Food Products. *Journal of Food Distribution Research*, 40(3), 1–15.
- Fuertes, G., Soto, I., Carrasco, R., Vargas, M., Sabattin, J., Lagos, C. (2016). Intelligent Packaging Systems: Sensors and Nanosensors to Monitor Food Quality and Safety. *Journal of Sensor*, 1–8, doi: org/10.1155/2016/4046061.
- Herbon, A., Levner, E., Cheng, E. (2014). Perishable inventory management with dynamic pricing using time–temperature indicators linked to automatic detecting devices. *International Journal of Production Economics*, 147(C), 605–613, doi: org/10.1016/j.ijpe.2013.07.021.
- Hong, S.-I., Park, W.-S. (1999). Development of Color Indicators for Kimchi Packaging. *Journal of Food Science*, 64, 255–257, doi: org/10.1111/j.1365-2621.1999.tb15877.x.

Kalpana, S., Priyadarshini, S.R., Leena, M.M., Moses, J.A., Anandharamakrishnan, C. (2019). Intelligent packaging: Trends and applications in food systems. *Trends in Food Science & Technology*, 93, 145–157, doi: [org/10.1016/j.tifs.2019.09.008](https://doi.org/10.1016/j.tifs.2019.09.008).

Market Key Figures, Challenges & Perspectives of World Wide Packaging (2018). all4pack, Paris, https://www.all4pack.com/Media/All-4-Pack-Medias/Files/FicheMarche_Emballage_Monde [access year] = [10/04/2020].

Mikkola, V., Lähteenmäki, L., Eero, H., Heiniö, R.L., Järvi-Kääriäinen, T., Ahvenainen, R. (1997). Consumer Attitudes Towards Oxygen Absorbers in Food Packages. *Technical Research Centre of Finland*, Espoo 1997. ISBN 951-38-5150-8.

Mills, A. (2005). Oxygen Indicators and Intelligent Inks for Packaging Food. *Chemical Society Reviews*, 34, 1003–1011, doi: [10.1039/b503997p](https://doi.org/10.1039/b503997p).

O'Callaghan, K.A.M., Kerry, J.P. (2016). Consumer attitudes towards the application of smart packaging technologies to cheese products. *Food Packaging and Shelf Life*, 9, 1–9, doi: [org/10.1016/j.fpsl.2016.05.001](https://doi.org/10.1016/j.fpsl.2016.05.001).

O'Connor, C.M. (2006). Pfizer Using RFID to Fight Fake Viagra. <https://www.rfidjournal.com/pfizer-using-rfid-to-fight-fake-viagra>[access year] = [28.01.2017].

Pałkowska, A., Steinka, I. (2013). Opakowania aktywne i inteligentne w świadomości konsumentów. Active and Intelligent Packaging in Consumers Awareness. *Zeszyty Naukowe Akademii Morskiej w Gdyni*, 80, 35–42. ISSN 1644-1818.

Pareek, V., Khunteta, A. (2014). Pharmaceutical packaging current trends. *International Journal of Pharmacy and Pharmaceutical Science*, 6(6), 480–485. ISSN- 0975-1491.

Pennanen, K., Focas, C., Kumpusalo-Sanna, V., Keskitalo-Vuokko, K., Matullat, I., Ellouze, M., Pentikäinen, S., Smolander, M., Korhonen, V., Ollila, M. (2015). HUMAN-PACKAGING INTERACTION European Consumers' Perceptions of Time – Temperature Indicators in Food Packaging. *Packag. Technol. Sci.*, 28, 303–323, doi: [org/10.1002/pts.2105](https://doi.org/10.1002/pts.2105).

Popowicz, R., Lesiów, T. (2014). Innowacyjne opakowania aktywne w przemyśle żywnościowym. Innovative active packaging in the food industry. *Engineering Sciences and Technologies*, 2(13), 34–48, doi: [10.15611/nit.2014.2.04](https://doi.org/10.15611/nit.2014.2.04).

Przyszłość globalnego rynku opakowań do roku 2020. (2020). <https://wiki.com.pl/przyszlosc-globalnego-rynku-opakowan-do-roku-2020/> [access year] = [10.04.2020].

Realini, C.E, Marcos, B., (2014). Active and Intelligent Packaging Systems for a Modern Society. ICMST, Proceedings of the 60th International Congress of Meat Science and Technology, Uruguay 2014, doi: [10.1016/j.meatsci.2014.07.022](https://doi.org/10.1016/j.meatsci.2014.07.022).

Regulation (EC) No 1935/2004 of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC.

Restuccia, D., Spizzirri, U.G., Parisi, O.I., Cirillo, G., Curcio, M., Iemma, F., Puoci F., Vinci G., Picci, N. (2010). New EU Regulation Aspects and Global Market of Active and Intelligent Packaging for Food Industry Applications. *Food Control*, 21, 1425–1435, doi: [10.1016/j.foodcont.2010.04.028](https://doi.org/10.1016/j.foodcont.2010.04.028).

Roberge, D. (2019). The IoT and Packaging – What's Trending and a Predictive Look Forward, *IndustrialPackaging* on January 31st, 2019 [access 10/04/2020].

Robertson, G.L. (2006). *Food Packaging: Principles and Practice*, Second Edition, CRC Press Taylor & Francis Group.

Commission Regulation (EC) No 450/2009 of 29 May 2009 on active and intelligent materials and articles intended to come into contact with food. L135, 3–11.

Schaefer, D., Cheung, W.M. (2018). Smart Packaging: Opportunities and Challenges. 51st CIRP Conference on Manufacturing Systems. *Procedia CIRP*, 72, 1022–1027, doi: [org/10.1016/j.procir.2018.03.240](https://doi.org/10.1016/j.procir.2018.03.240).

Smithers Pira, *The Future of Active and Intelligent Packaging to 2023*, 2018.

Światowy rynek opakowań powinien rosnać w tempie ok. 6 proc. rocznie, <https://www.portalspozywczy.pl/technologie/wiadomosci/swiatowy-rynek-opakowan-powinien-rosnac-w-tempie-ok-6-proc-rocznie,150936.html> [access year] = [7/04/2015].

Taoukis, P.S. (2001). Modelling the Use of Time Temperature Indicators in Distribution and Stock Rotation. In: L. Tijskens, M. Hertog, B. Nicolai (ed.), *Food Process Modelling*. Cambridge: Woodhead Publishing Ltd.

Tichoniuk, M., Radomska, N., Cierpiszewski, R. (2017). Application of food freshness indicators in intelligent packaging. In: H. Śmigielska (ed.), *Current Trends in Commodity Science: Food Safety and Analysis of Bioactive Substances*. Poznań: PUEB. ISBN 978-83-948206-1-9.

Tichoniuk, M., Biegańska, M., Cierpiszewski, R. (2021). Intelligent Packaging. In: M. Galanakis Charis (ed.), *Sustainable food processing and engineering challenges*, ISBN 978-0-12-822714-5, 279–313.

Ucherek, M. (2011). Opakowania inteligentne i ich postrzeganie przez konsumentów. Product Competitiveness through Intelligent Packaging in Consumers' Opinion. *Marketing i Rynek*, 1, 12–17.

WPO (2009). Market Statistics and Future Trends in Global Packaging, WPO – World Packaging Organization/PIRA International Ltd, www.worldpackaging.org [access 10/04/2012].

Wrześniak, G. (2009). Znaczenie ochrony patentowej dla polityki proinnowacyjnej. In: E. Okoń-Horodyńska, R. Wiśła (ed.), *Kapitał intelektualny i jego ochrona*. Warszawa: Instytut Wiedzy i Innowacji.

INTELLIGENT PACKAGING AS A TOOL IN SUPPLY CHAIN TRACEABILITY IN THE FOOD SECTOR

Marta Biegańska¹

Abstract

As a result of globalization, consumers have easier access to products from all over the world. It also influences the extension of supply chains. Ensuring food safety and quality throughout the entire supply chain is a real challenge for producers. Despite the implementation of various types of quality assurance and safety systems (e.g. GMP, HACCP, GlobalGAP), the use of better means of transport, innovative packaging materials or packaging systems, food contamination or its adulteration incidents are still not avoided.

To increase consumer confidence, traceability systems have been introduced to enable food chain monitoring 'from farm to fork'. Food producers can use traceability systems to identify sources of food contamination and withdraw a product from the market or a raw material / intermediate from the production process at the right moment. To improve the flow of information, the number of which increases with each stage of food production or an element of the logistics chain, intelligent packaging (e.g. barcodes, RFID tags) are suitable. Recently blockchain technology has been implemented for transparency and traceability in the food and beverage segment. Moreover, more stringent legal requirements in terms of food safety, quality and traceability are introduced in countries like USA, Europe and Japan.

Keywords:

intelligent packaging, traceability, blockchain, RFID, supply chain management

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Introduction

Today, consumers, especially in developed countries, are more aware of food quality and safety. What's more, the observed trends of a healthy lifestyle, eating on the go, or increased attention to the country of origin of products and/or the method of obtaining raw materials for their production, translate into growing requirements for food producers. A number of recent incidents related to food contamination and adulteration have negatively affected consumer confidence and increased their expectations of reliable information about the product, its quality, safety and origin (Tessitore, *et al.* 2021; Thi Phuong Dong, *et al.* 2021). In the European Union law has been implemented to monitor food safety and quality, but also to protect member states' culture, history and economy. Council Regulation, EEC No 2081/92 introduced specific names like Protected Designation of Origin (PDO), Protected Geographical Indication (PGI) and Traditional Specialties Guaranteed (TSG). Where PDO applies to food products processed, produced and prepared in a strictly defined geographical region like Italian ham *Prosciutto di Parma* or vinegar *Aceto Balsamico di Modena*. PGI identifies food products that are linked to a geographical area where at least one production step takes place (e.g. Danish cheese *Danablu*, Colombian coffee *Café de Colombia*). Whereas, TSG was introduced to protect traditional production methods (e.g. Italian cheese *Mozarella* or Greek *Feta*) (Dimitrakopoulou & Vantarakis, 2021). Due to numerous food adulterations, unfair competition food authentication is a great concern of producers, government authorities and consumers. It's crucial to be able to distinguish food products from their illegal substitutes. With the development of supply chains and IT technology food traceability is gaining interest among producers, traders, consumers. It's defined as the ability to track and trace products through the entire food supply chain "from farm to fork". These information not only enable better handling of recall, but also can contribute to better supply chain management and food waste reduction. Intelligent packaging solutions like barcodes or RFID tags facilitate traceability. Moreover blockchain technologies are gaining more interest and are being applied within supply chains (Wang, *et al.* 2021).

Traceability in the food supply chain

In traceability systems, the flow of information along the supply chain is crucial. Usually, the collection of data regarding e.g. the place of cultivation, the plant species, the method of harvesting in the first stages of obtaining raw materials for food production takes place on specific forms agreed with contractors. Traceability systems (TS) are designed to gather information of food producers, traders, manufacturers and other supply chain stakeholders which enable tracing

from whom to whom a food product has been obtained and supplied (Fig. 1). They enable producers and consumers to identify the origin of food, the stages at which contamination or adulteration occurred, as well as obtain information on transport and storage conditions. TS help improve food safety and quality, reduce operating costs and food waste and support sustainable production (Casino, *et al.* 2020; Thi Phuong Dong, *et al.* 2021). Only recently consumers gained interest in TS with increasing demand for safety, quality and ingredients information of food. Consumers are more aware of the originality/authenticity of food products like wine, meat, dairy products, honey or olive oil and different ingredients for example allergens, food additives (Dimitrakopoulou & Vantarakis, 2021; Sun, *et al.* 2021). Furthermore, mandatory labeling in the EU and traceability regulations help to introduce GM labels so that food or feed produced from genetically modified (GM) organisms are easily distinguished and monitored (Zhang, *et al.* 2021). The perception of traceability covers diverse aspects. It's not only providing information on product origin, used ingredients, but also on environment protection, animal welfare, supply chain and working conditions. Based on these information consumers' make their purchasing decisions (Tessitore, *et al.* 2021; Thi Phuong Dong, *et al.* 2021; Wu, *et al.* 2021).

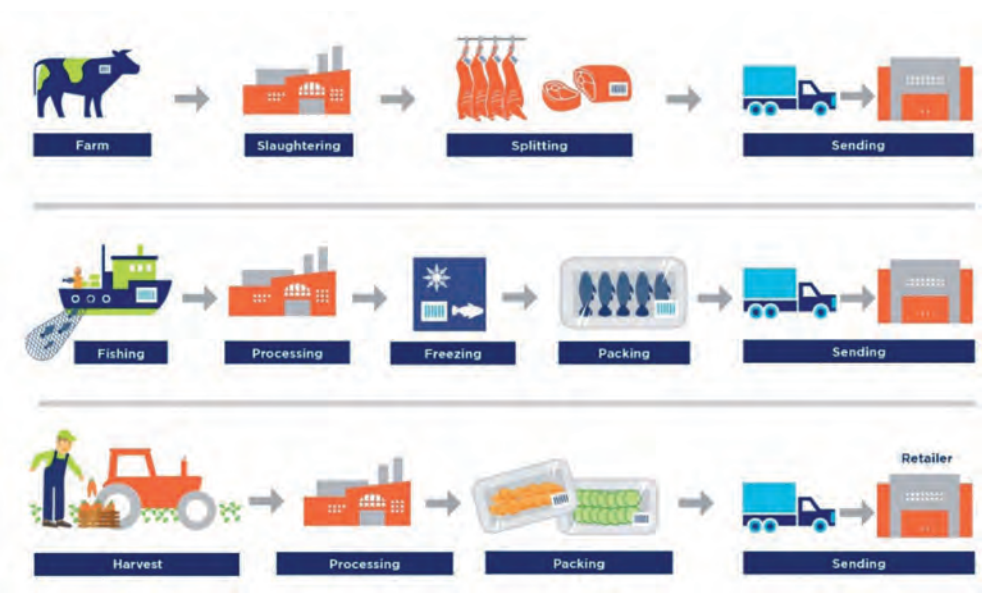


Figure 1. A simplified traceability model in food supply chains

Source: https://www.gs1ie.org/images_upload/Image_Files/fTrace-Images/fTrace-Food-Traceability-all-3.jpg

Due to growing interest in food safety, quality and traceability more and more countries impose more stringent regulations (e.g. The US, EU or Japan)

(el Sheikha & Xu, 2017; Thi Phuong Dong, *et al.* 2021). According to EU's regulation EC-178 of 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety traceability is a response to the potential risks of food and feed. Traceability is thus *"the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution. Moreover, food or feed which is placed on the market or is likely to be placed on the market in the Community shall be adequately labelled or identified to facilitate its traceability, through relevant documentation or information"* (Regulation (EC) No 178/2002).

Since 1990s the concept of traceability has evolved now covering product's full life-cycle. Through increased transparency in the food supply chain producers can gain consumer confidence in their products. This can also encourage farmers to reduce the use of pesticides or drugs, pay more attention to environment protection and proper working conditions (Zhou, *et al.* 2021). Other TS benefits include improved supply management, facilitation of trace-backs in case of recall, lower distribution costs and withdrawal expenses. It can also be a competitive advantage in the food supply chain (Casino, *et al.* 2020; Tessitore, *et al.* 2021). Traceability systems use information carriers such as barcodes, QR codes, RFID tags, NFC tags or labels (Wu, *et al.* 2021). More and more often modern Food Supply Chain (FSC) management relies on novel technologies such as the Internet of Things (IoT). Traceability systems combining IoT and RFID and/or NFC technologies can revolutionize the food industry by providing digital information in real time (Casino, *et al.* 2020). Despite, many advantages of modernized traceability systems there are also obstacles that need to be overcome. For instance, more complex understanding of traceability. With food supply chains getting more complex and fragmented along globalized networks, tracking of products becomes very difficult. With that in mind, traceability is no longer perceived as a mandatory safety tool, but also assures regulatory compliance, allows for food waste reduction (Casino, *et al.* 2020). The globalized food supply chains and growing consumer interest in e-commerce in the food sector (accelerated by SARS-CoV-2 pandemic) have scaled up the volume of traceability data generated. Those data have the characteristics of Big Data such as high volume, high rate input and heterogeneity (Yu, *et al.* 2020). The Big Data concept, IoT, cloud computing and emerging blockchain technologies are part of Industry 4.0.

Packaging identification system

The development of international general coding technology and different IT systems has supported improved traceability of products. Some of the first and

well known are barcodes, which are one-dimensional codes enabling coding of country of origin and manufacturer information. Those intelligent packaging systems include well known GS1 barcodes such as EAN-8, EAN-13 or code-128 and two dimensional QR code presented in Figure 2. The two dimensional QR code Quick response (QR) codes are more advanced than traditional barcodes, as they can store more data and can be readable by means of smartphones or computers (Tan & Ngan, 2020). Those two dimensional (2D) codes have the ability to store more data than barcodes.

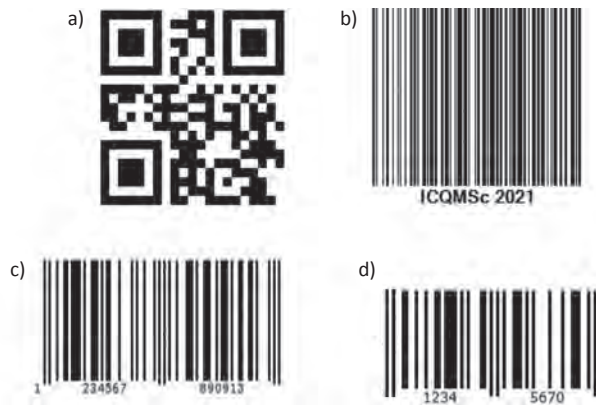


Figure 2. Examples of a two dimensional QR code a) and one dimensional barcodes: Code-128 b), EAN-13 c) and EAN-8 d)

Source: generated at <https://www.cognex.com/resources/interactive-tools/free-barcode-generator>

Radio frequency identification (RFID) systems are an invisible reading mode in which data are decoded without human interaction (Tan & Ngan, 2020). They are in a form of tags that transfer data automatically to track and trace them (tags) as well as identify them (Kuswandi, 2016). RFID technology within the supply chain can improve inventory control, change the checkout method at the retail stores, because they don't require direct scanning of a readable barcode by a scanner (Liukkonen, 2015). They simply need to be in the vicinity of checkout equipped with a RFID transducer. In the food sector they are usually utilized to provide complete traceability of products (Mirza Alizadeh, *et al.* 2020). Those tags can be applied to a single item or a primary packaging (e.g. in a form of a printed or adhesive flexible label), but also on secondary and tertiary packaging as rigid tags, chips or E-seals (Figure 3). RFID tags utilized in logistics management can enhance real-time traceability and sustainable use of resources. Greater information capacity and availability can significantly increase tracking and tracing of products in the supply chain. Such tags combined with central and cloud-based systems and warehouse management systems can enable processing of large volumes of data in a very short time.

For example, when an RFID tag is attached to a product and a camera or reader at warehouse gateways can capture the data transmitted from the tag and when integrated with warehouse management system (WMS) can quickly and precisely update information on pellets and items during inbound and outbound delivery (Fatorachian & Kazemi, 2021).



Figure 3. Examples of RFID tags (from the left) ELOG by Antra ID, label and an RFID E-seal

Source: <https://www.caenrfid.com/en/caen-rfid-products/tags/>



Figure 4. NFC product authentication solution

Source: https://www.orygene.io/wp-content/uploads/2020/05/facebook_header2.png

Near field communication (NFC) is another intelligent packaging technology that allows two NFC-enabled devices to communicate when held in close distance (ca. 4 cm). It evolved from RFID, however, an NFC chip operates as one part of a wireless link. Once it's activated by another chip, small amounts of data between the two devices can be transferred. This technology has a wide range of applications only to name a few: contactless payments, physical access (hotel rooms, garage gates, office rooms etc.), time and attendance measurement, personnel identification, ticketing. NFC smart packaging can be used to provide customers personalized experiences like with product information, videos and reordering reminders available with a simple tap of a smartphone. NFC tags are placed on each item, because they're small. This type of packaging has grown in popularity especially within the fast moving consumer goods (FMCG) (Anonymous, 2020). Moreover, NFC tags can play a vital role in product authentication. Simply

pointing a mobile phone at a product with such a tag could easily share information whether it's authentic or not (Figure 4). The “story telling” potential of the NFC technology is very wide. One can start with simple product ingredients information (including allergens), cooking recipes, packaging disposal guidelines, and many others.

Industry 4.0 and traceability in the food supply chain

The fourth industrial revolution (Industry 4.0) has brought about new solutions that revolutionized manufacturing, processing, distribution, warehousing and retail of goods including food products. Technological innovations are among other things the result of complex and constantly changing business environment and consumer demand. The introduction of automation and robotics and integration processes by means of the Internet led to creation of Smart Factories. Industry 4.0 is characterized by technological innovations such as Internet of Things (IoT), Cyber Physical Systems (CPSs), Big Data Analytics (BDA), artificial intelligence, blockchain technology (Fatorachian & Kazemi, 2021; Tomasiello & Alijani, 2021).

Supply chain management nowadays relies on effective sharing of trustworthy and tamper proof information. Agri-food supply chains (AFSC) are linked events in the agricultural production of food in its entire life cycle. Due to agri-food supply chains' complexity they are facing many risks like breakdowns, product deterioration and quality loss. The technologies associated with the Industry 4.0 are now setting direction to “Agri-Food 4.0”. The use of IoT can facilitate the gathering and sharing of information in real time, whereas, Big Data Analytics can support management withing the AFSC (Tomasiello & Alijani, 2021). Internet of Things incorporates billions of sensors, RFID tags, cameras, displays, smart phones and other devices connected together through the Internet. It offers convenience, real time data and remote communication of diverse media (Alfa, *et al.* 2021; Fatorachian & Kazemi, 2021). IoT has the ability to analyze large volumes of data, which in turn provides more information than in conventional food inspection technologies leading to improved food safety (Yu, *et al.* 2020).

Distributed ledger technology or in other words blockchain gains more and more interest in supply chains. Blockchain is basically a ledger (encoded and digital) stored on multiple devices of a private or public network. Data records called blocks are combined into chains that cannot be deleted or altered by a single user. It's a peer-to-peer network that reduces complex bilateral communications (e.g. payment transactions no longer require banks authorization etc.) (Alfa, *et al.* 2021). Once a transaction in a blockchain is validated by its participants and recorded it becomes permanent. It operates as a decentralized database thus enables supply chain actors to share control over access to the data. Although,

blockchain technology is in its infancy the type established in supply chains gives network members control over who can read the ledger and how the network is connected. Most data in supply chains are commercially sensitive which is one of the main reasons blockchains operate as permissioned or private networks with different type of permissions granted to supply chain actors (Wang, *et al.* 2021). Data security is a crucial factor and blockchain technology offers privacy as data are encrypted and verified. Blockchain solutions provide ledger integrity using cryptographic procedures such as SHA-256 hashing and elliptic curve cryptography schemes (Alfa, *et al.* 2021).

Smart packaging applications

Thi Phuong Dong, *et al.* (2021) studied the feasibility of traceability in shrimp supply chain in Vietnam. The supply chain of shrimps is both local and global. The obtained results showed that shrimp farmers were more eager to implement traceability system when its attributes were explained to them. Another factor supporting willingness of implementing such system were different international quality assurance certificates (e.g. Aquaculture Stewardship Council – ASC).

Research conducted by Tessitore *et al.* revealed that food traceability was more relevant for Italian restaurants than hotels or catering. Food service companies surveyed pointed out that they already provide sufficient information on products' origin and are unlikely to communicate more. On the other hand, restaurant consumers are totally dissatisfied with the amount of information given (Tessitore, *et al.* 2021).

Smart sensors and analytics allowed a snack foods producer Mondelez to create smart shelves that based on customer's physical characteristics and time spent in front of their displays customize advertisement. Not only smart advertising is in the reach of IoT, but smart labels can also facilitate sales forecasting and stock optimization (Fatorachian & Kazemi, 2021).

Another example of smart packaging in traceability is research on Halal food implementing QR codes in creating blockchain. Implementation of a blockchain framework was found to be possible to improve traceability in the food supply chain using RFID and QR codes (Tan, *et al.* 2020).

RFID technology (tags) is used also in the meat industry to identify individual animals and for traceability of their related products (Zhao, *et al.* 2020).

Conclusions

The growing world population and demand for safe food together with complex food supply chains and constantly changing consumer and market demands require better handling of food and information. Foodborne illnesses affect the world, consumers health, economy, and put the trust in producers to the test. Mandatory traceability in many countries allows for improved transparency, safety and quality of food. Use of intelligent packaging solutions like barcodes, QR codes, RFID tags or NFC tags combined with the Internet of Things or blockchain can have a tremendous impact on food supply chains management. Those smart labels/tags allow for monitoring of products through entire life cycle, assist operations in inventory management. The development of RFID and smart label applications in supply chains and traceability systems is increasing and has the potential to become more abundant in the future.

References

- Alfa, A.A., Alhassan, J.K., Olaniyi, O.M., Olalere, M. (2021). Blockchain technology in IoT systems: current trends, methodology, problems, applications, and future directions. *Journal of Reliable Intelligent Environments*, 7(2), 115–143, <https://doi.org/10.1007/s40860-020-00116-z>
- Casino, F., Kanakaris, V., Dasaklis, T. K., Moschuris, S., Stachtiaris, S., Pagoni, M., Rachaniotis, N.P. (2020). Blockchain-based food supply chain traceability: a case study in the dairy sector. *International Journal of Production Research*, 1–13, <https://doi.org/10.1080/00207543.2020.1789238>
- Dimitrakopoulou, M.-E., Vantarakis, A. (2021). Does Traceability Lead to Food Authentication? A Systematic Review from a European Perspective. *Food Reviews International*, 1–23, <https://doi.org/10.1080/87559129.2021.1923028>
- el Sheikha, A.F., Xu, J. (JP). (2017). Traceability as a Key of Seafood Safety: Reassessment and Possible Applications. In *Reviews in Fisheries Science and Aquaculture* (Vol. 25, Issue 2, pp. 158–170). Taylor and Francis Inc, <https://doi.org/10.1080/23308249.2016.1254158>
- Fatorachian, H., Kazemi, H. (2021). Impact of Industry 4.0 on supply chain performance. *Production Planning and Control*, 32(1), 63–81, <https://doi.org/10.1080/09537287.2020.1712487>
- Kuswandi, B. (2016). *Nanotechnology in Food Packaging* (pp. 151–183), https://doi.org/10.1007/978-3-319-39303-2_6
- Liukkonen, M. (2015). RFID technology in manufacturing and supply chain. *International Journal of Computer Integrated Manufacturing*, 28(8), 861–880, <https://doi.org/10.1080/0951192X.2014.941406>

- Mirza Alizadeh, A., Masoomian, M., Shakooie, M., Zabihzadeh Khajavi, M., Farhoodi, M. (2020). Trends and applications of intelligent packaging in dairy products: a review. In *Critical Reviews in Food Science and Nutrition*. Taylor and Francis Inc, <https://doi.org/10.1080/10408398.2020.1817847>
- Sun, X., Zhang, F., Gutiérrez-Gamboa, G., Ge, Q., Xu, P., Zhang, Q., Fang, Y., Ma, T. (2021). Real wine or not? Protecting wine with traceability and authenticity for consumers: chemical and technical basis, technique applications, challenge, and perspectives. In *Critical Reviews in Food Science and Nutrition*. Bellwether Publishing, Ltd, <https://doi.org/10.1080/10408398.2021.1906624>
- Tan, A., Gligor, D., Ngah, A. (2020). Applying Blockchain for Halal food traceability. *International Journal of Logistics Research and Applications*, <https://doi.org/10.1080/13675567.2020.1825653>
- Tan, A., Ngan, P. T. (2020). A proposed framework model for dairy supply chain traceability. *Sustainable Futures*, 2, 100034, <https://doi.org/10.1016/j.sfr.2020.100034>
- Tessitore, S., Iraldo, F., Apicella, A., Tarabella, A. (2021). Food traceability as driver for the competitiveness in Italian food service companies. *Journal of Foodservice Business Research*, <https://doi.org/10.1080/15378020.2021.1918536>
- Thi Phuong Dong, K., Fritz Matsushi, T., Minh Duc, N., Thi Ngoc Hoa, N., Saito, Y., Yen Dan, T. (2021). Does application of quality assurance certification by shrimp farmers enhance feasibility of implementing traceability along the supply chain? Evidence from Vietnam. *Journal of Applied Aquaculture*, <https://doi.org/10.1080/10454438.2020.1856751>
- Tomasiello, S., Alijani, Z. (2021). Fuzzy-based approaches for agri-food supply chains: a mini-review. *Soft Computing*, <https://doi.org/10.1007/s00500-021-05707-3>
- Wang, Y., Chen, C. H., Zghari-Sales, A. (2021). Designing a blockchain enabled supply chain. *International Journal of Production Research*, 59(5), 1450–1475, <https://doi.org/10.1080/00207543.2020.1824086>
- Wu, X., Xiong, J., Yan, J., Wang, Y. (2021). Perceived quality of traceability information and its effect on purchase intention towards organic food. *Journal of Marketing Management*, <https://doi.org/10.1080/0267257X.2021.1910328>
- Yu, Z., Jung, D., Park, S., Hu, Y., Huang, K., Rasco, B. A., Wang, S., Ronholm, J., Lu, X., Chen, J. (2020). Smart traceability for food safety. In *Critical Reviews in Food Science and Nutrition*. Bellwether Publishing, Ltd, <https://doi.org/10.1080/10408398.2020.1830262>
- Zhang, M., Fan, Y., Chen, C., Cao, J., Pu, H. (2021). Consumer perception, mandatory labeling, and traceability of GM soybean oil: evidence from Chinese urban consumers. *GM Crops and Food*, 12(1), 36–46, <https://doi.org/10.1080/21645698.2020.1807852>
- Zhao, J., Li, A., Jin, X., Pan, L. (2020). Technologies in individual animal identification and meat products traceability. In: *Biotechnology and Biotechnological Equipment* (Vol. 34, Issue 1, 48–57). Taylor and Francis Ltd, <https://doi.org/10.1080/13102818.2019.1711185>
- Zhou, X., Pullman, M., Xu, Z. (2021). The impact of food supply chain traceability on sustainability performance. *Operations Management Research*, <https://doi.org/10.1007/s12063-021-00189-w>

Anonymous. (2020). *100 million connected packs rolled out for UK dairy Brand — News on smart, active intelligent packaging*. Retrieved from <https://www.aipia.info/news-100-million-connected-packs-rolled-out-for-UK-dairy-Brand-1257.php> [21/04/2021]

Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. Retrieved from [https://eur-lex.europa.eu/legal-content/EN/ALL/?uri = celex%3A32002R0178](https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32002R0178) [15/07/2021]

Part 2

LOGISTIC AND PRODUCT MANAGEMENT

S-LCA FOR EVALUATING AN AGRO- -ECOLOGICAL MODEL OF ORGANIC CULTIVATION

Giuseppe Martino Nicoletti¹, Giulio Mario Cappelletti¹,
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Abstract

To make organic food production more efficient and competitive, a research project was developed, named “Organic farming Innovations to improve sustainability of Apulia farms for cereal and industrial crops”. This project studies new development models of supply chains such as industrial tomatoes, durum wheat and legumes. This model is being tested in some pilot farms to measure the increase in productivity and its sustainability in order to be transferred to farms in the area. As regards the measurement of social sustainability, a methodology based on life cycle assessment can be adopted: Social Life Cycle Assessment (S-LCA).

The paper presents a S-LCA methodology focused on the production of the organic food used in the crop rotation model. In particular, this research focuses on the issues regarding the system boundaries of the agro-ecological model and the individuation of the unit processes for the life cycle assessment as well. Results aim to highlight hotspots, principal stakeholders, impact categories, and indicators that were adopted in the questionnaires that the authors will submit to pilot farms.

Keywords:

Social Sustainability, S-LCA, Organic farming, Life Cycle Assessment

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Introduction

To overcome the market difficulties and to make the organic production of some supply chains more efficient and more competitive, a research project was implemented, called “Innovations in organic agriculture to improve the sustainability of Apulian farms for cereal and industrial crops”². The project is aimed at defining a new agro-ecological model, characterized by the use of solutions / innovations, based on the crop rotation of the main Apulian herbaceous crops.

The paper aims to describe the issues related to the measurement of social sustainability in project underway using the social life cycle assessment (S-LCA) methodology based on life cycle assessment. Research focuses on issues relating to system boundaries of agro-ecological model and to identification of unit processes units also for the assessment of the life cycle. The results aim to highlight the hotspots, the main stakeholders, the impact categories and the indicators that have been adopted in the questionnaires that will be submitted to the pilot companies.

Material and methods

Among the methodologies used to measure the social sustainability of products in the last 10 years, the interest of the scientific community for the social life cycle assessment (S-LCA) (Traverso, Petti & Zamagni, 2020) is increasing to try to adopt a methodology rigorous which is based on the assessment of the life cycle (ISO 40040, 2021) and supports that adopted for the measurement of environmental sustainability (environmental-LCA – E-LCA) and economic (life cycle costing – LCC).

However, the S-LCA approach it is still evolving. The first guidelines on S-LCA were published in 2009 (UNEP/SETAC, 2009), to which the methodological sheets (UNEP/SETAC, 2013) are added in 2013.

In 2020, the latest guidelines of the S-LCA (UNEP, 2020) were published. S-LCA is strategic as it contributes to the achievement of the sustainable development goals (SDGs) of Agenda 2030 mainly to SDG 12 on Responsible Consumption and Production and to SDGs 1 (No Poverty), 2 (Zero Hunger), 3 (Good Health and Well-Being), 4 (Quality Education), 5 (Gender Equality), 6 (Clean Water and Sanitation), 8 (Decent Work and Economic Growth), 10 (Reduced Inequalities), 16 (Peace, Justice and Strong Institutions), and 17 (Partnerships for the Goal). In relation to SDG 8, the S-LCA within the “ILO Decent Work Agenda” contributes to

² SOFT Project (N. 94250035584) funded by the Apulia Region (Italy) under the Puglia “PSR 2014-2020” (sub-measure 16.2).

the assessment of working conditions in value chains and life cycles worldwide (UNEP, 2020).

Despite the growing interest of the scientific community, significant implementations of the S-LCA methodology in relation to food issues are still few (D'Eusanio, *et al.* 2020) (Petti, *et al.* 2018) (Sanchez Ramirez, *et al.* 2014) (Martínez-Blanco, *et al.* 2014).

The choice of the S-LCA methodology to measure the social sustainability of the new agro-ecological model of the project, following the 2020 Guidelines (UNEP, 2020), used the Subcategory Assessment Method (SAM) (Sanchez Ramirez, *et al.* 2014) and following assessment path of ISO (UNI EN) 14040 (ISO, 2021).

This choice depends on the fact that being already employed in the food sector it could allow for an improvement in the implementation related to project experimentation. Furthermore, an S-LCA was sought that could be easily understood by the stakeholders of the supply chain so that there is a widespread implementation among the organic farms of the territory.

This is because the SAM is an objective method for the evaluation of subcategories (SBC) that allows an analysis of the behavior of organizations during the process relating to the product life cycle. In fact, the SAM makes it possible to obtain a result for each SBC by transforming qualitative information into a quantitative assessment. The vote 4 (best) shows a proactive behavior higher than the Basic Requirements (BRs); the vote 3 the compliance with the BRs; while the votes 2 and 1 (worst) denote the lack ability to meet the BRs of social sustainability (Table 1).

Table 1. Scale score and meaning

Scale score	1	2	3	4
Meaning	Denotes the inability to meet the basic requirements of social sustainability		Compliance with the basic requirements	Shows a proactive behavior higher than the basic requirements (best)

Source: own elaboration.

SBC and indicators have been selected from the methodological sheets (UNEP/ SETAC, 2013) and best practice in the food sector (Petti, *et al.* 2018) (Sanchez Ramirez, *et al.* 2014). The SAM developed for the experimentation is structured in relation to system boundaries, defined by the “gate of the farm to the gate of the product collection center, and any by-products” according to the circular economy.

A functional unit of 1 kg of organic product is chosen from the experimentation of the crop rotation model. For the Social Life Cycle Inventory (S-LCI), specific questionnaires were adopted for the collection of social data to implement the SAM according to the UNEP (2020). The questionnaires adopted in the food sector were adapted to the needs of project experimentation.

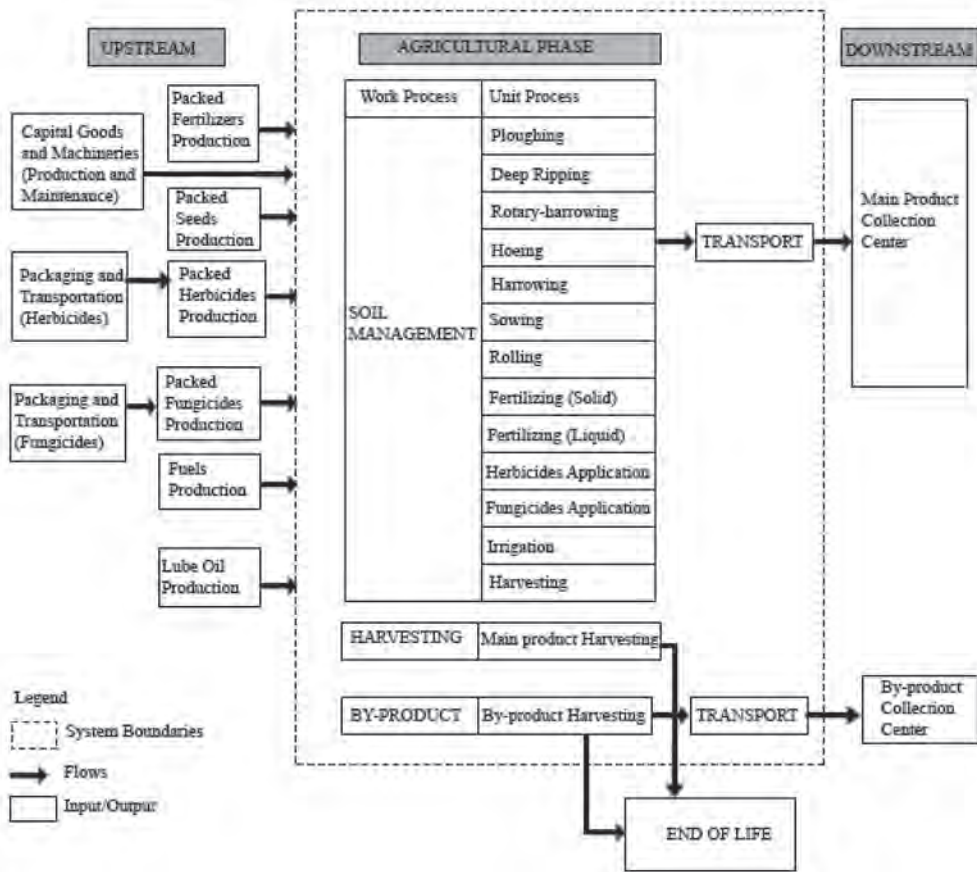


Figure 1. System boundaries of agro-ecological model with the same unit processes (durum wheat, chickpeas and peas)

Source: own elaboration.

Results

The identification of the unit processes is the preparatory phase. These unit processes are the same used for the E-LCA and LCC studies in order to carry out an integrated sustainability analysis according to Life Cycle Sustainability Assessment (LCSA) study. The identified work processes concern soil management, product

collection (and any by-product), with relative transport, for each type of production, according to experimentation plan, in two pilot organic farms, linked to crops rotations relating to legumes (chickpeas and peas), durum wheat (cultivar Senatore Cappelli and Nadif), industrial tomatoes, clover and field bean. On the basis of the plots 14 questionnaires are then prepared. Figure 1 shows the system boundaries of agro-ecological model with the same unit processes (durum wheat, chickpeas and peas).

The cutoff criteria are related to the amount of hours worked (Hunkeler, 2006) of each unit process. We then collect the number of workers (and gender), the type of employment contract, the number of weekly working hours of each employee, the number of working weeks in a year and the entire annual production of the product in each plot in order to provide the calculation of the working hours of each unit process (minutes or hours) (Ugaya, Brones & Corrêa, 2011).

Questionnaires have sections dedicated to multiple recipients since they must respond in relation to types of stakeholders involved in S-LCA study (Table 2).

Table 2. Questionnaires recipients, contents, stakeholders

Questionnaires recipients	Questionnaires Contents and/or Stakeholder
Legal Representative	Information about the farm, production, type of processing, manufacturing companies and workers; Stakeholder: Workers, Local Community; Consumer
Marketing /sales manager	Stakeholder: Consumer
Worker	Stakeholder: Workers
Trade union delegate	Stakeholder: Workers
Representative of the local community	Stakeholder: Local Community

Source: our elaboration (Petti, *et al.* 2018).

The legal representative answers the complete questionnaire relating to all types of stakeholders. While the other recipients respond to the questionnaire relating to their type of stakeholder in order to ‘triangulate’ the answers provided by the legal representative. Below, the categories of stakeholders with the related SBC (in brackets) (UNEP/SETAC, 2013) are listed (Table 3):

- a) workers (benefits / social security, working hours, forced labor, fair salary, freedom of association, health and safety in the workplace, equal opportunities / discrimination, child labor);
- b) local community (delocalization and migration, community engagement, cultural heritage, respect for the human rights of indigenous people, local

- employment, access to immaterial resources, access to material resources, safe and healthy living conditions);
- c) consumers (health and safety, feedback mechanism, consumer privacy, transparency, end of life responsibility).

Finally, hotspots are about respecting the BRs according to social sustainability. For example, the workers issues relating to compliance with employment contracts can be monitored by means of indicators set by the Italian legislation, such as the recognition of overtime hours and a level of basic salary.

Table 3. Categories of stakeholders with the related subcategories (SBC)

SUBCATEGORY	STAKEHOLDER		
	WORKERS	LOCAL COMMUNITY	CONSUMERS
	Benefits / Social security	Relocation and migration	Health & Safety
	Working hours	Community involvement	Feedback mechanism
	Forced labor	Cultural heritage	Consumer privacy
	Fair wage	Respect for the rights of indigenous	Transparency
	Freedom of association and collective bargaining	Local employment	End-of-life responsibility
	Health and safety in the workplace	Access to intangible resources	
	Equal opportunities / discrimination	Access to material resources	
	Child labor	Safe and healthy living conditions	
		Safe and healthy living conditions	

Source: own elaboration.

Conclusions

The administration (in progress) of the questionnaire for each plot of the experimentation of the project will allow to define a model with the S-LCA methodology to measure social sustainability in the pilot companies.

The use of the methodology is one of the first applications in the agri-food sector. Furthermore, the S-LCA represents an innovative application of the life cycle assessment approach to the experimentation of an agro-ecological model, through the complementary use of environmental-LCA and LCC, for carrying out an LCSA study.

In particular, for pilot companies, the results of the SAM allow the elaboration and implementation in a specific action plan to improve social performance for each category of stakeholders.

On the other hand, the multiplicity of stakeholders to be interviewed with their conflicting interests could easily lead to biases without a consolidated overview of the results of the S-LCA study. In fact, these biases could generate serious critical issues, for example, in terms of misunderstanding and a potential worsening in personnel management.

An important recommendation is to carry out the appropriate triangulations correctly. This allows you to develop a better understanding of the real situation with which to associate the related assessments.

Ultimately, a consolidated framework of the overall assessment, combined with adequate and effective communication, allows stakeholders an adequate understanding of their role and the measures to be taken to improve organizational behavior related to social sustainability.

The model can be used, also perfected on the basis of the business and geographical context, as a managerial tool to be adopted in organic farms in the area.

The next step of the research concerns the third party certification of the results obtained with the use of the S-LCA. This is in order to assess whether the institutional communication to the stakeholders of this certification improves the social reputation of the cultivated product and the attractiveness of the target consumers who attach high importance to social sustainability.

Contribution of the authors: *A. Di Noia carried out the bibliography, the collection and processing of the data, G.M. Cappelletti and A. Di Noia carried out the application of the methodology, G.M. Nicoletti and C. Russo reviewed the paper.*

References

D'Eusanio, M., Lehmann, A., Finkbeiner, M., Petti, L. (2020). Social Organizational Life Cycle Assessment: an approach for identification of relevant subcategories for wine production in Italy. *The International Journal of Life Cycle Assessment*, 25, 1119–1132.

Hunkeler, D. (2006). Societal LCA methodology and case study. *Int J Life Cycle Assess*, 11(6), 371–382.

UNI EN ISO 14040 (2021). *Gestione ambientale – Valutazione del ciclo di vita – Principi e quadro di riferimento*, http://store.uni.com/catalogo/uni-en-iso-14040-2021?josso_back_

to = http://store.uni.com/josso-security-check.php&josso_cmd=login_optional&josso_partnerapp_host=store.uni.com, [03/12/2021]

Martínez-Blanco, J., Lehmann, A., Muñoz, P., Antón, A., Traverso, M., Rieradevall, J., Finkbeiner, M. (2014). Application challenges for the social Life Cycle Assessment of fertilizers within life cycle sustainability assessment. *Journal of Cleaner Production*, 69, 34–48.

Petti, L., Sanchez Ramirez, P.K., Traverso, M., Ugaya, C.M.L. (2018). An Italian tomato “Cuore di Bue” case study: challenges and benefits using subcategory assessment method for social life cycle assessment. *The International Journal of Life Cycle Assessment*, 23, 569–580.

Sanchez Ramirez, P.K.S., Petti, L., Haberland, N.T., Ugaya, C.M.L. (2014). Subcategory assessment method for social life cycle assessment. Part 1: methodological framework. *The International Journal of Life Cycle Assessment*, 19, 1515–1523.

Traverso M., Petti L., Zamagni A. (eds.) (2020). *Perspectives on Social LCA*. Contributions from the 6th International Conference, Springer.

Ugaya, C., Brones, F., Corrêa, S. (2011). *S-LCA: Preliminary results of Natura’s Cocoa soap bar*. Proceedings of Life Cycle Management Conference, Berlin.

UNEP/SETAC. (2009). Guidelines for social life cycle assessment of products. United Nations Environment Programme and Society for Environmental Toxicology and Chemistry. Paris, France.

UNEP/SETAC (2013). The Methodological Sheets for Subcategories in Social Life Cycle Assessment (S-LCA). United Nations Environment Program. Paris SETAC Life Cycle.

UNEP, 2020. *Guidelines for Social Life Cycle Assessment of Products and Organizations 2020*. Benoît Norris, C., Traverso, M., Neugebauer, S., Ekener, E., Schaubroeck, T., Russo Garrido, S., Berger, M., Valdivia, S., Lehmann, A., Finkbeiner, M., Arcese, G. (eds.). U.N. Environment Programme.

FACING CIRCULARITY AND SUSTAINABILITY CHALLENGE IN AGRICULTURAL SECTOR – LCA APPROACH TOWARDS ASSESSMENT OF ITS CONSEQUENCES

Tomasz Nitkiewicz¹

Abstract

The process of transition to circular economy through the delivery of sustainable products has already started while its environmental consequences are not fully investigated yet. Agricultural sector, as not many other sectors, has a natural potential for contributing to circularity and sustainability of its products. The problem is with measuring the consequences of striving for circularity goals with regard to its environmental, economic or social consequences. The objective of the paper is to present the opportunities with LCA use on selected agricultural products to design its life cycles with the circularity and sustainability constraints. The study is based on presenting the approach within LCA to cope with circularity and sustainability of agricultural products. Also, extensions of LCA, like life cycle sustainability assessment (LCSA), social life cycle assessment (S-LCA) and life cycle costing (LCC) are considered as methodological support to deal with circularity assessment.

Keywords:

LCA, circular economy, agricultural sector, life cycle management

Introduction

Circular economy (CE) concept, at its core, refers to the forward and backward flow of goods and materials through application of different processes, such as reuse, repair and refurbishment, remanufacturing and recycling (EMF, 2013;

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Zink & Geyer, 2017). The challenge of CE refers to all economic sectors and all actors involved. CE aims to minimize or eliminate input materials from fossil or non-renewable sources in a production system and maximize the reuse of these materials within the same system (Barros, *et al.* 2020; Korhonen, *et al.* 2018). CE practices can offer opportunities for reducing emissions and waste generation in the agricultural sector through the circulation of raw materials, agricultural waste, and manure (Jurgilevich, *et al.* 2016). Agricultural sector has by far the biggest potential of developing CE solutions. Barros, *et al.* (2020) are referring to such areas as mushroom cultivation (Grimm & Wösten, 2018), food waste recovery (Ingrao, *et al.* 2018), bioenergy (Zabaniotou, 2018), biogas (Kapoor, *et al.* 2020; Kougias & Angelidaki, 2018), farming system (Therond, *et al.* 2017), waste biorefinery (Venkata Mohan, *et al.* 2016; Wainaina, *et al.* 2020; Dumont, *et al.* 2013), and the concept of restorative and regenerative systems (Morseletto, 2020).

The agricultural sector is particularly concerned by CE, as current food production and consumption habits are unsustainable (Barros, *et al.* 2020; Donner, *et al.* 2021; Jurgilevich, *et al.* 2016). The European Circular Economy Action Plan has defined food waste as a priority area of developing CE (EC, 2015). Food is wasted all along the food supply chain, in Europe mostly at the consumption stage (FUSIONS, 2016), but for some groups of agricultural products also in primary production or processing and manufacturing stages (Caldeira, *et al.* 2019). In this context, the CE represents a promising strategy for saving relevant resources and reducing agricultural activities' negative environmental impacts while improving economic and preferably social performance (Kuisma & Kahiluoto, 2017; Stegmann, Londo, & Junginger, 2020; Velasco-Muñoz, *et al.* 2021).

Since CE is being adopted as the current development strategy an appropriate monitoring tools need to be able to capture different issues related to CE solutions implementation. CE monitoring tools should be capable of not only measuring the degree of circularity of a system but also the extent to which circularity reduces environmental impacts and pressures (Helander, *et al.* 2019). Adapting systems perspective should contribute to the identification of the relationship between circular and environmental indicators (Rufi-Salís, *et al.* 2021). In particular, a life cycle approach enables a systematic evaluation of the environmental impacts and benefits resulting from the implementation of circular strategies in different life cycle stages of a product, system or service (Haupt & Zschokke, 2017; Niero & Kalbar, 2019; Pauliuk, 2018; Sauvé, Bernard & Sloan, 2016). Additionally, life cycle approach could contribute to the detection of cases where circularity does not necessarily result in reduced environmental impact (Niero & Kalbar, 2019).

Use of life cycle assessment to measure circularity

Life Cycle Assessment (LCA) is very well suited to assess the sustainability impacts of sustainability and CE strategies. LCA is a science-based technique for assessing the environmental impacts associated with entire product life cycles, which can provide technical support to decision-makers. LCA procedure enables the assessment of environmental impacts and its trade-offs and may also be applied to identify the most promising CE strategies and options for improving the environmental performance of society's consumption and production patterns (Pena, *et al.* 2020).

In order to support CE decisions, methods for assessing and quantifying the environmental benefits of CE strategies, such as LCA, are thus increasingly challenged by the need to reflect the systemic context of an organization (Schulz, *et al.* 2020). The objective of the paper is to present the possible scope of LCA use for CE solution assessment within agricultural sector. In order to present the possible scope of LCA use the example of closing the loop of selected agricultural supply chain. The example is focused on waste rapeseed oil use to get PHA group biopolymer. Since the biopolymers are being now regarded as the best possible replacement for fossil based plastics it is especially worthy to take a look at its possible manufacturing technologies that could contribute to circularity of the specific life cycles. The objective is realized through the application of LCA to the production of P(3HB) biopolymer from waste rapeseed oil. Biopolymer production through bacterial fermentation is used to close down the loop and meet the circularity requirements and to explain important choices within the assessment procedure.

In order to illustrate the possible use of LCA for CE solutions in agricultural sector the case of biopolymer production from waste PE is used. Biopolymers are currently perceived as perfect substitute for conventional fossil-based plastics and are expected to replace them (Ciardelli, *et al.* 2019; Gironi & Piemonte, 2011; Kookos, Koutinas & Vlysidis, 2019). Biopolymers can be derived from a wide range of biomass types, that includes agricultural products, such as corn or soybeans, as well as algae or food waste (Nitkiewicz, *et al.* 2020).

Among various types of biopolymers the production of P(3HB) polymer from PHAs group is assessed. PHAs group of polymers is characterized by useful properties that do not need to be improved unlike in case of conventional, polylactide or starch polymers. These features are comparable with those of poly(ethylene) and poly(propylene), but within much environmental friendly processing and biodegradability features (Koller, 2019). Microbial fermentation is one of the most widespread ways to produce PHAs (Heimersson, *et al.* 2014). Inputs for PHAs production are refined materials like monosaccharides, cellulose and starch to be extracted from a variety of crops, and waste flows like biomass residues,

post-process industrial waste streams, and wastewaters (Wojnowska-Baryła, Kulikowska & Bernat, 2020). PHAs production technologies are being developed in order to become more affordable but also in order to accelerate its possible role in introducing CE solutions to polymer manufacturing sector (Ingrao, *et al.* 2018). The wide use of biopolymers does not guarantee lack of environmental impact and different factors such as production processes, material feed, technical performance, as well as its disposal must be carefully considered throughout the life of the product (Ingrao & Siracusa, 2017; Ingrao, *et al.* 2015).

For the purpose of presenting the possible scope of LCA use to assess CE solutions with regard to its environmental impact the process of producing of specific type of PHAs: polyhydroxybutyrate (P(3HB)) and is investigated. The raw P(3HB) polymers produced from different substrates may have many applications – they can be used for mould injection, film blowing or 3D printing. Since the objective is to illustrate the possibilities of LCA use to check whether closing down the open loops with PHAs production the scenario of P(3HB) production from used cooking oil is considered.

The details of innovative P(3HB) production method, based on bacterial fermentation with *Zobellella denitrificans* (P(3HB)) strain, has been presented elsewhere (Nitkiewicz, *et al.* 2020). In this paper the focus is on production process that is fed with used rapeseed oil. The process is based on lab scale production but its assessment is related to the possibility of introducing CE solutions. The main life cycle refers to the production of rapeseed oil while P(3HB) production is one of the options to close down the open loops with used oil flows. The life cycle considered is also a good example of possible scenarios to introduce circular solutions to agricultural sector.

Since the issue of CE is not only focused on environmental aspects the use of LCA and its scope should be appropriately designed. The expected complexity of assessment and diversity of alternative variants considered make classic scope of LCA hardly enough for CE decision making. Therefore, supplementary life cycle based assessments should be considered, such as life cycle costing (LCC), social life cycle assessment (S-LCA) and Life Cycle Sustainability Assessment (LCSA). Usage of complex life cycle based assessment methodology could bring out additional insights, circumstances and consequences of CE solution implementation. Economic perspective, as introduced by LCC methodology, is usually considered within CE related studies (Dieterle & Viere, 2021; Joachimiak-Lechman, 2014) while social perspective seems to be rather peripheral while LCA approach is concerned. Nevertheless, S-LCA approach could be beneficial for avoiding problem shifting between different stakeholders and to contribute to more holistic CE sustainability assessment (Rusch & Baumgartner, 2020). In complex issues Niero and Hauschild (2017) recommend using the framework of Life Cycle Sustainability Assessment (LCSA) to evaluate circular economy solutions, to get the most comprehensive and

still operational framework for the assessment. LCSA combines major features and indicators of LCA, LCC and S-LCA and enables the identification and mitigation of burden shifting between stakeholders in the value chain.

The key factor of life cycle modelling of CE solutions is related to allocation process in LCA. Wernet *et al.* (2016) identifies the following approaches:

- “cut-off” approach, where end-of-life and side-product processes are excluded from the assessment,
- allocation at the point of substitution, where all the end-of-life processes are included in the assessment and contribute to environmental impacts,
- small scale and long-term consequential approach, where the allocation at the point of substitution approach is used but system boundaries are extended to cover indirect impacts as well.

The allocation of specific end-of-life and side flows, which are directed towards other life cycles, would be a critical issue here. Therefore, the combination of “cradle to cradle” definition of system boundaries with small scale consequential approach is the best possible, and very often the only feasible coverage for circular solutions.

Life cycle assessment of waste rapeseed oil processing to P(3HB) biopolymer

Figure 1 presents simplified life cycle of waste rapeseed oil to P(3HB) biopolymer. In general the life cycle could be divided into two different phases: rapeseed oil life cycle and its end-of-life processing to get P(3HB) biopolymer. This second phase of the life cycle is vital for closing the loop by using used oil it as by-product. The objective here is to recover its value from used oil and direct the life cycle towards circularity. Additionally, this scenario could provide economically, socially and environmentally sound solutions to match CE requirements. It is important to mention that there are multiple possibilities in end-of-life processing of used oil and not all of them are considered here.

Goal and scope definition

Since the objective of paper is to provide overview of possible scenarios of closing the loop of waste rapeseed oil with production of P(3HB) biopolymer mainly the impacts of specific end-of-life phases is considered. The functional unit for the study is defined as a life cycle 1 kg of P(3HB) biopolymer produced from used rapeseed oil in an experimental manufacturing process.

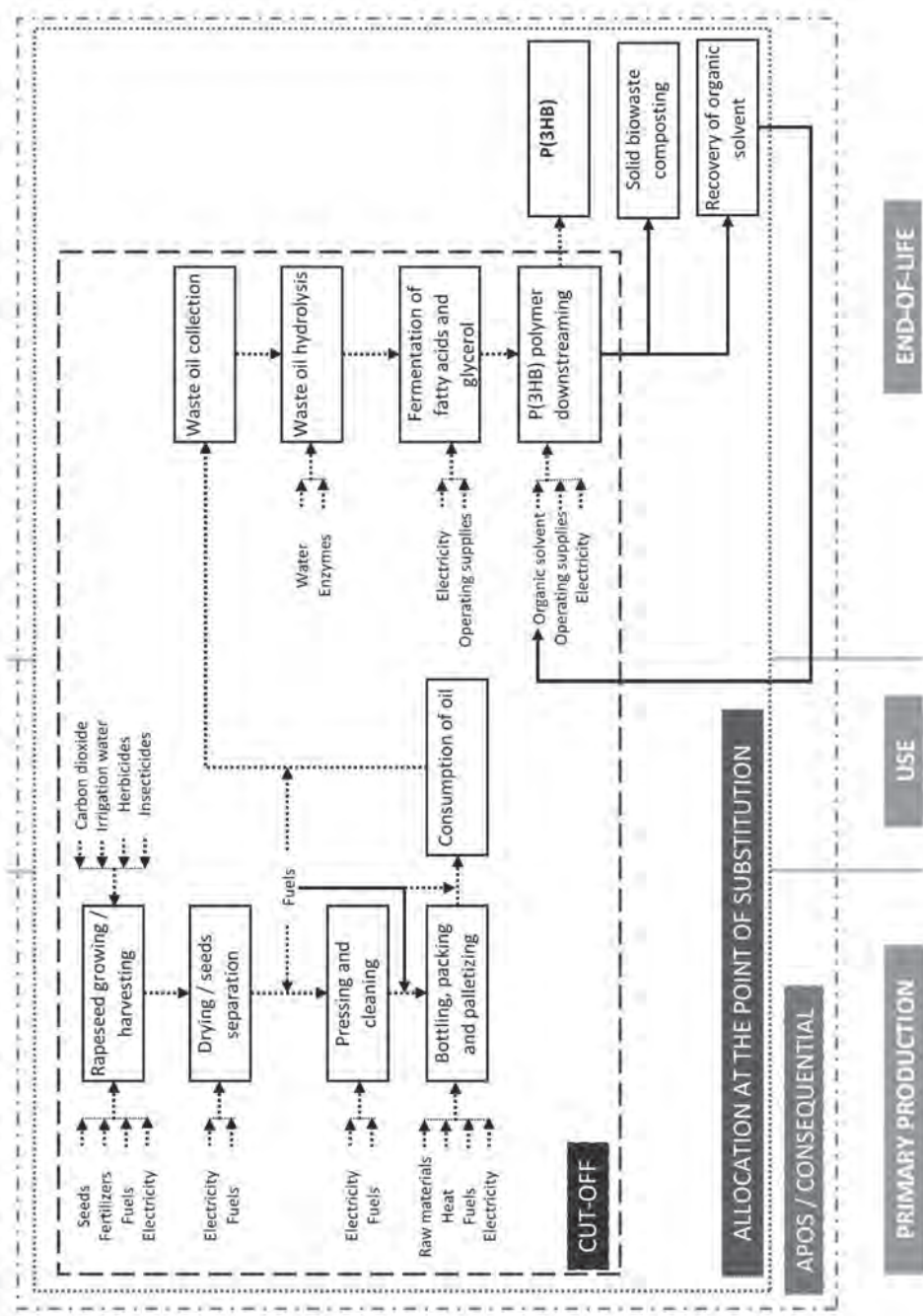


Figure 1. Schematic presentation of waste oil to P(3HB) life cycle with regard to different allocation approaches

The life cycle phases included in the study and system borders are presented in Figure 1. The study does not refer to the possibilities concerning the transformation of obtained biopolymer to final product. This is due to keep the study oriented on methodological choices related to LCA use and not to different options of biopolymer use for delivering final products.

Life cycle inventory analysis

The analysis of material and energy flows within considered life cycle is based on primary experimental production data as presented in Nitkiewicz *et al.* (2020). Primary data refers to the end-of-life phase, namely biopolymers production process only, while the production and provision of raw materials for the production is modelled with secondary data from the literature and ecoinvent 3.1 database. Table 1 presents the inventory data for both life cycles included in the study.

Table 1. Inventory data for waste oil to P(3HB) scenario (based on Nitkiewicz, *et al.* 2020)

Specification	Units	Quantities in life cycle of P(3HB)
Hydrolysis		
used rapeseed oil	kg	59.09
glycerine	kg	6.28
fermentation		
glycerine*	kg	1.57
ammonium	ml	605.82
Salt medium		
$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$	g/l	436.19
KH_2PO_4	g/l	72.70
NH_4Cl full / lim	g/l	48.47
$\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$	g/l	9.69
solution (total amount)	l	819.70
CaCl_2	g/l	0.000969
Fe(III)NH_4 citrate	g/l	0.000058
$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$	g/l	0.000194
$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$	g/l	0.000485
$\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$	g/l	0.000048
$\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$	g/l	0.000048
$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$	g/l	0.000048

NiCl ₂ ·6H ₂ O	g/l	0.000010
Na ₂ MoO ₄ ·2H ₂ O	g/l	0.000015
air flow	l/min	5
CO ₂ emissions	l	14895
Separation		
solvent	kg	1.26
alcohol	kg	12.63
fatty acids / glycerine	kg	1.05
extraction efficiency	%	0.95
product	kg	1
* – glycerine fermentation rate to P(3HB) is taken from Ibrahim and Steinbuechel (2009)		

Life cycle impact assessment

In order to give full coverage for possible life cycle impacts and include global as well as European perspective the ReCiPe method is used for the assessment. The impacts are calculated with SimaPro software and the endpoint variant of ReCiPe (H) V1.08 indicator. It is important to mention that the life cycle assessment is approached with three different strategies: (1) cut-off approach, (2) allocation at the point of substitution approach (APOS) and (3) consequential assumptions to allocation at the point of substitution approach (APOS/consequential). The differences between approaches are listed below:

- cut-off approach uses the whole life cycle data but does not account for environmental benefits from providing P(3HB) biopolymers; the database used for life cycle modelling is attributional oriented;
- APOS approach uses the whole life cycle data including the benefits from producing P(3HB) biopolymers; the database used for life cycle modelling is attributional oriented;
- APOS/consequential approach the whole life cycle data including the benefits from producing P(3HB) biopolymers; the modelling of life cycle is based on ecoinvent database records with consequentially oriented allocation; the change, which consequences are assessed is based on replacing virgin oil with used oil; the scope of the change is limited to the production process only.

Figure 2 and Figure 3 present the results of waste oil to P(3HB) for normalization and weighting stages, respectively. It is important to remind that all the life cycles considered are using the same data but different calculation approaches.

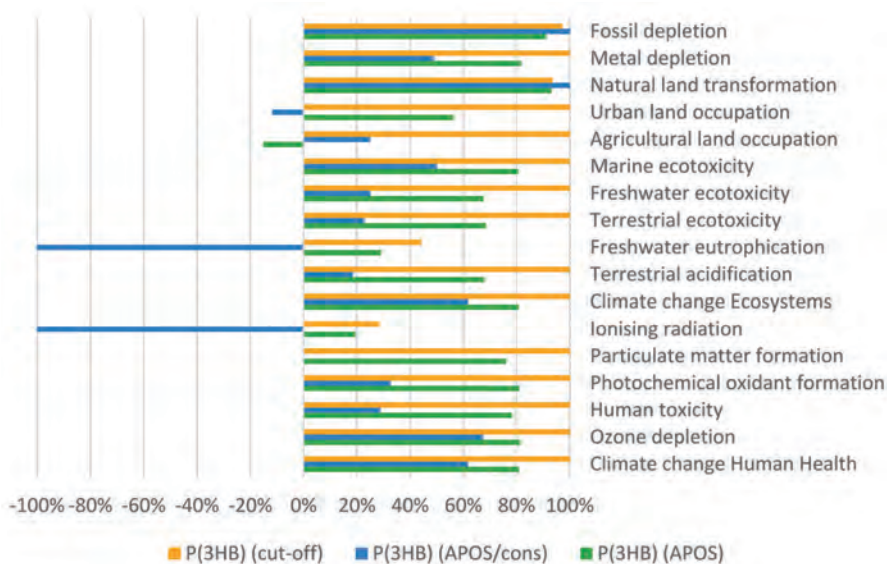


Figure 2. Characterization results for ReCiPe impact category endpoint indicators for different calculation approaches

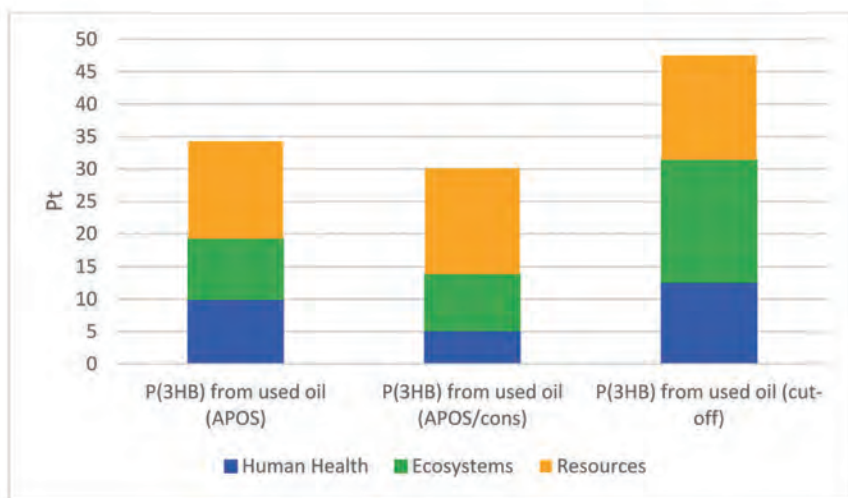


Figure 3. Weighted ReCiPe damage category endpoint indicators for P(3HB) calculation approaches

Comparing the results of different calculation set-ups that are included in the study brings out significant differences. Cut-off scenario does not include the possible environmental benefits from recovering biopolymers (only impact of its processing are included) and, therefore are the worst scenarios while

environmental impacts are concerned. The difference between the scores of cut-off and two remaining scenarios is quite significant. The difference between APOS and APOS/Consequential scenarios is rather slight and occurs mainly due to attributing all the positive impacts of biopolymers recovery to the LCIA results. Also, the difference occurs with the inclusion of organic solvent recovery, that is attributed only to the APOS/Consequential scenario.

Interpretation

The final part of the analysis is focused on the possible use of additional life cycle based assessment methods. Table 2 presents the possible outcomes of LCC and S-LCA use together with the LCA assessment. The general recommendations from LCA analysis are focused on mitigating impacts from primary production phase and optimizing P(3HB) production. LCC is introducing economic and financial aspects, which are referring to primary production and end-of-life as well but also in the use phase. That is connected to the need of organizing waste oil collection system and, first of all, developing its cost efficiency.

Table 2. Possible context of different assessment methods use

	LCA	LCC	S-LCA
Primary production	Reducing impacts from harvesting and primary production	Optimizing costs of harvesting and primary production	Considering demand-supply context; considering capabilities and needs of supply chain actors
Use		Economizing waste oil collection system	Mobilizing consumers for returning waste oil
End-of-life	Considering different scenarios for waste oil use	Considering scaling-up factors of P(3HB) production; deciding on final products selection	Managing side products; Responding to demand-supply factors

Finally, it is worth to consider the use of LCSA methodology that would somehow combine the results and recommendations from the former methods. The main trade-offs to consider with regard to waste oil to P(3HB) biopolymer, that would be raised with LCSA use:

- Considering the alternative scenarios for waste rapeseed oil end-of-life processing (i.e. biofuel),
- Balancing the economic (waste oil collection system), social (attitudes and compensations of waste oil collection) costs with environmental benefits,

- Investigating market response and consumers need on end-of-life side products (i.e. mcl-PHA vs. P(3HB),
- Improving the efficiency of P(3HB) production.

The latter issue could be only overwhelmed with developing the experimental production to the industrial level with some crucial improvements on the way. As the literature shows, the cost efficiency of PHAs production is highly depended on carbon sources used, in case of waste rapeseed oil derivatives, it is strongly supporting production of amorphous mcl-PHA instead of polyhydroxybutyrate P(3HB) (Nitkiewicz. *et al.* 2020).

Conclusions

Biopolymer production seems to be one of the key directions of making agricultural economy more circular. Basing on the example of rapeseed oil, the opportunities of closing the life cycle loops with P(3HB) biopolymer production are significant both in a sense of mitigating environmental impacts as well as providing viable economic resources. Using life cycle based methods for its assessment helps in identification of consequences of introducing circular solutions. Additionally, they could provide appropriate framework for complex decision-making while CE is concerned. Nevertheless, relying solely on LCA results could reduce the complexity of decision making process and direct it towards somehow limited options. As show in the example of P(3HB) production from waste oil, the use of additional methods, i.e. LCC, S-LCA or LCSA, could restore this complexity and introduce new factors in decision making.

References

- Barros, M.V., Salvador, R., de Francisco, A.C., Piekarski, C. M. (2020). Mapping of research lines on circular economy practices in agriculture: From waste to energy. *Renewable and Sustainable Energy Reviews*, 131(June), 109958, <https://doi.org/10.1016/j.rser.2020.109958>.
- Caldeira, C., De Laurentiis, V., Corrado, S., van Holsteijn, F., Sala, S. (2019). Quantification of food waste per product group along the food supply chain in the European Union: a mass flow analysis. *Resources, Conservation and Recycling*, 149, 479–488, <https://doi.org/10.1016/j.resconrec.2019.06.011>.
- Ciardelli, F., Bertoldo, M., Bronco, S., Passaglia, E. (2019). Environmental Impact. In: *Polymers from Fossil and Renewable Resources*, 161–187, https://doi.org/10.1007/978-3-319-94434-0_7.
- Dieterle, M., Viere, T. (2021). Bridging product life cycle gaps in LCA & LCC towards a circular economy. *Procedia CIRP*, 98, 354–357, <https://doi.org/10.1016/j.procir.2021.01.116>.

Donner, M., Verniquet, A., Broeze, J., Kayser, K., De Vries, H. (2021). Critical success and risk factors for circular business models valorising agricultural waste and by-products. *Resources, Conservation and Recycling*, 165, 105236, <https://doi.org/10.1016/j.resconrec.2020.105236>.

Dumont, B., Fortun-Lamothe, L., Jouven, M., Thomas, M., Tichit, M. (2013). Prospects from agroecology and industrial ecology for animal production in the 21st century. *Animal*, 7(6), 1028–1043, <https://doi.org/10.1017/S1751731112002418>.

EC. (2015). *Closing the Loop – an EU Action Plan for the Circular Economy*. Brussels.

EMF. (2013). *Towards the circular economy: Economic and business rationale for an accelerated transition*. Cowes, UK.

FUSIONS. (2016). Estimates of European food waste levels. Retrieved from <https://www.eu-fusions.org/index.php/publications>.

Gironi, F., Piemonte, V. (2011). Bioplastics and petroleum-based plastics: Strengths and weaknesses. *Energy Sources, Part A: Recovery, Utilization and Environmental Effects*, 33(21), 1949–1959, <https://doi.org/10.1080/15567030903436830>.

Grimm, D., Wösten, H.A.B. (2018). Mushroom cultivation in the circular economy. *Applied Microbiology and Biotechnology*, 102(18), 7795–7803, <https://doi.org/10.1007/s00253-018-9226-8>.

Haupt, M., Zschokke, M. (2017). How can LCA support the circular economy?—63rd discussion forum on life cycle assessment, Zurich, Switzerland, November 30, 2016. *The International Journal of Life Cycle Assessment*, 22(5), 832–837, <https://doi.org/10.1007/s11367-017-1267-1>.

Heimersson, S., Morgan-Sagastume, F., Peters, G. M., Werker, A., Svanström, M. (2014). Methodological issues in life cycle assessment of mixed-culture polyhydroxyalkanoate production utilising waste as feedstock. *New Biotechnology*, 31(4), 383–393, <https://doi.org/10.1016/j.nbt.2013.09.003>.

Ibrahim, M.H.A., Steinbüchel, A. (2009). Poly(3-hydroxybutyrate) production from glycerol by *Zobellella denitrificans* MW1 via high-cell-density fed-batch fermentation and simplified solvent extraction. *Applied and Environmental Microbiology*, 75(19), 6222–6231, <https://doi.org/10.1128/AEM.01162-09>.

Ingrao, C., Bacenetti, J., Bezama, A., Blok, V., Goglio, P., Koukios, E. G., Huisingh, D. (2018, December). The potential roles of bio-economy in the transition to equitable, sustainable, post fossil-carbon societies: Findings from this virtual special issue. *Journal of Cleaner Production*, 204, 471–488, <https://doi.org/10.1016/j.jclepro.2018.09.068>.

Ingrao, C., Faccilongo, N., Di Gioia, L., Messineo, A. (2018). Food waste recovery into energy in a circular economy perspective: A comprehensive review of aspects related to plant operation and environmental assessment. *Journal of Cleaner Production*, 184, 869–892, <https://doi.org/10.1016/j.jclepro.2018.02.267>.

Ingrao, C., Siracusa, V. (2017). Quality- and sustainability-related issues associated with biopolymers for food packaging applications: A comprehensive review. In: *Biodegradable*

and Biocompatible Polymer Composites: Processing, Properties and Applications, 401–418, <https://doi.org/10.1016/B978-0-08-100970-3.00014-6>.

Ingrao, C., Tricase, C., Cholewa-Wójcik, A., Kawecka, A., Rana, R., Siracusa, V. (2015). Polylactic acid trays for fresh-food packaging: A Carbon Footprint assessment. *Science of the Total Environment*, 537, 385–398, <https://doi.org/10.1016/j.scitotenv.2015.08.023>.

Joachimiak-Lechman, K. (2014). Środowiskowa ocena cyklu życia (LCA) i rachunek kosztów cyklu życia (LCC). Aspekty porównawcze and life cycle cost. Comparative aspects. *Ekonomia i Środowisko*, 1(48).

Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., Schösler, H. (2016). Transition towards circular economy in the food system. *Sustainability*, 8(1), 1–14, <https://doi.org/10.3390/su8010069>.

Kapoor, R., Ghosh, P., Kumar, M., Sengupta, S., Gupta, A., Kumar, S.S., Pant, D. (2020). Valorization of agricultural waste for biogas based circular economy in India: A research outlook. *Bioresource Technology*, 304, 123036, <https://doi.org/10.1016/j.biortech.2020.123036>.

Koller, M. (2019). Polyhydroxyalkanoate Biosynthesis at the Edge of Water Activity-Haloarchaea as Biopolyester Factories. *Bioengineering*, 6(2), 34, <https://doi.org/10.3390/bioengineering6020034>.

Kookos, I.K., Koutinas, A., Vlysidis, A. (2019). Life cycle assessment of bioprocessing schemes for poly(3-hydroxybutyrate) production using soybean oil and sucrose as carbon sources. *Resources, Conservation and Recycling*, 141, 317–328, <https://doi.org/10.1016/j.resconrec.2018.10.025>.

Korhonen, J., Nuur, C., Feldmann, A., Birkie, S.E. (2018). Circular economy as an essentially contested concept. *Journal of Cleaner Production*, 175, 544–552, <https://doi.org/10.1016/j.jclepro.2017.12.111>.

Kougias, P.G., Angelidaki, I. (2018). Biogas and its opportunities—A review. *Frontiers of Environmental Science Engineering*, 12(3), 14, <https://doi.org/10.1007/s11783-018-1037-8>.

Kuisma, M., Kahiluoto, H. (2017). Biotic resource loss beyond food waste: Agriculture leaks worst. *Resources, Conservation and Recycling*, 124, 129–140, <https://doi.org/10.1016/j.resconrec.2017.04.008>.

Morseletto, P. (2020). Restorative and regenerative: Exploring the concepts in the circular economy. *Journal of Industrial Ecology*, 24(4), 763–773, <https://doi.org/10.1111/jiec.12987>.

Niero, M., Hauschild, M.Z. (2017). Closing the Loop for Packaging: Finding a Framework to Operationalize Circular Economy Strategies. *Procedia CIRP*, 61, 685–690, <https://doi.org/10.1016/j.procir.2016.11.209>.

Niero, M., Kalbar, P.P. (2019). Coupling material circularity indicators and life cycle based indicators: A proposal to advance the assessment of circular economy strategies at the product level. *Resources, Conservation and Recycling*, 140, 305–312, <https://doi.org/10.1016/j.resconrec.2018.10.002>.

Nitkiewicz, T., Wojnarowska, M., Sołtysik, M., Kaczmarek, A., Witko, T., Ingrao, C., Guzik, M. (2020). How sustainable are biopolymers? Findings from a life cycle assessment of polyhydroxyalkanoate production from rapeseed-oil derivatives. *Science of The Total Environment*, 749, 141279, <https://doi.org/10.1016/j.scitotenv.2020.141279>.

Pauliuk, S. (2018). Critical appraisal of the circular economy standard BS 8001:2017 and a dashboard of quantitative system indicators for its implementation in organizations. *Resources, Conservation and Recycling*, 129, 81–92, <https://doi.org/10.1016/j.resconrec.2017.10.019>.

Pena, C., Civit, B., Gallego Schmid, A., Druckman, A., Caldeira-Pires, A., Weidema, B., Motta, W. (2020). *Using Life Cycle Assessment to achieve a circular economy*, 10.

Rufi-Salís, M., Petit-Boix, A., Villalba, G., Gabarrell, X., Leipold, S. (2021). Combining LCA and circularity assessments in complex production systems: the case of urban agriculture. *Resources, Conservation and Recycling*, 166, 105359, <https://doi.org/10.1016/j.resconrec.2020.105359>.

Rusch, M., Baumgartner, R.J. (2020). Social Life Cycle Assessment in a Circular Economy – A mixed-method analysis of 97 SLCA publications and its CE connections. *7th International Social Life Cycle Assessment Conference At: Sweden (Online)*, 73–76.

Sauvé, S., Bernard, S., Sloan, P. (2016). Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research. *Environmental Development*, 17, 48–56, <https://doi.org/10.1016/j.envdev.2015.09.002>.

Schulz, M., Bey, N., Niero, M., Hauschild, M. (2020). Circular economy considerations in choices of LCA methodology: How to handle EV battery repurposing? *Procedia CIRP*, 90, 182–186, <https://doi.org/10.1016/j.procir.2020.01.134>.

Stegmann, P., Londo, M., Junginger, M. (2020). The circular bioeconomy: Its elements and role in European bioeconomy clusters. *Resources, Conservation Recycling: X*, 6, 100029, <https://doi.org/10.1016/j.rcrx.2019.100029>.

Therond, O., Duru, M., Roger-Estrade, J., Richard, G. (2017). A new analytical framework of farming system and agriculture model diversities. A review. *Agronomy for Sustainable Development*, 37(3), <https://doi.org/10.1007/s13593-017-0429-7>

Velasco-Muñoz, J.F., Mendoza, J.M.F., Aznar-Sánchez, J.A., Gallego-Schmid, A. (2021). Circular economy implementation in the agricultural sector: Definition, strategies and indicators. *Resources, Conservation and Recycling*, 170(April), <https://doi.org/10.1016/j.resconrec.2021.105618>.

Venkata Mohan, S., Nikhil, G.N., Chiranjeevi, P., Nagendranatha Reddy, C., Rohit, M.V., Kumar, A.N., Sarkar, O. (2016, September). Waste biorefinery models towards sustainable circular bioeconomy: Critical review and future perspectives. *Bioresource Technology*, Vol. 215, pp. 2–12, <https://doi.org/10.1016/j.biortech.2016.03.130>.

Wainaina, S., Awasthi, M.K., Sarsaiya, S., Chen, H., Singh, E., Kumar, A., Taherzadeh, M.J. (2020). Resource recovery and circular economy from organic solid waste using aerobic and anaerobic digestion technologies. *Bioresource Technology*, 301, 122778, <https://doi.org/10.1016/j.biortech.2020.122778>.

- Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., Weidema, B. (2016). The ecoinvent database version 3 (part I): overview and methodology. *International Journal of Life Cycle Assessment*, 21(9), 1218–1230, <https://doi.org/10.1007/s11367-016-1087-8>.
- Wojnowska-Baryła, I., Kulikowska, D., Bernat, K. (2020). Effect of Bio-Based Products on Waste Management. *Sustainability*, 12(5), 2088, <https://doi.org/10.3390/su12052088>.
- Zabaniotou, A. (2018). Redesigning a bioenergy sector in EU in the transition to circular waste-based Bioeconomy-A multidisciplinary review. *Journal of Cleaner Production*, 177, 197–206, <https://doi.org/10.1016/j.jclepro.2017.12.172>.
- Zink, T., Geyer, R. (2017). Circular Economy Rebound. *Journal of Industrial Ecology*, 21, 593–602, <https://doi.org/https://doi.org/10.1111/jiec.12545>.

THE ROLE OF PACKAGING IN MODERN SUPPLY CHAINS

Mariusz Tichoniuk¹

Abstract

Packaging is one of the fundamental elements in the supply chain. It makes products safer and easier to handle. Packaging protects them against adverse factors during storage, transport, and delivery. A complement to these functions is the provision of information allowing for the identification and tracking of the product, as well as encouraging the members of the chain to decide on a given product and/or informing on how to proceed with it.

Modern supply chains place greater demands on packaging in terms of improving its competitiveness, and sustainability. In particular, freight forwarding and e-commerce place great emphasis on the optimal use of packaging. Proper matching of packaging materials and construction forms facilitates their automation and increases efficiency. An increasingly important criterion is the reduction of environmental impact and the introduction of sustainable technologies. Recycled materials and bio-based packaging are gaining more and more interest. Reusable packaging and reverse logistics are also considered. Modern supply chains incorporate often smart packaging technologies which improve the information transfer, product traceability, and efficiency of logistic processes such as Radio-Frequency Identification or Internet of Things technologies. All the above-mentioned solutions have been presented, which confirms the important role of packaging in modern supply chains.

Keywords:

packaging, supply chain, intelligent / smart packaging

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Introduction

Packaging is the inevitable part of a product in the supply chain. Besides bulk materials and large unit products, all other ones require packaging to be portioned, marked, and, above all, properly protected. It is estimated that from 90% to 97% of various types of products manufactured in the world requires support for the use of packaging during transport and storage (Zenka-Podlaszewska & Tichoniuk, 2012). Packaging plays a key role in ensuring the required warehouse and transport susceptibility of products in the logistics chain. Properly selected packaging not only contributes to reducing losses in the logistics chain, but the use of modern packaging materials, well-thought-out forms of construction, or functional labels allows increasing the efficiency of logistics processes (Verghese, *et al.* 2013). The development of new materials and packaging construction forms could improve the efficiency of logistics processes, contribute to better use of resources and reduce their losses (Poyatos-Racionero, *et al.* 2018).

The efficiency of logistics systems and packaging solutions in supply chains is becoming more and more important not only in terms of reducing potential losses, but also contributes to increasing the competitiveness of enterprises (Zachłowski, 2016). Choosing the right packaging may contribute to reducing unnecessary stocks, streamlining logistics processes, more precise information about the cargo, and above all, to better securing the goods in transport and storage (Lydekaityte & Tambo, 2020). Traditional packaging and packaging materials provide all the above-mentioned logistic and information functions, but the development of new packaging solutions raises their functionality and usability to a higher level. Increased packaging demands are caused by the increasing speed, scale, and complexity of modern logistic processes. This is especially exaggerated in e-commerce and omni-channel retail (DHL, 2020).

Nowadays, the packaging is struggling to keep up with the changes in customers' behavior, the rise in e-commerce, and the growing demand for sustainability (DHL, 2020). Modern packaging can increase the availability of current information about packed goods and conditions for the implementation of logistics processes, which in turn will enable a quick response to changes in the supply chain. Solutions in the field of intelligent packagings, such as Time Temperature Indicators (TTIs) or packaging integrity indicators are already available on the market. Together with constantly developed indicators of food freshness, could signal directly undesirable changes in the product environment, which in turn affect the condition of packed goods (Shaefer & Cheung, 2018). These freshness indicators can provide information on the actual condition of the packed goods and thus indicate to the members of the supply chain the actual use-by date of the products (Herbon, *et al.* 2012). More efficient flow of information about goods is additionally possible through the introduction of modern data carriers,

also included in the elements of intelligent packagings, such as radio-frequency identification (RFID) systems (Müller & Schmid, 2019). RFID systems associated with electronic sensors (*e.g.* temperature and/or humidity sensors) are the most advanced example of intelligent packaging elements that can be used to increase the efficiency of supply chains and reduce product losses occurring in them (Ghaani, *et al.* 2016, Cerqueira, *et al.* 2019). On the other hand, the technologies of the Internet of Things (IoT) and other electronic solutions (*e.g.* e-printing techniques) enable the introduction of smart packaging, which significantly expand the information possibilities of packaging.

Packaging functions in the supply chain

The physical flow of goods in the supply chain often depends on the use of packaging adapted to the properties of the packed goods and the conditions in which they will be transported/stored. In many cases, the packaging allows for the separation of a certain amount of goods that will be distributed in the logistics chain. The selection of the appropriate material (*e.g.* with the required barrier properties) and the design of the packaging allows for the protection of the packed goods against adverse environmental factors, as well as against uncontrolled release of the packaging content (Kozik, 2020). The protection of the goods by the packaging is considered the most important logistic function of the packaging, which should protect the cargo against loss or deterioration of quality on the way from the manufacturer to the consumer and protect the goods against mechanical and climatic stress during shipment (Unilever, 2009).

Good functionality of packaging in the supply chain is associated with improved handling of packaged goods as well as increased efficiency of transport and storage through the use of appropriate packaging. Improving the manipulation of goods in the supply chain using packaging facilitates the convenient handling of goods by individual participants in the supply chain. In this regard, the type of supply chain and the number/nature of its participants must be taken into account. In conventional (“brick-and-mortar”) retail, most products are organized in palletized load units and shipped from a producer, through a distribution center/wholesaler to the retail store (Fig. 1a). It is a streamlined, linear, and simple supply chain that require packaging that can be easily grouped on a pallet (Heck & Ward, 2019). In the increasingly important e-commerce, parcels are handled up to 20 times more than in traditional retail and go through more extensive supply chains (Fig. 1b). The packaging must be adapted to the frequent forming and disassembling of unit loads.

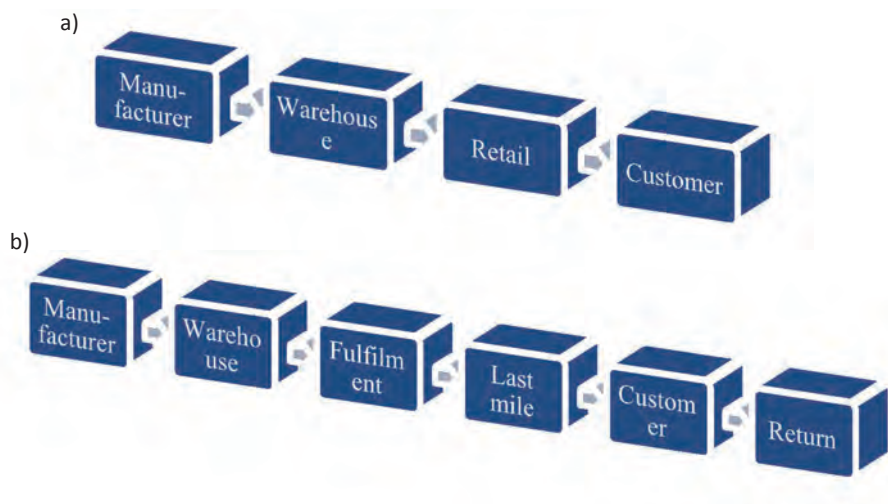


Figure 1. Comparison of packed goods transportation in the supply chain in traditional retail (a) and e-commerce (b)

Source: own work based on (Heck & Ward, 2019).

In the context of increased transport efficiency, packaging should provide not only good cargo securing, but also facilitate the transport of goods, with a relatively low weight of the packaging itself. In addition, the dimensions and shapes of the packaging should allow for the optimal use of means of transport. A similar requirement applies to an efficient storage process for packaged goods (Knauf Industries Automotive, 2021). Regular and stable shape packages should allow for efficient use of the capacity of storage devices or storage space when stacking goods on top of each other. There is also an ecological context here, because the packaging, after its use in logistic processes, should either be reused (reusable packaging) or be suitable for recycling, minimizing the negative impact on the environment as much as possible.

The packaging is a carrier of information about the packed product, which may be of a marketing and typically logistic nature. The latter includes information useful in handling and storage processes, such as data identifying the packed goods, their quantity, and instructions on their proper transport and storage (Kozik, 2020). The information obtained in this way facilitates the efficient flow of goods in the supply chain. It is also related to legible marking and labeling of packages, which should enable fast and reliable identification of goods, and constitute the basis for the automation of the flow of goods in the supply chain.

Packaging optimization and automatization in the supply chain

The selection of optimal packaging in the supply chain is a challenge especially in a complex and fast-moving environment where every shipment has very little preparation time. According to data provided by DHL, approximately 24% of the volume of an average transport packaging is empty (Heck & Ward, 2019). In some e-commerce branches, the parcels sent can contain up to 40% of air, moreover. The use of inefficient packaging in the supply chain with mismatched (too large) dimensions to its content is associated with the fact that we bear the costs of packing, transporting, and storing not used space. On the other hand, the wrong selection of too small packages for goods (not properly securing their contents) may increase the risk of damage to the goods during transport (Kaszubowski, 2016). Quickly making a good decision about the choice of packaging (including the preparation of a loading unit) requires the ongoing collection and processing of data on goods appearing in the supply chain. Automatic Data Collection (ADC) systems based on barcodes placed on the packaging allow for quick gathering of information about the packed goods and their properties. An even more efficient collection of information about the goods can be ensured by the introduction of intelligent packaging equipped with optical 3D codes (*e.g.* QR codes) or RFID (Radio-Frequency Identification) tags. Easily available and reliable information about the product allows the supply chain participants to adjust the optimal packaging both in terms of shape and size, as well as following other properties required by the product. The constantly developing IT support in the form of software for optimizing the formation of load units enhances the effectiveness of the logistics chain and allows for the automation of some of its processes. Specialized computer programs (connected with IoT technologies) facilitate the planning of the packaging needed to secure the goods, optimize the use of space on the pallet (by organizing, for example, multi-item shipments), or help to efficiently arrange loads in means of transport or storage areas (*e.g.* as a part of Warehouse Management System software) (Blanck, 2015). Labels and codes placed on the surface of the packaging, as well as electronic tags or chips placed in loads, allow for automatic location of goods in supply chains and protection against product fraud and counterfeiting.

The choice of packaging during storage and transport is a balancing act between the degree of protection of the goods (packed product compatibility), the efficiency of packaging filling and use of cargo/warehouse space, and a cost reduction (Blanck, 2015). Of course, the use of limited packaging variations for a wide range of goods is the simplest solution from an operational point of view, but not necessarily the most optimal packaging choice in the supply chain. On the other hand, the use of packaging with the optimal structure for each type of packed goods increases the complexity of logistics operations and increases costs. Participants in individual supply chains must find a balance between the optimal

variety of goods packaging, the efficiency and complexity of their application, and the costs of use and disposal (Kaszubowski, 2016). A symbol of our time and the development of e-commerce is the significant increase in the types of cardboard boxes commonly used for the distribution of goods in this supply chain. Courier companies have expanded the range from a few or a dozen standard boxes to over twenty models. Fortunately, most of these types of packaging are easily recyclable, which is another important trend in the selection of packaging in supply chains – sustainable development and increasing environmental awareness.

Sustainable packaging technologies and eco-friendly materials

Packaging in the supply chain can be both an environmental problem and a tool to improve the chain's impact on the environment. The negative aspect of irresponsible packaging application in transport and storage is the generation of large amounts of packaging waste, especially those that are difficult to recycle. Large corporations implement long-term programs to reduce packaging waste and introduce environmentally friendly packaging solutions (Nestle, 2020). Table 1 presents an average packaging time of use in the supply chain and average decomposition time of popular packaging types. Cardboard boxes, which are the most widely used packaging, have a relatively long average lifetime, but also a short decomposition time (and high recyclability). The most problematic are packaging, which has a relatively short average life in the supply chain but represents a significant environmental burden (if not recycled efficiently).

Sustainable packaging materials will be the number one near-future packaging priority, it should be developed to provide the lowest environmental impact maintaining the required functionality (Unilever, 2009). Already, there is a great social emphasis on replacing plastic disposable packaging and plastic wrapping materials with substitutes that would be environmentally friendly. This is followed by legal requirements that impose a more sustainable approach on packaging users. Nevertheless, the appropriate selection of packaging must meet the rigor of profitability and meet the expectations of consumers and other members of the supply chain (Kozik, 2020). A sustainable approach to packaging could be enhanced through the widespread use of eco-friendly and/or reusable packaging materials and closed-loop recycling programs. This latter solution is a particularly difficult undertaking from the point of view of maintenance of cost-effective systems of reusable packaging, which include so-called reverse logistics processes (Knauf Industries Automotive, 2021). The sustainability of packaging in the supply chain should follow the principles of waste hierarchy: reduce, reuse and recycle (Unilever, 2009).

Table 1. Packaging lifetime comparison

Typical packaging used in the supply chain	Average time of packaging use	Average time to packaging decompose
Cardboard box	2 days	2 months
Plastic bag	1 hour	20 years
Polystyrene cup	0.5 hour	50 years
Aluminum can	1 day	200 years
Plastic bottle	4 days	450 years

Source: own work based on (Heck & Ward, 2019).

The most popular method of securing load units (mainly pallet units) is the use of stretch film. Plastic shrink wrap materials seem ideal because of their low price, versatile and easy application, and high usability, but supply chains generate huge amounts of packaging waste that needs to be managed by customers (Kozik, 2020). To reduce the negative impact of supply chains on the environment, materials such as plastic shrink and stretch films are replaced with recyclable materials, high-efficiency fiber-reinforced stretch films (reducing the amount of packaging waste), re-usable alternatives to plastic films (*e.g.* pallet lid-and-strap systems) or are removed from the use in favor of *e.g.* removable joints between packages.

The idea of sustainable development in the supply chain is fulfilled very well by the introduction of closed-loop logistics models with durable, multi-trip packaging applications. This model of using packaging is particularly advantageous in the flow of goods in B2B exchange, but can also be used in e-commerce. The scale of returns in e-commerce reaches 30% and the introduction of returnable packaging will reduce the amount of generated packaging waste in disposable postal parcels (Heck & Ward, 2019). The use of reusable packaging in B2B exchange seems easier to implement, but here it is also necessary to maintain the economic and technological profitability of activities in the field of cleaning, inspecting, and storage of reusable packaging. Therefore, the reverse logistics system should also include deposit schemes, discounts for the return of containers, and no refund fees.

Smart packaging

Smart packaging technologies, which are applicable in the supply chain, focus mainly on strengthening the connection between the customer, the supply chain, and the package through real-time updates on the condition and location of the packed product (Lisińska-Kuśnierz, 2010). The monitored parameters are very useful in supervising both transport and storage of goods, and the information obtained in real-time can improve the operation of the supply chain and support

the decision-making process of each of its participants (Shaefer & Cheung, 2018; Tichoniuk, 2019). Intelligent packaging systems rely on indicators and sensors, but in combination with modern methods of data collection and transmission are recognize as a wider group of smart packaging. Some smart packaging technologies are already applied in the supply chains (e.g. Time Temperature Indicators (TTIs), Radio Frequency Identification (RFID) tags) or are intensively developed but the cost of their implementation and/or technical limitations slow down the spread of these technologies (Fuertes, *et al.* 2016; Mlalila, *et al.* 2016). Nevertheless, this barrier is becoming easier to overcome – for example, the average cost of using a sensor in a package was around 1.30 USD in 2005, and in 2020 it was estimated at less than 0.40 USD (Fazio, Herrmann & Duckworth, 2018).

The majority of smart packaging is based on indicators or sensors monitoring a specific parameter(s) of the product or its environment and provide information about the presence or concentration of a certain chemical compound or the intensity of the phenomenon under study is checked (Ahmed, *et al.* 2018). The most popular types of intelligent packaging used in the supply chains are packaging equipped with time and temperature indicators (TTIs), packaging tightness indicators (gas sensors), and freshness indicators (mainly used for food packaging). The examples of popular intelligent and smart packaging available on the market are shown in Table 2.

Table 2. Examples of intelligent and smart packaging applicable in the supply chain

Intelligent / smart packaging (manufacturer)	Type of packaging system
3 M Monitor Mark™ (3 M Company)	Time temperature indicator
Fresh Check® (Temptime Corp.)	Time temperature indicator
OnVu™ (Freshpoint and Ciba)	Time temperature indicator
VITSAB® (VITSAB International AB)	Time temperature indicator
Ageless Eye® (Mitsubishi Gas Chemical)	Oxygen (packaging integrity) indicator
Fresh Tag® (COX Technologies)	Freshness indicator
RipeSense (RipeSense)	Freshness indicator
Easy2log® (CAEN RFID Srl)	RFID tag with time temperature sensor
CS8304 (Convergence Systems Ltd.)	RFID tag with time temperature sensor
TempTRIP (TempTRIP LLC)	RFID tag with time temperature sensor

Source: own work based on (Fuertes, *et al.* 2016; Ahmed, *et al.* 2018; Poyatos-Racionero, *et al.* 2018).

The last three smart packaging systems presented in Table 2 are a combination of a temperature and time sensor with a device that enables data transmission

via radio waves (not in a visual way). Radio Frequency Identification (RFID) systems are a kind of successor of automatic optical recognition technologies because they offer a contactless and not visual transfer of information in real-time (Müller & Schmid, 2019). RFID tags have various forms and are generally divided into groups of active, semi-active (semi-passive), and passive devices depending on their design (mainly related to the type of power supply of a given device). Transmission of data through the transmission of electromagnetic (radio) waves between RFID tags and receivers located in means of transport, elements of warehouse equipment and in mobile devices controlling the course of logistics processes, improves the flow of information about loads in the supply chain and increases the possibility of tracking them during transport and storage (Ahmed, *et al.* 2018).

A quick indication of the packed product condition or information about its surroundings can be provided by smart labels printed with thermochromic or photochromic ink – sensitive to changes in temperature or light intensity, respectively. Electroactive labels are also paying more and more attention in the supply chain. An integrated e-ink display is offered for example by E Ink Holdings and LivingPackets. which can change a the information on shipping label up to 1000 times on the reusable packaging called THE BOX (NS Packaging, 2020). Another example of a smart label is a self-illuminating tag based on organic light-emitting diode (OLED) technology produced by Inuru company (Inuru, 2021). The information on the OLED label is lighted up or animated depending on the programmed actuator – touch, motion, or approaching the integrated sensor. Such smart labels significantly increase the responsiveness of the packaging surface and the possibility of direct transmission of information through them.

Conclusions

Packages are designed and applied in the supply chains to fulfill many different functions important for its users. Traditionally, they protect goods against adverse factors in the supply chain, facilitate their transport and storage, enable identification and location in the chain, and provide users with information about the goods. Optimal adjustment of the construction form and packaging materials to the characteristics of the packed goods and the conditions of the logistic processes allows to increase their efficiency and introduce automation, if necessary. The selection of packaging also affects the cost-consumption of individual supply chains and their impact on the environment. Modern supply chains can implement a policy of sustainable development by introducing reusable packaging, packaging materials that are recyclable or made of environmentally friendly components (*e.g.* highly biodegradable). Increased control over individual elements of the supply chain can be obtained by introducing smart packaging,

which ensures ongoing monitoring of the condition of the packed goods or their surroundings and/or more efficient information transfer between participants in the chain.

References

- Ahmed, I., Lin, H., Zou, L., Li, Z., Brody, A.L., Qazi, I.M., Lv, L., Pavase, T.R., Khan, M.U., Khan, S., Sun, L. (2018). An overview of smart packaging technologies for monitoring safety and quality of meat and meat products. *Packaging Technology and Science*, 31, 449–471.
- Blanck, T. (2015). How IKEA Saves Millions Through Packaging Optimization, <https://www.chainalytics.com/ikea-save-millions-packaging-optimization/> (access: 02.06.2021).
- Cerqueira, M.A., Nurmi, M., Gregor-Svetec, D. (2018). Intelligent Packaging. Industry Leaflet, <http://www.actinpak.eu/leaflets-intelligent-packaging/> (access: 01.06.2021).
- DHL (2020). 5 ways the logistic industry can rethink packaging in 2020, <https://lot.dhl.com/5-ways-the-logistics-industry-can-rethink-packaging-in-2020/> (access: 01.06.2021).
- Fazio, F., Herrmann, D. Duckworth, D. (2018). Capturing value from the smart packaging revolution, <https://www2.deloitte.com/us/en/insights/industry/retail-distribution/smart-packaging-how-to-create-and-capture-value.html> (access: 02.05.2021).
- Fuertes, G., Soto, I., Carrasco, R., Vargas, M., Sabattin, J., Lagos, C. (2016). Intelligent Packaging Systems: Sensors and Nanosensors to Monitor Food Quality and Safety. *Journal of Sensors*. vol. 2016, article ID 4046061.
- Ghaani, M., Cozzolino, C.A., Castelli, G., Farris, S. (2016). An overview of the intelligent packaging technologies in the food sector. *Trends in Food Science Technology*, 51, 1–11.
- Heck, M., Ward, J. (2019). Rethink Packaging. A DHL perspective on the future of packaging in logistics industry. *DHL Trend Research*, Bonn, Germany.
- Herbon, A., Levner, E., Cheng, E. (2012). Perishable Inventory Management and Dynamic Pricing using TTI Technologies. *International Journal of Innovation, Management and Technology*, 3(3), 262–266.
- Inuru (2021). Atomic packaging. Bright with impact, <https://www.inuru.com/products> (access: 02.06.2021).
- Kaszubowski, R. (2016). What is Packaging Optimization? The Complex Role of Packaging, <https://www.chainalytics.com/packaging-optimization-complex-role-packaging-defined/> (access: 25.05.2021).
- Knauf Industries Automotive (2021). Packaging in logistics and packaging management. What do you need to know about optimization of the logistics in a production company?, <https://knaufautomotive.com/packaging-in-logistics-vs-packaging-management-what-do-you-need-to-know-about-optimization-of-the-logistics-in-a-production-company/> (access: 25.05.2021).

Kozik, N. (2020). Sustainable packaging as a tool for global sustainable development. *SHS Web of Conferences. Globalization and its Socio-Economic Consequences*, 74, 04012.

Lisińska-Kuśnierz, M. (2010). Społeczne aspekty w opakowalnictwie. Kraków: Wydawnictwo Uniwersytetu Ekonomicznego.

Lydekaityte, J., Tambo, T. (2020). Smart packaging: definitions, models and packaging as an intermediary between digital and physical product management. *The International Review of Retail. Distribution and Consumer Research*, 30(4), 377–410.

Mlalila, N., Kadam, D.M., Swai, H., Hilonga, A. (2016). Transformation of food packaging from passive to innovative via nanotechnology: concepts and critiques. *Journal of Food Science and Technology*, 53(9), 3395–3407.

Müller, P., Schmid, M. (2019). Intelligent Packaging in the Food Sector: A Brief Overview. *Foods*, 8, 1–16.

Nestle (2020). The Rules of Sustainable Packaging. Société des Produits Nestlé. Vevey, Switzerland.

NS Packaging (2020). E Ink and LivingPackets' new packaging solution can be reused up to 1,000 times, <https://www.nspackaging.com/news/e-ink-livingpacket/#> (access: 01.06.2021).

Poyatos-Racionero, E., Ros-Lis, J.V., Vivancos, J.-L., Martínez-Máñez, R. (2018). Recent advances on intelligent packaging as tools to reduce food waste. *Journal of Cleaner Production*, 172, 3398–3409.

Shaefer, D., Cheung, W.M. (2018). Smart Packaging: Opportunities and Challenges. 51st CIRP Conference on Manufacturing Systems. *Procedia of CIRP*, 72, 1022–1027.

Tichoniuk, M. (2019). Innovative packaging improving food quality and extending its shelf life. *Polish Journal of Commodity Science*, 1(58), 21–35.

Unilever (2009). Sustainable packaging?, https://www.unilever.com/Images/sd_sustainable-packaging--2009_tcm244-409779_en.pdf (access: 25.05.2021).

Verghese, K., Lewis, H., Lockrey, S., Williams, H. (2013). *The role of packaging in minimising food waste in the supply chain of the future*. Melbourne: Centre for Design, RMIT University, Australia.

Zachłowski, P. (2016). Inteligentne opakowania jako narzędzie budowania przewagi konkurencyjnej przedsiębiorstwa. *Zeszyty Naukowe Wyższej Szkoły Ekonomiczno-Społecznej w Ostrołęce*, 2(21), 92–107.

Zenka-Podlaskewska, D., Tichoniuk, M. (2012). The role of packaging in supply chain risk management. In: J. Lewandowski, A. Walaszczyk, M. Sekieta (ed.). *Product and packaging. Tendencies for development in logistics*. Łódź: Wydawnictwo Politechniki Łódzkiej, 183–198.

SELECTED ASPECTS OF ROAD TRANSPORT OF FRESH PRODUCTS

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Abstract

The article presents selected aspects and problems of operating in the road transport of fresh products industry in general and on the example of a company dealing with international fruit and vegetable deliveries.

Transport of fresh products must be carried out in accordance with applicable formal and legal acts, since the health and even life of consumers depend on the proper condition of the products. The most important documents regulating issues related to the transport of these goods include the Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage (ATP). In this document, e.g. the temperatures at which individual products should be carried are defined. Meeting certain requirements is not the only problem faced by companies operating in this industry. The seasonality of product supply and demand is also an important issue.

In the article, the legal requirements for the transport of fresh fruit and vegetables are presented and the analysis of selected problems occurring in this industry based on data on deliveries from years 18-19 is performed. Factors affecting the occurrence of the problems are identified and measures are proposed to increase the effectiveness of the enterprise being the subject of the analysis.

Keywords: road transport, food products, fresh products, seasonality, food safety

Introduction

The carriage of food products is one of the biggest challenges in the transport industry, mainly because the health of consumers depend on a properly

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organized transport process of this type of products (Satora & Szkoda, 2019; Satora, Gajewska & Szkoda, 2019). Particularly noteworthy among food products are perishable goods, i.e. goods that perish easily and require protection against exposure to high or low temperatures during transport. According to the ATP agreement (Journal of Laws of 2015, item 667), perishable products include, among others such goods as: fish, meat, fresh fruit and vegetables or frozen products. The transport of fresh fruit and vegetables is a technical challenge, as these products are living organisms, both during the vegetation period and after harvest, in which physiological processes are constantly taking place, which cause their ripening and aging (Górecka-Orzechowska & Raczek, 2012; Tanner, 2016). Due to the specificity of raw materials (fruit and vegetables), companies operating in the industry are obliged to maintain the cold chain in order to ensure the health safety of consumers. It consists in providing a constant (specified by the manufacturer) temperature to the cooled products along the entire route from production to purchase by the final buyer (Baran & Sint, 2014; Szulc & Łukawska, 2009) Transporting perishable goods in unsuitable conditions not only carries huge financial losses, but also poses a threat to the health of consumers. Transport of this type of goods must therefore take place quickly and taking into account many formal and legal requirements regarding its quality and safety (Satora & Szkoda, 2019; Wasiak & Leleń, 2018). However, meeting legal requirements is not the only problem that companies dealing with food transport may encounter.

The aim of the article is to present and analyze selected problems occurring in the road transport of fresh products in general and on the example of a company dealing with international fruit and vegetable deliveries. In the article, the market of road transport of food products in Poland is presented in order to illustrate the number of these products transported by this mode of transport. Then the selected aspects of road transport of fresh products, more specifically fresh fruit and vegetables are presented – in general terms and on the example of a selected company operating in this industry. In general, the problems resulting from the legal acts in the field of road transport of perishable products, which include fresh products, are illustrated. The requirements for means of transport and temperatures inside the vehicle loading space are presented. Then, the remaining aspects are analyzed using the example of a company dealing with international transport of fresh fruit and vegetables.

The market of road transport of food products in Poland

In order to present the market of road transport of food products, i.e. to show what quantities of products are transported annually in Poland by means of road transport, statistical data from the studies entitled “Transport – activity results” of the Central Statistical Office in Poland from years 2015-2019 were used. However,

statistical data do not directly provide information on the volume of shipments of this type of product. There is also a lack of detailed information on the volume of perishable goods shipped. For the purposes of this article, two groups of products have been classified as food products, i.e. (I) products of agriculture, hunting and forestry; fish and other fishery products and (II) food, beverages and tobacco.

The article focuses on issues related to the road transport of food products, mainly due to the fact that in 2019 the largest number of loads was transported by means of transport of this branch, which is illustrated by the data in Table 1.

Table 1. Transport of goods by mode of transport in 2019 in Poland

Mode of transport	The volume of freight [thousand tons]	Share in the total number of transported goods [%]
Road transport	1.506.450	85.902
Railway transport	233.744	13.329
Maritime transport	8.727	0.498
Inland waterway transport	4.680	0.267
Air transport	77	0.004

Source: based on: Central Statistical Office, 2019.

Based on Table 1, it can be concluded that in 2019 over 80% of products were transported by means of road transport. The second place was taken by rail transport, whose share in the transport of cargo is 13.3%. It is therefore advisable to focus on the aspects related to road transport of this type of product.

In Table 2 numerical data on road transport of food products in Poland in 2015-2019 is presented.

Table 2. The volume of road transport of food products in Poland in years 2015-2019 in thous. tonnes (I – products of agriculture, hunting and forestry; fish and other fishery products, II – food products, beverages and tobacco)

Year Group of products	2015	2016	2017	2018	2019
I	92.497	100.647	116.572	104.322	93.237
II	140.160	140.386	177.968	162.395	154.529
SUM	232.657	241.033	294.540	266.717	247.766

Source: based on: (Central Statistical Office, 2015-2018; Central Statistical Office, 2019).

In the table above it is shown that over 200,000 thousand tonnes of food products are transported annually by road means of transport. This proves that the issues related to road transport of food products, including fresh products, are extremely important and problems occurring in the industry, including individual enterprises, are worth further analysis.

Based on the data of (Central Statistical Office of Poland, 2019) on road transport of loads by vehicle body types, it can be determined that in the year 2019, 88,015 thousand tonnes of load were transported with the use of temperature controlled boxes. This may also include perishable products, which, according to the information contained in the introduction, must be transported at strictly defined temperatures.

In the following part of the paper, emphasis will be placed on issues related to the road transport of perishable products, including fresh products, and more specifically fresh fruit and vegetables.

Formal and legal requirements in the field of road transport of perishable products

Adapting to the formal and legal requirements in the field of road transport of perishable products is one of the most important aspects in this industry. Any deviation from the standards may pose a threat to the health and even life of consumers. That is why it is so important to strictly comply with national and international regulations regarding the transport of food products by road and take care of the proper operational condition of vehicles transporting these loads as well as devices responsible for temperature monitoring and proper product control. The most important regulations in the field of road transport of perishable products include the Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such Carriage (the ATP agreement) and Hazard Analysis and Critical Control Points System (HACCP), which will be briefly characterized in the following subsections.

The ATP Agreement

The Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such Carriage was drawn up on 1 September 1970 (Journal of Laws of 2015, item 667) in Geneva. In Poland, it was legalized in 1984. This document contains numerous standards and requirements that must be respected during the transport of perishable food products from the moment of loading to unloading in a designated place in order to ensure the high quality of goods, their healthiness and properties (Journal of Laws of 2015, item 667).

The ATP Agreement describes articles that can be referred to as perishable food products, the temperatures that must be met during the transport and storage of deep-frozen and frozen products. Temperature is one of the most important factors that ensures the freshness of products, therefore the cooling unit has the obligation to maintain or lower temperatures in the vehicle body.

The countries that decide to conclude an ATP Agreement are guided by the growing need for healthy and ecological nutrition of consumers, and by themselves seek the best possible improvement in maintaining the high quality of perishable products during their transport. An additional aspect that decided about the accession of countries to the ATP Agreement was and still is a large development of export and import of food products.

Hazard Analysis and Critical Control Points System (HACCP)

In order to guarantee the freshness, high quality and taste of the transported goods to the recipients, short transport time and equipment are not enough. It is also necessary to implement appropriate systems that will help ensure and meet specific requirements.

The main and most important system for managing the safety of transported food is the HACCP system (Hazard Analysis and Critical Control Points System). The genesis of HACCP was originally characterized at the 1971 food convention. The next important stage was the event in 1980, where the International Commission on matters related to Microbiological Food Requirements presented the official regulations and procedures regarding this system. In Poland, this structure is required to protect the safety of food products in all companies involved in their production. The HACCP concept consists of the detailed identification, observation of food products and monitoring of emerging dangers, both biological, physical and chemical, in order to protect them against threats from the moment of obtaining resources through subsequent steps such as preparation of measures, modification, packaging and consolidation, serving and distribution of these products, until food is placed on the domestic or international market (European Commission, 2004). The use of the HACCP system in the transport and distribution of food enables ensuring its health safety, as well as minimizing losses resulting from the necessity to withdraw raw materials and products of insufficient quality from the market, which are caused by mistakes made during these processes.

Conditions for road transport of fresh products

In this chapter, the requirements regarding the conditions of transport of fresh products, resulting from applicable legal regulations, will be presented. The means of road transport, and more specifically the types of bodywork for transporting such products, and the required temperatures inside the cargo space of the vehicle for selected types of fruit and vegetables will be specified. Choosing the right means of transport and maintaining the right temperature inside the cargo space has a huge impact on the safety and quality of the transported food. This is one of the most important aspects in the road transport of fresh products.

Types of trucks for transporting fresh products

Companies that deal with road transport of food products must at the very beginning of their activity find out what vehicles must be used to deliver such products. The list and division of vehicles intended for transporting food products have been presented in detail in the ATP Agreement. The selection of the appropriate mean of transport by the carrier depends primarily on the temperature required by legal norms for individual groups of food products during transport.

The main division of vehicles for the transport of food products is as follows (Journal of Laws of 2015, item 667):

- vehicles with a refrigeration mechanism, so-called refrigerators,
- vehicles with heating equipment,
- tanker vehicles,
- isothermal transport vehicles, so-called isotherms,
- vehicles with a cold tank, so-called ice-makers. In this type of vehicle, as the following factors can be used to provide the required cold:
 - dry ice,
 - natural ice with or without salt,
 - eutectic boards,
 - liquefied gases.

In Table 3 the characteristic of chosen means of transport intended for transporting fresh products by road is presented.

In the above table, it is illustrated how many different factors affect the choice of the appropriate mean of transport in order to transport food products in a correct and safe way. The most important thing is to choose the right type of trailer for specific goods to be transported.

Table. 3. Characteristics of the chosen types of means of transport used for the road transport of fresh products, including fresh fruit and vegetables

The type of the mean of transport	Characteristics
Vehicles with a refrigeration mechanism, so-called refrigerators	<ul style="list-style-type: none"> • has an individual or general cooling mechanism, • it is a universal vehicle, • mostly used for transporting food products, • the maximum load is 22 tons, • the smallest possible temperature to obtain in the refrigerator is -35°C (used to transport deep-frozen articles), • standard dimensions of the cargo area are in the range of 82–92 m³, • the body must have a system that allows the inside temperature of the cooling tower to lower if the temperature in the environment is + 30°C, • maintains the right temperature on the entire route, • standard width of the body is 2.42–2.45 m, • standard body height is 2.45–2.7 m, • standard length of the body is 13.2–13.5 m, • capacity: 33 Euro-pallets, • these vehicles have 6 classes of refrigeration mechanisms, • vinyl or polyurethane foam, as well as foamed polystyrene and cork are used for insulation, • the body is made of thermal insulation boards, • refrigerator walls are made of sandwich panels, • the refrigerator floor has to maintain a pressure of 54 kN, which is possible due to additional reinforcements, • the whole structure of the cold store is connected by means of properly shaped locks, which ensures proper heat transfer of the corners and other elements of the refrigerator.
Isothermal transport vehicles, so-called isotherms	<ul style="list-style-type: none"> • walls, doors, floor and body roof are made of thermo-insulating materials, • this type of vehicle is used for the transport of perishable foodstuffs, • transported goods must be in refrigerated or frozen form, • used mainly for transportation of goods requiring temperature in the range from 0°C to + 16°C, • ensures adequate heat exchange between the middle of the trailer and the ambient temperature, • must ensure a certain temperature of the products, even if there is a negative temperature in the environment, • thermo insulated trailer, • the trailer does not have a refrigeration unit, • the isotherm is able to maintain the required temperature in the body on the principle of “thermos”.

Source: based on: (Journal of Laws of 2015, item 667).

Required temperatures in the transport of fresh fruit and vegetables

Another significant issue is to discuss the required temperatures in the loading area of vehicles for transporting food products. It is essential since their condition and high quality depends mainly on the control and maintenance of the

appropriate temperature during the transportation process. The temperatures that are required are strictly defined in the ATP Agreement. This act of law presents the most-specific list of foodstuffs, along with the temperatures discussed in detail during their transport. The ATP Agreement deals mainly with frozen and deep-frozen products as well as refrigerated food. Failure to meet the required temperatures is associated with high fines for the driver and high fines for the carrier. In Table 4 the required temperatures in accordance with the ATP Agreement of selected types of food products are shown.

Table 4. Required transport temperatures in accordance with the ATP Convention for selected types of food products

Product	Required temperatures	Limited time/transport conditions
Fruit		Storage period
lemon	10–11°C	1–6 months
Idared apple	3.5–4.5°C	5 months
Golden apple	1.5–2°C	4–6 months
strawberry	0°C	2–7 days
kiwi	from -0.5 to 0°C	2–3 months
watermelon	10–12°C	2–3 weeks
pear	from -1.5 to 0.5°C	2–7 weeks
plum	from -0.5 to 0°C	2–5 weeks
tangerine	4–8°C	3–8 weeks
cherry	from -1 to 0°C	2–3 weeks
peach	from -1 to 0°C	2–6 weeks
green banana	13–15°C	1–4 weeks
Vegetables		Storage period
cabbage	0–1°C	5–6 months
garlic	0°C	6–8 months
champignon	0°C	5–7 days
early season potato	10–15°C	10–14 days
late season potato	4–5°C	5–10 months
cucumber	8–11°C	1–2 weeks
beet	0–1°C	–
parsley	0–1°C	–
ripe tomato	8–10°C	1 week
onion	-1-0°C	1–8 months
pepper	7–10°C	2–3 weeks
carrot	0–1°C	3–6 months

Source: based on: (Journal of Laws of 2015, item 667).

In the table, it is presented data on the required temperatures during the transport of chosen types of food products and information on the time in which they can be stored or in which they should be transported. Such a precise characterization and attribution of specific food products to the temperature of their transport is great facilitation for both companies, carriers and drivers who have to monitor and control the temperature of the loading area during the whole transport. Transported loads should not have a higher temperature than the highest values of specific products in the table above. Their temperature should be constant both during loading, unloading and during transport.

Analysis of other aspects of the road transport of fresh fruit and vegetables industry on the example of company X

Earlier chapters discussed the problems encountered in the road transport of food products, including fresh products, in general. The legal acts regulating this type of transport and the resulting conditions of transport have been described. The remaining problems, on the other hand, will be specified on the basis of an analysis of data on road transport of fresh fruit and vegetables from company X operating in this industry.

Characteristics of the enterprise X

The company that is the subject of the research was established in 1992. Thanks to the combination of competence, experience, diligence, passion and courage of its founders, company X is one of the leading Polish distributors of fresh fruit and vegetables. The essence of the activity is the import of products from other countries and the wholesale deliveries of products in Poland. Table 5 shows the most common types of fruit and vegetables transported by the company.

Table 5. Types of fruit and vegetables transported by the company

Fruit	Vegetables
grape	broccoli
grapefruit	carrot
lemon	cucumber
orange	potato
peach	pepper
watermelon	tomato

Source: own elaboration.

In order to transport the above-mentioned products in appropriate conditions, the company has its own fleet of high-class refrigerated vehicles that allow maintaining the highest quality of the product on the way to the customer. This is especially important considering that more than 250 deliveries are made each week. It has the appropriate certificates confirming the quality of the services provided, as well as the products delivered to individual markets, such as: Hazard Analysis and Critical Control Points System (HACCP) certificate, GLOBAL G.A.P., International Featured Standards (IFS), AGRO EKO, Quality Scheme for Food (QS). The company has 23 refrigeration sets in its fleet. The table 6 shows the transport potential of the company with the number of available vehicles on a given day, the number of pallets and the volume of the transported cargo.

Table 6. The transport potential of the company X

Number of vehicles [pieces/day]	23
Number of transported pallets (EUR type pallets) [pieces/day]	759
The volume of transported cargo [tonnes/day]	506

Source: own elaboration.

The values given in Table 6 are average values. There may be deviations from these values due to the specificity of the goods transported. For example, 33 pallets of potatoes weigh about 22 tons, and 33 pallets of peppers weigh a maximum of 16 tons, therefore large differences in the weight of the goods can be observed, and in both cases the cargo space of the trailer is used along its entire length.

The company uses refrigerating sets consisting of a tractor unit and refrigerated semi-trailers with complete equipment for the transport of fresh fruit and vegetables. The use of this type of vehicle (in accordance with the provisions contained in the ATP agreement) enables the transport of goods at the required temperature, and thus the correct implementation of the transport process of fresh fruit and vegetables. The vehicles are regularly serviced so that they can meet the conditions of safe food transport and are checked in terms of the efficiency of cooling chillers. Having the right vehicles to carry out the transport of products is not the only aspect that entrepreneurs dealing with road transport of fresh fruit and vegetables must take into account. Activities in this industry may also be associated with the occurrence of other problems and challenges, which will be identified on the basis of the analysis of data concerning the performed transports.

Analysis of the data from the company

In this subsection the data on deliveries to domestic customers and imports carried out by the previously characterized enterprise will be analyzed. First, the data on loaded vehicles will be discussed, as well as the number of pallets and tonnes of fresh fruit and vegetables delivered to customers in individual months in 2018 and 2019. Then, data on imports of products from individual countries in each month of 2018 and 2019 will be presented. Comparison of data for the years 2018 and 2019 is made in order to determine whether similar regularities appear in the following years.

Table 7. Number of pallet loading units delivered to customers and the number of loaded vehicles in each month of years 2018 and 2019

Month	Number of vehicles loaded	Number of delivered pallets	Number of delivered tonnes
Year 2018			
January	967	30928	16392
February	988	31622	16760
March	1159	37097	19661
April	1039	33248	17621
May	987	31572	16733
June	1056	33792	17910
July	1456	46576	24865
August	1160	37120	19674
September	898	28728	15226
October	875	28013	14847
November	990	31675	16788
December	1165	37276	19756
Year 2019			
January	996	31856	16884
February	1018	32571	17263
March	1194	38210	20251
April	1070	34245	18150
May	1017	32519	17235
June	1088	34806	18447
July	1500	47973	25611
August	1195	38233	20264
September	925	29590	15683
October	901	28853	15292
November	1020	32625	17292
December	1200	38394	20349

Source: own elaboration.

Table 7 contains data on domestic loadings carried out on the territory of Poland in the individual months of 2018 and 2019. These are all loadings transported from the warehouse of company X to individual customers located in Poland.

On the basis of the above table, a problem in the form of irregularities in the deliveries can be observed. In the summer period, i.e. in July and August, the highest number of shipments throughout the year occurs. This regularity can be noticed in the case of both analyzed periods. Two other months, March and December, are also important. The number of products shipped also increased during these months. This is due to the fact that then it is Easter and Christmas, so there is an increased demand for products. Therefore, the irregularity of supplies is caused by the seasonality of demand.

According to the information presented in the previous section, company X deals with the import of fresh products from other countries and their delivery to customers in Poland. Table 8 shows the number of vehicles loaded in each direction in 2018–2019.

Based on Table 8, the irregularities in the number of loaded cars in individual months of 2018 and 2019 can be also observed. The largest number of products is imported in such months as February, March, December, May and August. This is due to, *inter alia*, the previously observed seasonality of the demand for fresh fruit and vegetables. Company X tries to provide the number of products required by the recipients for such periods as Christmas or Easter, as well as during the summer season. In addition, it is also necessary to take into account the number of loaded cars in individual countries and the products that are imported from them. Therefore, another factor causing the irregularity of transports may be the seasonality of the supply of fresh fruit and vegetables. The phenomenon of the seasonality of supply is strictly associated with harvest periods of fresh fruit and vegetables which may be different for individual products. They could also be different depending on the country of origin of the product.

Knowing the factors which lead to the occurrence of the irregularity of deliveries, one can determine what actions can be taken in order to reduce it. In case of the analyzed enterprise, which deals mainly with international transport, reducing the impact of seasonality of supply and demand of fresh fruit and vegetables on its functioning can be obtained by seeking new producers and consignees, expanding operations on the domestic market or exporting products from Poland. It is also possible, for example, to expand the business to the transport of frozen products.

Table 8. Import of products from individual countries

	Number of vehicles loaded on each directions								
Month	Spain	France	The Benelux countries (The Netherlands, Belgium)	Italy	Greece	Turkey	Slovenia	Hungary	The total number of loaded vehicles in a given month
Year 2018									
January	322	10	69	71	0	2	61	0	535
February	224	42	67	35	0	0	39	0	407
March	200	65	117	64	2	1	33	0	482
April	129	25	129	35	0	0	0	0	318
May	69	17	199	61	0	0	0	0	346
June	34	11	117	31	19	10	0	1	223
July	48	2	153	42	7	0	0	82	334
August	31	0	57	42	0	1	0	30	161
September	21	0	17	69	1	7	0	5	120
October	121	19	31	42	0	5	0	0	218
November	295	18	87	28	1	19	2	0	450
December	369	14	101	32	10	23	7	0	556
Year 2019									
January	332	10	71	73	0	2	63	0	551
February	231	43	69	36	0	0	40	0	419
March	206	67	121	66	2	1	34	0	496
April	133	26	133	36	0	0	0	0	328
May	71	18	205	63	0	0	0	0	356
June	35	11	121	32	20	10	0	1	230
July	49	2	158	43	7	0	0	84	344
August	32	0	59	43	0	1	0	31	166
September	22	0	18	71	1	7	0	5	124
October	125	20	32	43	0	5	0	0	225
November	304	19	90	29	1	20	2	0	464
December	380	14	104	33	10	24	7	0	573

Source: own elaboration.

Conclusions

The article presents selected aspects of the road transport industry of fresh products. The market of road transport of food products in Poland was presented, then the selected legal acts related to the transport of perishable products were discussed. Next, the requirements for means of transport and temperatures in the cargo space for fresh products were described. Then, an analysis of the remaining problems was carried out on the example of a Polish company dealing mainly with the import of fresh fruit and vegetables and the delivery of these products to recipients in Poland.

Companies face challenges related to ensuring the quality and safety of transported food products, including the selection of appropriate means of transport and maintaining the temperatures in their cargo space required by legal acts. Problems in this industry result not only from the obligation to comply with the legal regulations in the field of the transport of perishable products, which include fresh fruit and vegetables, but also from other reasons related to the specificity of the transported cargo. One such aspect is the irregularity in the transport of fresh fruit and vegetables, which was illustrated by the example of a company dealing with international road transport of fresh fruit and vegetables. After analyzing the company's data regarding the number of products delivered to customers on the Polish market and the number of loaded vehicles from individual countries in years 2018 and 2019, it was determined that the irregularity of transport is related with the seasonality of supply and demand for this type of product. Actions aimed at reducing the scale of this phenomenon have been proposed, including searching for new producers or expanding the activity by exporting products from Poland or transporting frozen products.

References

- Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such Carriage (Journal of Laws of 2015, item 667).
- Baran, J., Sint, A. (2014). Organizacja transportu w sektorze przetwórstwa świeżych owoców i warzyw. *Logistyka*, 4, 3479–3486.
- Central Statistical Office (2019). Transport – activity results in 2019, Warsaw.
- Central Statistical Office (2015–2018). Transport – activity results from years 2015–2018, Warsaw.
- European Commission (2004). Regulation No. 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs, Brussels.

Górecka-Orzechowska, J., Raczek, A. (2012). Transport świeżych owoców i warzyw w kontrolowanej atmosferze. *Autobusy: technika, eksploatacja, systemy transportowe*, 5, 192–198.

Satora, M., Szkoda, M. (2019). Zapewnienie jakości i bezpieczeństwa produktów żywnościowych w transporcie drogowym. *Autobusy: technika, eksploatacja, systemy transportowe*, 6, 86–92.

Satora, M., Gajewska, T., Szkoda, M. (2019). Analysis of selected factors influencing the irregularity of deliveries of fruit and vegetables. In: A. Koliński, J. Strojny, D. Głowacka-Fertsch (ed.), *Contemporary challenges in supply chains*, 1. Radom: Instytut Naukowo-Wydawniczy Spatium.

Szulc, R.K., Łukawska, D. (2009). Unikalny proces dystrybucji żywności mrożonej realizowany w „łańcuchu zimna” przez Jago S.A. *Zeszyty Naukowe Wyższej Szkoły Zarządzania i Marketingu w Sochaczewie*, 8.

Tanner, D. (2016). Food Quality, Storage, and Transport, Start Afresh Limited, Mounth Maunganui, New Zealand.

Wasiak, M., Leleń, P. (2018). Uwarunkowania prawne realizacji przewozu ładunków szybko psujących. *Prace naukowe Politechniki Warszawskiej*, 120, 437–446.

QUALITY AND FOOD SAFETY MANAGEMENT SYSTEMS IN OFFICIAL STATEMENTS OF SELECTED FOOD SECTOR ORGANIZATIONS OPERATING ON THE POLISH STOCK MARKET

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Abstract

The main goal of the conducted researches is to get knowledge and analyze the official information on fulfilment of food safety and quality management systems aspects provided by the food organizations listed on the Polish Stock Exchange. The content analysis of reports of the management board on the company's activities issued by food organizations has been done. The reports were published in accordance with the requirements of Directive 2014/95/EU. Only food industry organizations were selected for the study. The total number of analysed companies was 18. Due to small population of food companies listed on the Polish Stock Exchange, the whole sample was analysed. As a result, it can be concluded, that the supplier standards such as BRC and IFS are more commonly mentioned by organizations that quality and food safety management systems based on ISO management standards. Moreover, the TQM philosophy is not any more a concept that is used in market communication. Considering the risks with relation to the quality or safety of products, it can be concluded, that generally food sector organizations that are listed on the polish stock market are well aware of that risks and usually mention it in the nonfinancial statements.

Keywords:

stock market, food safety, management systems, nonfinancial statements

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Introduction

The well-known definition of quality proposed in ISO 9000 series of standards, define quality as degree to which a set of inherent characteristics of an object fulfils requirements (ISO, 2015). In case of food and beverages products, that kind of requirements, among others, are related with food safety issues. It is a reason were quality management and food safety management systems have common goals and usually constitute a common area for the integration of these systems.

In accordance with the requirements of Directive 2014/95/EU of the European Parliament and of the Council of October 22, 2014 amending Directive 2013/34/EU with regard to disclosure of non-financial and diversity information by certain large entities and groups, introduced in national law by provisions contained in the Polish Accounting Act, in Article 49 para. 3, the report on the company's activities should include at least (EU, 2014; Journal of Laws, 1994):

- 1) key financial performance indicators related to the activities of the entity;
- 2) key non-financial performance indicators related to the entity's operations and information on employee issues and the natural environment.

Within the nonfinancial statements, there should be such information as (Journal of Laws, 1994):

- a brief description of the entity's business model,
- key non-financial performance indicators related to the business units,
- a description of the policies applied by an individual in relation to social and labor issues, the natural environment, respect for human rights and counteracting corruption, as well as a description of the results of applying these policies,
- a description of due diligence procedures – if the entity applies them as part of the policies listed above,
- description of significant risks related to the activities of the entity that may have an adverse effect on the issues referred to above.

In practice, that kind of statements usually contain the emphasis of the food safety and quality management systems implementations and other activities related to the topic of quality and safety issues.

Due to that, the main goal of the conducted researches as well as this paper is to get knowledge and analyze the official information about the food safety and quality management systems within the annual nonfinancial statements of polish food organizations listed on the Polish Stock Exchange.

Methodology

The main goal of the conducted researches is to get knowledge and analyze the official information on fulfilment of food safety and quality management systems aspects provided by the polish food organizations listed on the Polish Stock Exchange. This study followed an explorative approach. In order to answer the research questions, the research team performed a content analysis of reports of the management board on the company's activities issued by food organizations coming from Poland. Only food industry organizations were selected for the purpose of this study. The total number of analysed companies was 18, of which 14 are from the main market and 4 coming from the *New Connect* market. Due to small population of food companies listed on the Polish Stock Exchange, the whole sample was analysed. From the study, there were excluded organizations from polish stock market, that are registered abroad. Due to that, there is no requirement to publish official standards in Poland and in polish language. There were 10 organizations excluded. All statements from the 18 organizations were obtained from the polish official website dedicated to publish that data (<https://ekrs.ms.gov.pl/>) for the operation of which the Polish Ministry of Justice is responsible. Consequently, there were no restrictions in sample selection taking into consideration such items as its size, type of activity or others. For the purposes of this study, the latest available official reports on the activities of companies published in 2019 or 2020 were analysed. This study was a part of bigger project with methodology described in (Kafel & Nowicki, 2021). In Table 1 there is a description of organization's that nonfinancial statements were analysed.

Most often studied organizations were multi-plant structures in the form of holding companies. Within them the number of employees were between 41 and 1118, with the average of 523 people. Due to that most of them are big organizations. The detailed data concerning the employment was presented in Table 2.

The average number of pages of the analyzed report was 57. The extracted data were charted using Microsoft Excel forms. Next quantitative and qualitative content analysis was used to examine the data. Particularly, quantitative content analysis was managed in the manner in which it was originally conceived: to systematically identify, categorize and count the objective elements of the explored issue (Rourke & Anderson, 2004). Distinguished categories enabled the research team to describe food safety management systems activities in the selected sample. The results of the study are presented in the next section in accordance with the adopted theoretical framework.

Table 1. Description of studied organization's

No	Main type of activity	No	Main type of activity
1	Activities in the production, import and distribution of wines.	10	Fish processing products, mainly pickled and salted.
2	Production and processing of nuts and dried fruit as used in cooking.	11	Production, processing and sale of meat and meat products.
3	Trade and distribution of meat and meat products, slaughter and cutting of red meat, livestock and plant crops production.	12	Production of confectionery such as chocolates, sweets, bars.
4	Production of beer and beverages	13	Producer of food products mainly sweets, breakfast and cereal.
5	Import and sale of dried fruits and nuts, production of packaged dried fruits and nuts, production of cake masses and their distribution.	14	Producer of products based on vegetable fats (oils, margarines, fats).
6	A producer of energy drinks, classified as foods for nutritional uses and carbonated drinks.	15	Agricultural services, from agro-asset management to production high-quality oils (rapeseed, sunflower), soil quality testing, up to crop optimization.
7	Production and sale of pasta.	16	Selling gardening products as well as e.g. fertilizers, substrates or seeds.
8	Manufacture of meat products, including poultry meat products.	17	Trade and production of honey and bee products.
9	Processing of starch potato, crystalline glucose as well as potatoes farming.	18	Provision of warehouse and logistics services in a food sector.

Source: (Kafel & Nowicki, 2021).

Table 2. Number of people in the studied organizations

Number of employees	Number of organizations
Less than 50	1
From 51 to 250	6
From 251 to 500	2
From 501 to 1000	6
More than 1000	3

Source: based on (Kafel & Nowicki, 2021).

Results and discussion

Among studied organizations usually there were information's concerning the most popular quality and food safety systems. Only in case of 5 organizations there were no statements concerning quality or food safety management systems. For the other 13 organizations, more or less extensive references to the implemented quality or food safety management systems as well as product quality have been found. The most popular systems that were communicated to the readers of published statements were suppliers' requirements certified according to BRC (British Retail Consortium Global Standard for Food Safety) and IFS (International Food Standard) requirements. In 4 organizations there were mentioned food safety management system complied with ISO 22000 standard requirements. In two cases integrated with FSSC 22000. It is not surprise, that quality management system certified according to ISO 9001 was the least frequently indicated management system. Only 3 organization boasted with that particular management system. In Table 3 there are presented data concerning the management system implementation within studied organizations that are related to the quality or food safety.

Table 3. Examples of management systems in nonfinancial statements

Standard	Number of organizations
<ul style="list-style-type: none">▪ BRC▪ IFS▪ ISO 22000 and FSSC 22000▪ ISO 9001	<ul style="list-style-type: none">▪ 9▪ 7 (one within the logistic requirements)▪ 4 and 2▪ 3

Source: own study.

It is worth emphasizing, that supplier standards certification is much often addressed in the statements that standards published by ISO. It is not only due to the fact, that that standards are more popular within food sector organization (Kafel, 2017). Some of the companies in the sample, has the quality management system implemented and certified but did not include this information in the annual statement. It is possible, that quality management system certificate is not any longer an information worth underlining and present as and advantage. That conclusion is in line with other studies that indicate the decrease in the marketing benefits of ISO 9001 certification (Ferreira & Cândido, 2021). In one case, only environmental management systems were mentioned (ISO 14001 and ISO 50001) and integrated management system, but without the detailed list of integrated systems. The amount of different management systems could be the reason, why organization prefer to only inform about the integrated management system

(4 organizations) and do not give detailed list of them. In one statement, there was only the information that:

“...The company has implemented an Integrated Quality Management System, as well as quality certificates (IFS Food Standard and BRC Food Standard), which guarantee production at the highest level...”

The number and types of implemented systems can differ within the scope of implementation organizations. Studied organizations are usually big multi-plant holding companies. Different plans or even line of products can be certified according to unlike requirements. In that situation, it is easier to inform only about the general idea about the integrated management system.

References only to the environmental management systems without quality or food safety systems is part of the growing trend related to sustainability or organizations. The green economy, circular economy or sustainability is nowadays important factors of the market advantages for food sector companies (Sharma, Mangla & Patil, 2021).

In 3 organizations, there were information about the lean management. Lean is more general management concept than well specify standards such as e.g ISO 22000 or BRC. That can be compared to well-known TQM philosophy that was popular in the past. The TQM mentions, were not found within studied documents at all. The TQM it is not any more a concept worth advertising by companies even if there are similarities and common ideas between TQM and currently popular systems such as lean management. On the other hand, based on bibliometric analysis Lee & Hew (2018) claim that TQM still remains a current and relevant research topic at this moment. In that case, probably the organizations are ahead of scientists and are leading new trends.

Quality and food safety of products can be confirmed not only by management but also product and process certification. The possibilities related to voluntary certification in this area are very large. Within studied sample, there were identified such product certification schemes as: Q label issued by PCBC and the “Jakość-Tradycja” mark that is polish high quality food program. There was also one mention of organic food certification which is European high-quality food program. The more popular were mentions related to certificates of according to the requirements of religious groups. Certificates such as Kosher and Halal were mentioned respectively by 1 and 2 organizations. There was also mentioned *Vege* and *Gluten Free* marks.

Quality – is it a risk or chance?

In one of the statements, the authors of the organizations statement that were studied, claimed:

“Food safety issues have been classified as the main source of reputational risk for our business. Quality problems can potentially lead to product recalls and penalties that can materially affect the Company’s operations. We have implemented a rigorous quality control plan to mitigate food safety risks. We also have a food hygiene training and audit program to ensure that our high-quality standards are met.”

That kind of statement emphasizes the potential risk of low-quality food products. According to the minimal requirements of annual nonfinancial statements, there should be indication of significant risks related to the activities of the organization. Some typical risks, that were usually identified by organizations were: currency risk, risk of bad weather conditions, risk of changes in legal regulations or the risk associated with a covid-19 pandemic. The intriguing question was, if studied companies consider quality or food safety issues as a significant risk factors that can affect the financial performance of a holding.

Table 4. Examples of risks related directly with quality or food safety matters

Risk	Statement citation
<ul style="list-style-type: none"> ▪ Risk of complaints 	<p><i>...The quality of raw materials is closely related to the stages of growth, transport and storage. During these stages, the contamination of the raw materials can occur... The company maintains the ISO 9001:2015 quality management system certification, which aims to meet customer requirements and constantly improve the quality of manufactured products and services.</i></p>
<ul style="list-style-type: none"> ▪ Product liability risk 	<p><i>...Food production is associated with a number of specific requirements and regulations regarding production processes and labeling of food products. The companies of the Group meet the requirements in this respect, which is confirmed by the certificates held. However, there is a risk that a defective product or a product posing a threat to the health of consumers will be introduced to the sale...</i></p>
<ul style="list-style-type: none"> ▪ Risk to the health and life of the consumer 	<p><i>In the event of a sale of a product creating a threat to health or life, there would be ... the obligation to pay compensation for customers and consumers, and costs incurred in connection with the recall of the product and its disposal. The risk is low due to the implemented Quality and Food Safety Management System.</i></p>

Source: own study.

Risks related to quality or food safety were declared by 6 organizations, the other 12 did not indicate them directly. The group of organizations that indicate the quality and food safety risks were on average bigger than the organizations that

did not identify such risks. The average employment in the first group was 662 people and in the second group 486 people. An example of provisions directly related to quality and safety are described in Table 4.

In some cases, organization indicated other risk factors, at the same time referring to, e.g. poor product quality or loss of brand credibility related to product recalls. For example: “...*The level of prices of food raw materials is influenced by many factors beyond the control of the company, such as, for example, the size of the harvest in a given year, climatic conditions, affecting the quality and thus the price of raw materials or the availability of raw materials of the desired quality...*”. In Table 5 there are examples or topics related to the risks where quality or food safety are mentioned.

Considering the above-mentioned risks with relation to the quality or safety of products, it can be concluded, that generally food sector organizations that are listed on the polish stock market are aware of that risks. When the risk is given then usually the quality management and food safety standards are indicated as a way to minimize the risk. That is in line with the goals of the standards as well as results of other studies e.g. Spadoni, *et al.* (2014) or Smith (2019).

Table 5 . Examples of risks where quality or food safety matters

Risk	Statement citation
▪ Competition risk	<i>In order to eliminate this risk, the Company conducts activities aimed at strengthening its strong market position by providing high-quality products and building brand awareness...</i>
▪ Risk related to commercial contracts with customers	<i>... in the event of failure to comply with the terms of the contract (e.g. in terms of timeliness, quantity or quality of deliveries) ...</i>
▪ Risk of fluctuations in raw material prices	<i>...climatic conditions affecting the quality and availability of raw materials of the desired quality...</i>
▪ Risk of legal changes	<i>...quality teams follow all legal regulations regarding products and packaging on an ongoing basis, and changes required by law are implemented without undue delay...</i>

Source: own study.

Conclusions

The goal of the conducted researches as well as this paper is to get knowledge and analyze the official information about the food safety and quality management systems within the annual nonfinancial statements of polish food organizations listed on the Polish Stock Exchange. As a result, it can be concluded, that the supplier standards such as BRC and IFS are more commonly mentioned by

organizations that quality and food safety management systems that are based on ISO management standards. Moreover, the TQM philosophy is not any more a concept that is advertising by food sector companies. Considering the risks with relation to the quality or safety of products, it can be concluded, that generally food sector organizations that are listed on the polish stock market are well aware of that risks and usually mention it in the nonfinancial statements directly or indirectly.

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References

- EU, (2014). Directive 2014/95/EU of the European Parliament and of the Council of 22 October 2014 amending Directive 2013/34/EU as regards disclosure of non-financial and diversity information by certain large undertakings and groups Text with EEA relevance. *Official Journal of the European Union*, L 330/1
- Ferreira, L.M., Cândido, C.J. (2021). Factors influencing firm propensity for ISO 9001 withdrawal: Evidence on decertification tendency and antecedents. *International Journal of Production Economics*, 233, 108024.
- ISO, (2015). ISO 9000 Quality management systems. *Fundamentals and vocabulary*.
- Journal of Laws, 1994, Accounting Act (in polish) Dz. U. 1994 Nr 121 poz. 591 z późn. zm., Ustawa z dnia 29 września 1994 r. o rachunkowości.
- Kafel, P. (2017). *Integracja systemów zarządzania. Trendy, zastosowania, kierunki doskonalenia*. Kraków: Wydawnictwo UEK Kraków.
- Kafel, P., Nowicki P., (2021). Industry 4.0 Aspects in Official Statements of Selected Food Sector Organizations Operating on the Polish Stock Market, IEEE ICTE 2021 conference proceedings, DOI: 10.1109/ICTE51655.2021.9584547
- Lee, V.H., Hew, J.J. (2018). Is TQM fading away? A bibliometric analysis of a decade (2006–2015). *International Journal of Services, Economics and Management*, 8(4).
- Rourke, L., Anderson, T. (2004). Validity in quantitative content analysis, *Educational Technology Research and Development*, vol. 52, No. 1, 5–18.
- Sharma, Y.K., Mangla, S.K., Patil, P.P. (2021). Risks in sustainable food supply chain management. In: *Research Anthology on Food Waste Reduction and Alternative Diets for Food and Nutrition Security*, 265–280. IGI Global.
- Smith, D.L. (2019). Global Food Safety Initiative scheme audit requirements regarding cleaning tool and utensil selection and maintenance – a review. *Quality Assurance and Safety of Crops & Foods*, 11(7), 603–611.
- Spadoni, R., Lombardi, P., Canavari, M., Hingley, M. (2014). Private food standard certification: analysis of the BRC standard in Italian agri-food. *British Food Journal*, 116(1), 142–164.

PRICE-AFFECTING QUALITIES OF OXYGEN ABSORBERS EMPIRICAL STUDY

Joanna Olszewska¹, Dawid Szutowski²

Abstract

Oxygen absorbers are chemical compounds or mixtures of substances, which involve in a chemical or enzymatic reaction with the oxygen. The result of the reaction is removal of the oxygen from a package.

Oxygen absorbers can be classified due to their different qualities. However, the most popular division is due to the kind of active substance and ipso facto the way of functioning of oxygen absorbers. In the paper, the qualities of oxygen absorbers based on ferrum compounds existing on the market are analyzed due to it is the largest and most popular group of oxygen absorbers, which has multiple possibilities of using. Reviewing focused on the most crucial appropriable qualities of absorbers such as: ability to oxygen sorption, amount of ferrum in sorbent packet, oxygen sorption efficiency, absorbent dimensions and, of course, the market price. Then, the following qualities are evaluated to assess their influence into a market price.

The purpose of the review publication is determining the ability of formulation conclusions, which parameters have impact to absorbers. It enables to estimate the competitiveness of ZEVIFOS prototype oxygen absorber patented at the Poznań University of Economics and Business in terms of market competition (Foltynowicz, 2014).

Keywords:

oxygen absorber, oxygen scavenger, packaged product, quality, market price

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Introduction

Nowadays, when we observe an increase in the pace of life, the consumer expects food products that are distinguished by high quality, attractive appearance, low processing and high sensory and nutritional values (Panghal, *et al.* 2018). In order to meet these customer expectations, food producers are looking for new methods of food preservation. As a result, the interest in innovative packaging methods has increased, which includes not only the packaging materials themselves, but also packaging technologies, modifications of the atmosphere inside the packaging, as well as packaging structures.

It can therefore be seen that the functions of product packaging are extended. It is no longer only a form of protection against harmful external factors, but also fulfills information, marketing, ecological and logistic functions (Jankowski, 1998). Despite these new aspects of the use of packaging, the ultimate goal of product packaging remains unchanged: to maintain the best possible product quality for as long as possible. In other words, protection against physical factors (temperature, pressure, sunlight, oxygen or mechanical deformation), chemical (water, air pollution, etc.) and biological factors (i.e. pathogenic microorganisms and pests).

This high quality and food safety, which are the overriding goal of packaging, largely depends on the quality of raw materials and the method and conditions of packaging. However, even obtaining high-quality ingredients and appropriate packaging conditions does not guarantee that we will obtain a food product with a long shelf life. An additional problem for food producers is obtaining products that are not chemically preserved, as consumers more and more often choose low-processed products and without preservatives.

In order to meet these expectations, food producers are forced to look for new solutions ensuring food safety, maintaining the best quality with the longest possible shelf life (Olszewska, 2014).

The solution is modern food packaging methods. An example of an innovative and at the same time very effective method that extends the shelf life are oxygen absorbers, classified as active packaging. Due to the many benefits of using oxygen scavengers, they are the focus of this study.

Every reasonably innovative solution is created not only for the idea itself, but to find application and be commercialized (Rafinejad, 2007). It is in line with the very definition of innovation describing it as “a process of implementing positive and new ideas into business practice” (Szutowski, 2016). At this stage, apart from the usability of the product, the price has crucial meaning. This article does not focus on the technological aspects of oxygen absorbers, but on the market aspect of price and its determinants. According to the authors, the most important features

affecting the price will be: the ability to absorb oxygen and the dimensions of the absorber. These are two features that affect the efficiency of the absorber and the possibilities of its use.

The aim of this study is to determine the relationship between the oxygen sorption capacity and the dimensions of the absorber and its market price.

Oxygen absorbers

Oxygen absorbers are a great alternative to modified atmosphere packaging systems (MAP, CAP) due to their lower cost of use. Oxygen absorbers do not require specialized packaging equipment. The basis of their operation is an active substance, e.g. metallic iron, enzymes or polymers, which absorbs oxygen during storage, which is necessary for many adverse reactions in food. The use of absorbers during packaging is extremely simple, as it consists in placing the sachet with the absorber inside the package. Often the absorber is an integral part of the packaging itself. Oxygen absorbers are one of the most popular solutions of active technology in the food industry. They are compounds or mixtures of substances which enter into a chemical or enzymatic reaction with oxygen. This reaction results in the removal of oxygen from the package (Ahvenainen, 2003).

It is very difficult to completely eliminate oxygen from the package. This is due to several aspects (Brody, 2001):

- Barrier of the packaging material, which does not completely protect against the penetration of oxygen through the packaging and gas exchange is possible through the walls of the material,
- The presence of oxygen inside the packaging material and inside the product itself,
- Possibility of oxygen formation as a result of processes taking place in the product during the storage process.

Therefore, in view of these facts, it can be concluded that oxygen absorbers do not completely eliminate oxygen, but only limit its level to the lowest possible. In this way, the resistance to oxidation processes is increased, and thus the shelf life of food products is extended.

There are oxygen absorbers on the market which differ in terms of their chemical and mechanical action. The principle of their operation is based, among others on the oxidation of ascorbic acid or iron powder, the use of singlet oxygen scavengers and photosensitive dyes, the use of oxidative enzymes (from the group of oxidases) and the oxidation of fatty acids with multiple bonds (linoleic acid, oleic acid). In addition, they also use transition metals, synthetic polymers, hydrocarbons or yeast immobilized on a carrier (Czapski, 2007).

The aim of this study is to determine the relationship between the oxygen sorption capacity and the dimensions of the absorber and its market price. The need for such a statement took its origins from the currently prepared valuation of the ZEVIFOS oxygen absorber, and the valuation itself is a preparatory element for the commercialization process of this innovative solution. This absorber is an invention patented by the Poznań University of Economics and Business, and its creators are the employees of this university, headed by Professor Zenon Foltynowicz. The mentioned absorber is an innovative solution because it does not require a catalyst or the presence of moisture for activation, it can be used in refrigerated conditions, what is more, it has a very high efficiency of oxygen absorption, which has been confirmed by numerous efficiency tests. It is also characterized by the lack of any effect on the product stored with it, which was found during migration studies using various model fluids in accordance with the standards of these tests. It also has multiple possibilities of placing it inside the package with the product, it can be used in the form of a sachet inside the package, but also as a laminate coating the inner wall of the package or be an integral part of, for example, a plug or a package cap.

Determinants of the price of oxygen absorbers

In this work, the features of iron-based oxygen absorbers on the market will be analyzed due to the fact that it is the largest and most popular group of oxygen absorbers, which has many possibilities of use. The review focuses on the most important functional properties of the absorbers, such as: oxygen sorption capacity, absorber dimensions and, of course, the market price. According to the authors, the above parameters are the key to the selection of a given absorber for the product that is to be protected against the adverse effects of oxygen. Sorption capacity is the potential for absorbing one substance by another. In the case of oxygen absorbers, oxygen is absorbed by the active substance contained in the absorber, e.g., iron. The sorption capacity of oxygen absorbers is also a measure of their efficiency, which is why it is such an important parameter in the analysis and selection of the absorber for a given product.

The oxygen sorption capacity of individual absorbers is strictly dependent on the amount of iron in the sachet with the oxygen absorber. Due to the fact that there is a strong relationship between the oxygen sorption capacity and the amount of iron in the absorber sachet, the amount of iron was not included in this study as a separate variable. Thanks to such action, the substantive value of the study did not decrease, and it allowed to avoid the problem of variable autocorrelation. As a result, only one of the above factors will be subjected to regression analysis, namely the oxygen sorption capacity.

In this study, it was assumed that the dimensions of the absorber are another key determinant of its price, apart from the oxygen sorption capacity. It is dictated by the fact that the size determines the practical possibility of applying the absorber. The size of the absorber can greatly influence its utilization potential. For example, not every product can use a large size absorber, while a small absorber can be used for both small and large products.

As a result of the above considerations, the key determinants of the absorber's price are the oxygen sorption capacity and its dimensions. These are two features of absorbers that greatly affect the possibility of using absorbers. These differentiators will certainly influence the market price of oxygen absorbers.

Methodology of empirical research

The most popular oxygen absorbers on the world market are those, which are based on iron compounds in the oxygen absorption mechanism. Therefore, the analysis focused on this type of oxygen absorbers. Some oxygen absorbers, applicable e.g. in a specific industry or for selected products, are not commercially available and are created according to strictly defined production parameters. Due to their narrow application specificity, such absorbers were not taken into account. The focus was on universally applicable absorbers. Another criterion for the selection of individual oxygen absorbers was also the access to data on the specifications of commercial absorbers. The collected data on commercial absorbers were obtained from the specifications of the manufacturers of individual oxygen absorbers and from inquiries, while the data on the ZEVIFOS oxygen absorber was obtained directly from the manufacturers of the absorber. Data acquisition took place in 2019, but was updated for this publication in 2021. The sample size is 10 commercial oxygen absorbers, world market leaders. The collected data is presented in Table 1.

To analyze the above data, a linear regression model was used to determine how the parameters of the absorbers mentioned above affect their market price. The model was constructed in line with the theoretical recommendations (Berry & Feldman, 1985; Edwards, 2007). This issue is crucial because the final success of the absorber is determined by the possibility of placing it on the market. From the point of view of potential buyers, price is one of the key determinants of choice. It was assumed that for the analysis we will use the minimum achievable market price of a given absorber. As presented in Table 1, the prices of most absorbers fluctuate within certain ranges (the ranges are given in the "price" column). In this analysis, each time the lower limit of the range was taken into account, representing the minimum price at which a given absorber could be purchased on the market. From the point of view of the entrepreneur offering the absorber,

this is particularly valuable information. As a result of considering the minimum price that can be obtained on the market in the study, the analysis shows that an absorber with given parameters (given oxygen sorption capacity and a given dimension) will obtain a market price “not lower” than that determined on the basis of the equation determined in this study.

Table 1. Parameters of oxygen absorbers

	oxygen sorption capacity [ml]	dimensions [inches]	price [\$]
Absorber Zevifos	250	1.18 x 0.39 x 0.39	0.03–0.04
OXY-SORB OXYGEN ABSORBERS FOR FOOD STORAGE (USA)	50–300	2 x 0.2 x 1.5	0.30–0.40
OXY-SORB OXYGEN ABSORBERS WITH OXY EYE FOR DEHYDRATED FOOD AND EMERGENCY LONG TERM FOOD STORAGE	50–500	2 x 0.2 x 1.5	0.2
SORBENT SYSTEMS – IMPAK CORPORATION	20–3000	2.2 x 0.2 x 1.8	0.54–11
USA EMERGENCY SUPPLY	100–2000	1.14 x 1.68 x 0.18	0.09–0.67
MULTISORB TECHNOLOGIES – FreshPax OXYGEN ABSORBER	10–3000	2.3 x 0.3 x 1.4	0.26
AGELESS – MITSUBISHI GAS CHEMICAL	20–3000	1.42 x 0.3 x 2.74	0.88
Sea Star – Qingdao Sea Star Packaging Industry Co. (China)	30–3000	2.7 x 1.56 x 0.2– –3.51 x 4.49 x 0.3	0.005–0.025
CASANO (Fujian, China)	30–2500	1.17 x 1.56 x 0.18– –3.32 x 3.51 x 0.3	0.005–0.025
Chunwang (Guangdong, China)	20–250	1.37 x 1.56 x 0.18– –2.73 x 1.76 x 0.25	0.001–0.3
Sorbread India	50–3000	2.25 x 3 x 0.125	0.01–0.03

Source: own study.

In view of the above assumptions, the minimum price of the absorber that can be obtained on the market depends on two factors: the maximum oxygen sorption capacity and minimal possible dimensions.

Cognitive Outcomes

This section presents the results of an empirical study, the aim of which was to determine the relationship between the oxygen sorption capacity and the dimensions of the absorber and its market price. In accordance with the adopted methodology, the study was carried out using regression analysis, in which the minimum market price was assumed as the dependent variable, and the independent variables: the oxygen sorption capacity and the dimensions of the absorbers.

The obtained model has an R2 coefficient of 0.27539. The Durbin-Watson test, carried out in order to examine the autocorrelation of variables, returned a value of 1.92008, which means that there is a minimal positive autocorrelation of variables. However, this level is so low that it did not constitute an obstacle for the study. The results obtained are presented in Tables 2 and 3. Table 2 presents the results of the ANOVA analysis and is presented and discussed below. Table 3 shows the results of the regression analysis and is discussed later in this section.

Table 2. ANOVA analysis results

	d.f.	SS	MS	F	p-value
Regression	2	0.21563	0.10782	1.52018	0.27569
Residual	8	0.56739	0.07092		
Total	10	0.78302			

Source: own study.

The table above is the ANOVA table that indicates how well the regression equation predicts the dependent variable. This table indicates that the regression model is able to predict the outcome variable to some extent, however, the significance index is not very high.

The above table summarizing the results of the regression analysis provides us with the information necessary to predict the minimum price of the absorber depending on the oxygen sorption capacity and dimensions. The coefficients obtained on the basis of the above table allow for the formulation of the following regression equation:

**minimum price [\$] = 0.13055 + 0.0011 * maximum oxygen sorption capacity [ml]
– 0.09238 * dimensions [inches]**

Table 3. Regression analysis results

	Coefficients	Std Err	LCL	UCL	t Stat	p-value	H0 (5%)	VIF	TOL	Beta
Intercept	0.13055	0.1514	-0.21859	0.47969	0.86227	0.41364	Accepted			
maximum oxygen sorption capacity [ml]	0.00011	0.00007	-0.00006	0.00028	1.50585	0.17053	Accepted	1.20603	0.82917	0.4977
dimensions [inches]	-0.09238	0.06493	-0.2421	0.05734	-1.42287	0.19258	Accepted	1.20603	0.82917	-0.47028

Source: own study.

The results obtained on the basis of the regression analysis suggest that the minimum achievable price on the market increases when the maximum oxygen sorption capacity increases and when the dimensions of the absorber are reduced. In other words, an absorber with high oxygen sorption capacity and small dimensions is likely to get a higher minimal market price. Based on the above analysis, the minimal market price, which can be reached by the absorbers under investigation should range between 0.11 \$ (value theoretically obtained for OXY-SORB Oxygen Absorbers for food storage, which is an example of relatively low sorption and relatively high dimensions), and 0.39 \$ (value theoretically obtained for SORBENT SYSTEMS – IMPAK Corporation, which is an example of a very high sorption capacity). The ZEVIFOS prototype oxygen absorber patented at the Poznań University of Economics and Business should reach a market price no lower than 0.14 \$, which situates it in the middle of the stake and indicates its high commercialization potential.

Conclusions

The above relationship is logical and is justified by the possibility of using a small size absorber and the maximum oxygen sorption capacity. A small absorber with maximum efficiency will meet much greater demand on the market than an absorber with opposite features. The results of the analysis may therefore suggest and indicate a trend for the developers of oxygen absorbers, including the developers of the ZEVIFOS oxygen absorber, to properly position the price of such solutions on the market. Moreover, they also indicate what features of the absorber are reflected in its market price, such as the oxygen sorption capacity and the dimensions of the absorber.

References

- Ahvenainen, R. (2003). *Novel food packaging techniques*. Woodhead Publishing Limited, 22–33.
- Berry, W., Feldman, S. (1985). *Multiple Regression in Practice, Series on Quantitative Applications in the Social Science*. SAGE Publications, Newbury Park, No. 07–050.
- Brody, A.L., Strupinsky, E.R., Kline, L.R. (2001). *Active Packaging for Food Applications*. Lancaster: Technomic Publishing Co.
- Czapski, J. (2007). Trends in the technology of active food packaging, with particular emphasis on fruit and vegetable products. *Fermentation and fruit and vegetable industry*, 10, 14–17.

Edwards, J. (2007). Polynomial Regression and Response Surface Methodology. In: Ostroff, C., Judge, T. (eds.), *Perspectives on organizational fit*, Jossey-Bass, San Francisco, 361–372.

Foltynowicz, Z., Kozak, W., Olszewska, J. (2014). Instead of antioxidants. *Agroprzemysł*, 2, Racibórz, 17–19.

Jakowski, S. (1998). Protective function of packages. *Packaging*, 10, 16–17.

Panghal, A., Janghu, S., Virkar, K., Gat, Y., Kumar, V., Chhikara, N. (2018). Potential non-dairy probiotic products – A healthy approach. *Food Bioscience*, 21 (December 2017), 80–89, <https://doi.org/10.1016/j.fbio.2017.12.003>

Olszewska J., Kozak, W. (2014). Oxygen absorbers as an alternative to chemical food preservation. In: R. Salerno-Kochan, A. Wolak (ed.), *Commodity science in research and practice*. Radom.

Rafinejad, D. (2007). *Innovation, Product Development and Commercialisation*. Case Studies and Key Practices for Market Leadership, J Ross Publishing, Lauderdale.

Szutowski, D. (2016). *Innovation and market value*. Warsaw: Difin.

ASSESSMENT OF READABILITY OF LABELING NATURAL COSMETIC PRODUCTS

Natalia Kozik¹

Abstract

The purpose of this study was to investigate the readability of packaging labeling of natural cosmetic products. An assessment was carried out of 10 packaging of shower gels available in the domestic market – 5 produced in Poland and 5 imported. The research was conducted using the TVScore (Typography Variable Score) method, which evaluates 15 typographic parameters of the text placed on the packaging: style of print, print size, leading, use of boldface or italic print, case, line length, justification, organization, contrast, reverse print, packaging surface, reproduction, read through, hyphenation and abbreviation. The obligatory information on each packaging were assessed. It was found that every packaging obtained total scores above 8 points TVScore, which allows according to method guidelines to conclude that they are characterized by low readability. This article recommends that all tested packages should be redesigned due to low informativeness and making it difficult for consumers to perceive the information placed on them.

Keywords: labeling, natural cosmetics, packaging, legibility, TVScore.

Introduction

Cosmetic products are among the first necessities products. Therefore, the cosmetics industry is one of the biggest and fastest-growing. Statista (2018) forecasts that it will be worth USD 545 billion in 2027, up from USD 345 billion in 2018. Mintel (2020), on the other hand, predicts that between 2020 and 2030, consumers will expect reliable information about products and so-called clean

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cosmetics – both regarding their composition and their impact on the environment and people throughout the product lifecycle. Natural cosmetics fit perfectly into this trend, where the market is forecast to grow at an annual rate of 9.6% until 2023 (Market Research Future, 2019).

A tool often used to inform consumers about the properties of a cosmetic product, including its natural character, is the packaging, which is an important element of marketing communication. It is one of the basic sources of information about the product on which obligatory labeling is placed, i.e. the one without which the packaged cosmetic product will not be placed on the market. Its presence results from legal regulations. In addition to the obligatory marks required by law, producers often place additional information on the promotional, educational, and informational character.

The packaging, therefore, constitutes a certain space for the producer as well as the seller, within which the enterprise informs the consumer, among others, about the type and features of the product, its handling, and benefits resulting from its purchase, as well as about the features of the packaging itself. Therefore, it is worthwhile for manufacturers to take care of the appropriate architecture of information and marks on packaging. Their correct placement and exposure may effectively improve the finding of specific information, as well as its interpretation, and thus the effectiveness of the marketing communication of the packaging.

There are many studies in the literature related to the topic of product perception through the prism of packaging and labeling however, the subjects of these studies are mainly foodstuffs or products in general, e.g. Dmowski & Marjańska (2017), Drexler, Fiala, *et al.* (2017), Kabaja (2018), Żuchowska-Grzywacz (2019), Moreira, *et al.* (2019), Ankiel & Brzezińska-Grzybowska (2020), Nawrot (2020), Swasty, Mustikawan & Eridani (2020) and Orquin, *et al.* (2020). The bibliographic review showed that there is a research gap in the evaluation of labeling and perception of natural cosmetics through the prism of packaging. There is a large discrepancy between the increasing market share of natural cosmetics and the still limited research attention in this aspect. To date, mainly consumer behavior in the natural cosmetics market has been analyzed. Research work in the field of cosmetic product labeling has been undertaken rarely and mostly concerns cosmetics in general.

Research on the information value of cosmetic product packaging has been conducted, among others, by Ankiel & Sojkin (2018). They indicated that the key information for Polish female consumers is the name of the product, the name of the manufacturer – i.e. obligatory marks – and the brand. In turn, Klaschka's (2016) research reached the conclusion that natural cosmetic products available on the European market are labeled inappropriately and do not provide full information to the consumer, and that action should be taken in this regard by

both manufacturers and legislative bodies, which will positively affect the safety of users of these products. Research conducted by the Naturativ brand (2018) has shown that the information that people purchasing natural cosmetics pay attention to are: the performance of the cosmetic, the presence of specific ingredients, the place of production, certificates and information about the absence of certain ingredients. Nearly half of the respondents looked for this information on product labels. In contrast, a study by Młoda-Brylewska (2019) found that Polish respondents pay attention to the information provided on cosmetic product packaging, and more than half do so just before making a purchase. Mäkiä (2021) in her research showed that consumers trust more the companies whose declarations are true, understandable and precise, and natural cosmetics manufacturers should focus on verbal communication, because all kinds of suggestive symbols and pictograms are often perceived as an element of greenwashing.

As can be seen from the above, the great interest in the subject of labeling and packaging influence on consumer decisions proves the importance of this issue. However, there is still little research treating labelling and marking of natural cosmetics packaging, which was the reason for undertaking this study.

EU labelling requirements for cosmetics

The legal act governing all cosmetic products, including natural cosmetics, is Regulation (EC) No 1223/2009 of The European Parliament and of The Council of 30 November 2009 on cosmetic products. This regulation contains a number of requirements, including which information for consumers is in the form of mandatory labelling on the outer packaging, for which specific content and form of message are defined. For cosmetics, the manufacturer is obliged to display this information on the packaging in a legible, visible, understandable, and indelible form. Obligatory signs in the form of inscriptions on the packaging of products available on the Polish market should be placed in the Polish language, with the exception of the list of ingredients.

Obligatory information includes (Regulation No 1223/2009):

- data identifying the responsible entity – the name of the person or company and address; in the case of imported products, their country of origin must also be indicated,
- the content of the product in the packaging – presented in units of weight or volume; in the case of packaging containing less than 5 grams or 5 milliliters of the product, free samples, and disposable packaging, this information is not obligatory,

- the date of minimum durability of the product – preceded by the hourglass symbol or the words “best used before the end”, comprising a month and a year or a day, a month and a year; for products with a date of minimum durability of more than 30 months, only the period of use after opening shall be mentioned,
- precautions to be taken when using the product,
- the batch number or an indication allowing identification of the product,
- the function of the product – if this is obvious from the presentation of the product, this information is not obligatory,
- list of ingredients of the product – shall be preceded by the word “ingredients”; the ingredients shall be listed in descending order of weight at the time of their addition to the product, with ingredients that constitute less than 1% listed at the end of the list in no particular order; the composition shall be stated in accordance with the International Nomenclature of Cosmetic Ingredients (INCI), i.e. the names of chemical ingredients in English and the names of substances of plant origin in Latin.

If the packaging is small and it is justified for practical reasons, precautionary information, the batch number, the function of the product, and the list of ingredients may be provided on an additional element accompanying the product, e.g. label, leaflet, tag (Regulation No 1223/2009).






Research objective and material

The purpose of this study was to investigate the readability of obligatory labelling on the packaging of natural shower gels on the domestic market and to examine their differentiation in terms of the readability of labels. The study was conducted on 10 products manufactured in Poland and imported to the domestic market. The research material was selected due to market trends. As indicated by Nielsen (2020), products from the personal care category account for the largest share of value sales in the market – 21.3% in the period April 2019–March 2020. The value of the aforementioned category is mainly influenced by sales of soaps, intimate hygiene gels and shower gels. As intimate hygiene gels are mainly intended for women, only shower gels have been selected for evaluation, which are universal products similar to soaps and their range is large.

The selected research material was purchased in drugstores on the territory of Cracow. The main criterion for selection was the natural composition of the cosmetic. The packaging of the purchased gels was characterized by various features. The characteristics of the packaging of natural shower gels together with photographs are listed in the Table 1.

Table 1. The characteristics of packaging of natural shower gels

Product	A	B	C	D	E
	alviana, Feel Fresh Duschgel	Alterra NATURKOSMETIK Sensitiv Dusch-shampoo	be organic, shower gel	cosmia bio, gel douche nourrissant à l'olive	LaQ, hands & body gel firming
Image					
Capacity [ml]	250	250	200	250	300
Text background colour	light green	white	green	white	white
Font colour	black	black, grey	white, green	light grey	black
Place of text	additional label (sticker)	additional label (sticker)	original label (packaging)	original label (sticker)	original label (sticker)

Product	F		G	H	I	J
	ONLYBIO hypoallergenic body wash gel		organic shop, fresh shower gel	Planeta Organica, natural shower gel	YOPE, natural regenerating shower gel	YUMI, Aloe shower gel
Image						
Capacity [ml]	250		280	250	400	200
Text background colour	light pink		white	clear (visible red gel with black basil seeds), white	white	light green
Font colour	black		black, green	black	black	dark green
Place of text	original label (sticker)		original label (sticker)	original label (sticker)	original label (sticker)	original label (packaging)

Source: own elaboration.

The evaluated products, with respect to the packaging construction form, can be divided into those in bottles (8 products) and tubes (2 products). Of the packages tested, 4 had a pump cap and the remaining 6 had a flip-top closure. In terms of packaging material, one can distinguish packaging made of glass (1 product) and plastic (9 products). In terms of the color of the packaging material, white (4 products), brown (3 products), green (2 products) and transparent (1 product). The greatest variation occurs in terms of volume, with packaging containing 200 ml of gel (2 products), 250 ml of gel (5 products), 280 ml of gel (1 product), 300 ml of gel (1 product) and 400 ml of gel (1 product).

Research methodology

The research was conducted using the TVScore (Typography Variable Score) method, which was developed by Metz (1996). A modified version, by Kabaja (2016) who adapted the TVScore method to the product labeling conditions found on the domestic market, was used. This method is based on the so-called Zone of Optimal Typography – ZOT for short. It also uses numerous assumptions and research results concerning printing parameters by authors such as Paterson & Tinker (1940), Tinker (1963), Spencer (1969), Gilliland (1972), Craig (1980), Vanderplas & Vanderplas (1980), Sutherland (1989), Black (1990), Hartley (1994), Metz (1996). The method aims to examine the typography of the text placed on the packaging and determine its ease of reading. It assumes that the typography of text on packaging is of paramount importance in the process of content reading by consumers and that the correct reading of the information is a necessary condition for its proper understanding (Cholewa-Wójcik, Kabaja & Kawecka 2018).

TVScore is based on the evaluation of fifteen typographic parameters of the text placed on the package, namely (Kabaja, 2016; Kozik, 2019; Metz, 1996):

- style of print – the spacing between characters,
- print size – the distance between the baseline and the top line of the capital letter; measured with a typometer,
- leading – the distance between the lines of a font; it is the ratio of the length of a line of a font (font size including line spacing) to the font size itself and is expressed as a percentage,
- use of bold or italic print – the use of bold and italics to highlight headings and keywords is desirable and helps draw the consumer's attention to certain information,
- case – the size of the letters in the text, i.e. majuscule (upper case), capitals, minuscule (lower case) or a combination of these,
- line length – expressed in pica units (1 pica = 4.2333 mm),
- text alignment – e.g. left, right, centered, justified or geometric,

- text organization – highlighting the most important groups of information,
- contrast – the ratio of the color of the font to the color of the background on which it is printed; measured with a greyscale typometer; expressed as a percentage,
- reverse print – the use of light fonts on a dark background,
- packaging surface – matt or reflective to a certain extent,
- reproduction – clean, clear or faded, unclear, blurred,
- print background – solid, transparent or with graphics,
- hyphenation,
- abbreviation.

For each of the above 15 characteristics, points are awarded according to the degree to which the criterion is met. A distinction is made between the optimum level of a criterion and a slight and significant deviation. Points are awarded for each deviation occurring. If a criterion meets all the recommendations, it is given 0 points. A small deviation is given 1 point and a major deviation 2 or more points. The fewer points a packaging receives overall, the clearer the information on it. M. Metz assumes that a readable label has TVScore points of no more than 4. A score between 5 and 8 points indicates packaging with poor readability, and a score above 8 points indicates packaging on which the printed information is difficult to read. In other words, two significant deviations indicate that the packaging design is unacceptable in terms of labelling. A similar situation occurs in the case of four insignificant deviations (Mackey & Metz, 2009; Metz, 1996). Detailed criteria and scoring are presented in Table 2.

Using the aforementioned criteria, 7 obligatory marks were assessed according to the Regulation (EC) No 1223/2009 of The European Parliament and of The Council of 30 November 2009 on cosmetic products. These were:

- data identifying the responsible entity,
- the content of the product in the packaging,
- the date of minimum durability of the product,
- precautions to be taken when using the product,
- the batch number or an indication allowing identification of the product,
- the function of the product,
- the list of ingredients of the product.

In the case of information whose content was short, the assessment of line length was waived, i.e. date of minimum durability, batch number, as well as net quantity of the product. In addition, no assessment was made of the case for the numerical record of the date and the occurrence of abbreviations for the net quantity of the product.

Table 2. TVScore criteria

Criterion		Optimal range	Minor non-optimal	Major non-optimal
		0 pts	1 pts	2 or more pts
1.	Style of print	normal, according to the arrangement in the font	condensed, a space remains between the letters	condensed, letters touching each other
2.	Print size	minimum 8 point	7 to 7.5 point	6–6,5 = 2 pts 5–5,5 = 3 pts less than 5 = 4 pts
3.	Leading	minimum 120%	below 120% to 100%	less than 100%
4.	Use of bold or italic print	only headings, important words	no use or use up to 2 lines	more than 2 lines
5.	Case	most important words and phrases	most text in capital letters	all capital text
6.	Line length	14–28 pica	over 28 pica or between 14 and 7 pica	less than 7 pica
7.	Text alignment	left	justified	centred, right, shaped text
8.	Text organization	clear, allowing information to be separated, important words are highlighted, e.g.: boxed text, colourful textbackground, typeface	partial highlighting of certain groups of information	lack of organisation, end-of-line headings, no spacing, text in one block
9.	Contrast	80% and more	less than 80% to 75%	less than 75% to 70%, below 70% for every 5% 1 pts
10.	Reverse print	dark letters on a bright background	bright letters on a dark background with optimal contrast	bright letters on a dark background
11.	Packaging surface	matt, no reflection of light from the surface packaging	slightly shiny, causing minor reading difficulties	glossy, making it very difficult to read, requiring the package to be re-angled while reading
12.	Reproduction	clean, clear text	edges of letters slightly blurred, text slightly faded making it difficult to read	edges of letters blurred, text blurred, faded, unreadable
13.	Print background	uniform	graphics making the text slightly difficult to read	graphics making the text difficult to read
14.	Hyphenation	no	occasional	frequent
15.	Abbreviation	no	occasional	frequent

Source: based on: (Kabaja, 2016).

Labeling in Polish of foreign products was often placed on an additional label, applied to the packaging by the entity placing the product on the market. In this case, the information contained on this label was evaluated.

The research was carried out using a typometer “DCS Typo+Lithometer” from the company grafipress GmbH.

Research results and discussion

The overall, cumulative results of the research conducted with the TVScore method are presented in Table 3. Due to the fact that two tested products: cosmia bio (D) and organic shop (H) did not have information on the date of minimum durability, but only the PAO symbol, it was decided not to take this labeling into account in the context of the overall TVScore analysis.

Table 3. The characteristics of the packaging of natural shower gels

Product	Mark*					
	1	2	3	4	5	TOTAL
	TVScore points					
A	8	3	2	9	4	26
B	5	1	4	5	8	23
C	7	4	25	6	6	48
D	4	3	7	5	8	27
E	10	2	3	8	11	34
F	5	0	24	6	6	41
G	4	1	3	3	6	17
H	11	5	6	6	11	39
I	9	3	14	7	6	39
J	5	0	23	3	3	34
*explanations: 1. data identifying the responsible entity, 2. content of the product in the packaging, 3. the batch number or an indication allowing identification of the product, 4. the function of the product, 5. list of ingredients of the product.						

Source: own elaboration.

Similarly, information on precautions to be taken when using the product was missing from the packaging of two products: alviana (A) and LaQ (E).The TVScore study showed that all evaluated packages of natural shower gels available on the domestic market have unreadable labeling. However, packaging did not receive

the same number of points, which means that they are not to the same extent unreadable by the consumer. After discarding – in the context of the overall analysis – the points awarded for the date of minimum durability and precautions to be taken while using the product, all the tested packages failed to meet the readability criteria proposed by the author of the method and obtained more than 4 TVScore points.

A summary of assessed packaging according to increasing TVScore points is presented in Figure 1.

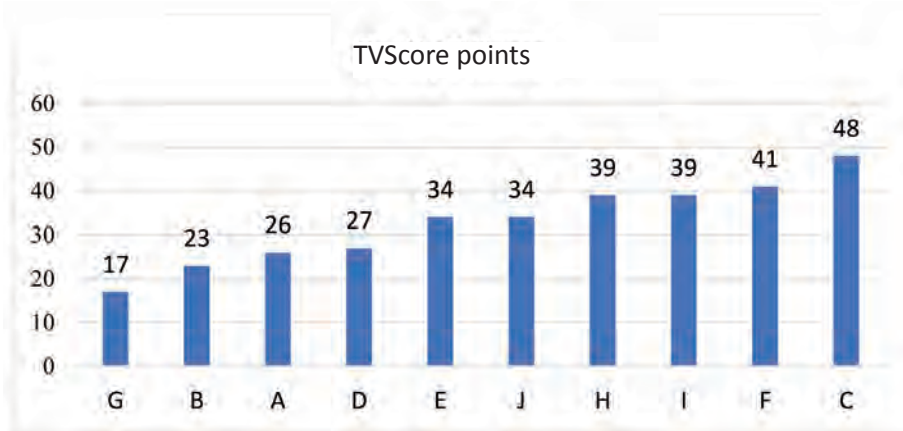


Figure 1. The assessed packaging according to increasing TVScore points

Source: own elaboration.

The packaging of the organic shop natural shower gel (G) was characterized by the best labeling among the products studied, with a total score of 17 points. In this case, the baddest-scoring criteria were: leading (5 points), line length (5 points), text alignment (5 points) and abbreviation (1 point). The remaining criteria were awarded 0 points. The mark that received the most TVScore points was the list of ingredients (6 points). This was followed by the data identifying the responsible entity (4 points), the batch number or marking allowing identification of the product (3 points), the function of the product (3 points) and the content of the product in the packaging (1 point). The labeling was placed on an additional label, stuck on top of the original label, as this is an imported product. The information was printed in black font on a white background. Unfortunately, a condensed font was used for all the information, which made it difficult to receive the message and affected the result obtained by this packaging. The labeling of organic shop natural shower gel is shown in Figure 2.

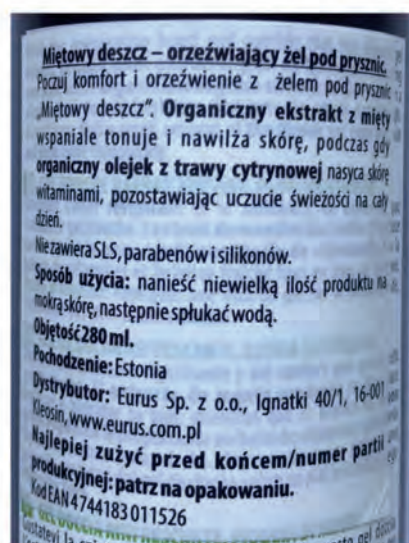


Figure 2. The labeling of organic shop shower natural shower gel

Source: own elaboration.

The second-best packaging in terms of readability of labeling was the Alterra NATURKOSMETIK's packaging (H), which obtained 23 TVScore points. The criteria that scored points were the style of print (6 points), line length (5 points), print size (4 points), text alignment (3 points), case (2 points), text organization (2 points), use of bold or italic and print (1 point). The list of ingredients (8 points) was the mark awarded the most points. This was followed by data identifying the responsible entity (5 points), the function of the product (5 points), the batch number or designation allowing identification of the product (4 points). The last one was the content of the product in the package (1 point). The packaging had a condensed font and most of the information was justified, but it was mainly characterized by high contrast, proper reverse print and correct organization of the text.

Next in order were the packaging of natural shower gels of the following brands: Alterra (B; 23 points), alviana (A; 26 points) and cosmia bio (D; 27 points). The labeling of these packages was placed on an additional label. Above 30 points were awarded to Polish brands: LaQ (E; 34 points), YUMI (J; 34 points), Planeta Organica (H; 39 points), YOPE (I; 39 points) and ONLYBIO (F; 41 points). For these packages, all assessed information was available on the original labels.

The packaging with the lowest score in terms of readability was the be organic gel packaging (C), which received 48 TVScore points. It scored points in the following criteria: contrast (16 points), print size (7 points), reverse print (6 points), text

alignment (4 points), line length (3 points), style of print (2 points), use of bold or italic print (2 points), case (2 points), packaging surface (2 points), reproduction (2 points), text organization (1 point) and abbreviation (1 point). The batch number or an indication allowing identification of the product scored highest (25 points). This was followed by data identifying the responsible entity (7 points), the function of the product (6 points), the list of ingredients (6 points) and the content of the product in the packaging (4 points). The biggest influence on the score was the presentation of the product batch (and also the use-by date, which was finally rejected from the overall assessment), which was embossed on the seal. Unfortunately, the embossing was the same color as the packaging and due to the very low contrast, it was extremely difficult to read. The labeling of be organic natural shower gel is shown in Figure 3.

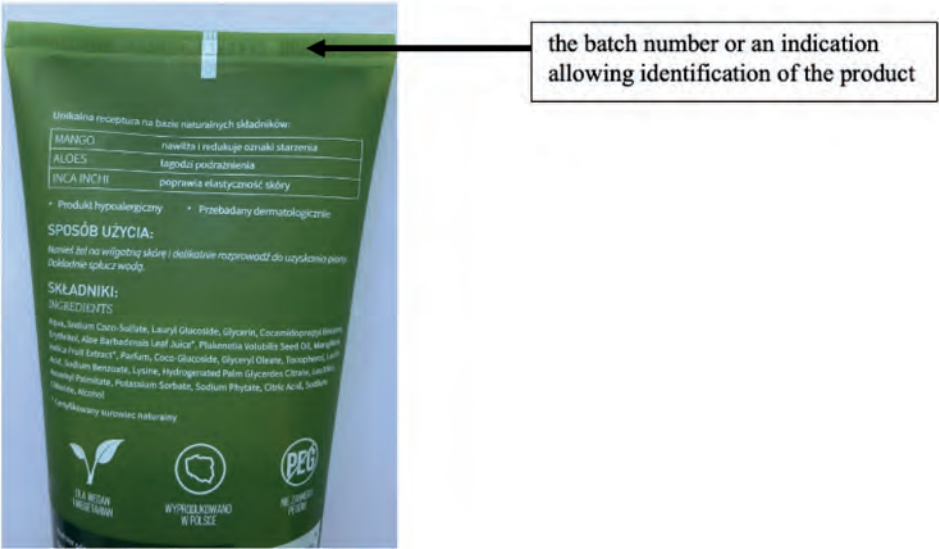


Figure 3. The labeling of be organic natural shower gel

Source: own elaboration.

Considering the marks assessed, the most irregularities occurred in the presentation of the batch number or an indication allowing identification of the product. In this case, the average score per packaging was 11.1 TVScore points. This was followed by the list of ingredients (6.9 points), the data identifying the responsible entity (6.8 points), and the product's function (5.8 points). The best scoring mark was the product's contents in the packaging, which had an average score of 2.2 points per packaging.

On the basis of the analysis of the TVScore criteria evaluation, it can be concluded that among the tested natural shower gels packaging the highest number of irregularities occurred in print size (69 points) and terms of contrast (51 points). The size of the font in the vast majority of packs was smaller than the recommended 8 typographic points and most often fell within the range of 6-7 points. In turn, the contrast rating was mainly affected by the embossing of the batch number on the package seal and the lack of distinction of the embossing from the color of the package, which made it significantly more difficult to read. The next criteria in which there were irregularities were the following: style of print (37 points) – on most products the font was condensed, line length (36 points) – the lines of text were very short, especially in the case of products which had information on an additional label, text alignment (34 points) – the text was often justified. The other were: packaging surface (21 points), use of bold or italic print (17 points), reverse print (15 points), reproduction (11 points) and text organization (10 points). The following scored below 10: print background (9 points), abbreviation (7 points), case (5 points), leading (3 points) and hyphenation (3 points).

Conclusions

Nowadays, the consumer is mainly guided by the packaging when deciding whether or not to buy a particular product, and the packaging plays an important role in the market communication process. The potential buyer must make a good choice from the ever-increasing assortment. In order to attract the consumer's attention, manufacturers use various solutions in the field of unit packaging, which also applies to natural cosmetics. These are most often: colors, which are based on the colors of the Earth and influence the consumers' perception of the product, as well as product declarations in the form of e.g. text information, promotional slogans or logotypes (Kuzincow, 2018), the presence of which may affect the readability of obligatory information, which the consumers often do not fully understand (Kozik, 2020). It is therefore important that once attention has been drawn to the product because of the packaging, the consumer's interest is maintained through a correctly positioned and legible information message, taking into account above all the obligatory signs.

The analysis of the obtained results allows us to state that the applied research methodology, developed by Metz (1996) and modified by Kabaja (2016), allows us to determine the variability of packaging in terms of readability and organization of text information placed on it. It can be seen that the evaluated packaging are characterized by varying levels of informativeness. Moreover, the size of the label does not affect the readability of the messages conveyed. The labeling of the investigated imported products was provided on additional small labels, and yet it was this type of packaging that received the least points. However, according

to the interpretation proposed by Metz (1996), which assumes that a readable label has no more than 4 TVScore points, none of the tested packaging should be allowed to be sold due to the poor readability of the text information on it and they should be redesigned.

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References

- Ankiel, M., Brzezińska-Grzybowska, M. (2020). Wartość informacyjna opakowań jako determinanta zakupu żywności. *Marketing Instytucji Naukowych i Badawczych*, Vol. 36, Issue 2, 31–44.
- Ankiel, M., Sojkin, B. (2018). Wartość informacyjna opakowań kosmetyków jako determinanta decyzji nabywczych konsumentów. *Handel Wewnętrzny*, 4(375), 296–306.
- Cholewa-Wójcik, A., Kabaja, B., Kawecka, A. (2018). Analiza czytelności informacji zamieszczonych na opakowaniach płynów do mycia naczyń. *Chemia i Biznes. Rynek Kosmetyczny i Chemii Gospodarczej*, 3.
- Dmowski, P., Marjańska, E. (2017). Opinie młodych konsumentów na temat oznakowania opakowań kawy i herbaty. *Handel Wewnętrzny*, 1(366), 167–179.
- Drexler, D., Fiala, J., Havlíčková, A., Potůčková, A., Souček, M. (2017). The Effect of Organic Food Labels on Consumer Attention. *Journal of Food Products Marketing*, 24(1), 1–15.
- Kabaja, B. (2016). Możliwości wykorzystania metody TVScore do oceny znakowania opakowań na przykładzie suplementu diety. *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*, 8(956), 87–105.
- Kabaja, B. (2018). *Kryteria oceny znakowania opakowań jednostkowych suplementów diety*. Kraków: Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie.
- Klaschka, U. (2016). Natural personal care products – analysis of ingredient lists and legal situation. *Environmental Sciences Europe*, 28(8), 2–14.
- Kozik, N. (2019). Opakowanie jako narzędzie wpływania na wybory konsumentów i czytelność przekazywanych przez nie komunikatów na przykładzie ekskluzywnych wód mineralnych. *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Krakowie*, 4(982), 19–38.
- Kozik, N. (2020). Rozpoznawalność certyfikatów kosmetyków naturalnych i organicznych wśród młodych konsumentów. In: M. Popek (Ed.), *Innowacje w kształtowaniu jakości wyrobów i usług*. Gdynia: Uniwersytet Morski w Gdyni, 62–78.
- Kuzincow, J. (2018). *Opakowanie jako element zielonego marketingu*. Warszawa: COBRO – Instytut Badawczy Opakowań.

Market Research Future. (2019). Natural and Organic Cosmetics Market Size, Share, Segmentation By Type (Skin Care, Hair Care, Oral Care, Makeup Cosmetics and Others), By Consumer Group (Male and Female), By Distribution Channel (Store-Based and Non-Store Based) – Global Forecast till 2027, <https://www.marketresearchfuture.com/reports/natural-organic-cosmetics-market-7257>.

Mackey, M.A., Metz. M. (2009). Ease of Reading of Mandatory Information on Canadian Food Product Labels. *International Journal of Consumer Studies*, 33(4), 369–381.

Mäkiä, E. (2021). How Cosmetics Companies Can Improve the Credibility of Green Marketing – A Consumer Perspective, <https://www.theseus.fi/handle/10024/497786>.

Metz, M. (1996). *Preferences of consumers age 50+ for typography of product instruction labels*. Montreal: UMI.

Mintel. (2020). Global Beauty and Personal Care Trends 2030, <https://www.mintel.com/beauty-trends-2030>.

Młoda-Brylewska, K. (2019). Czynniki wpływające na zwracanie uwagi przez konsumentów na informacje zamieszczane na opakowaniach produktów kosmetycznych. In: T. Wysockański (ed.), *Nauka, badania i doniesienia naukowe 2019. Nauki humanistyczne i społeczne*. Część II. Świebodzice: Idea Knowledge Future, 103–112.

Moreira, M. J., García-Díez, J., de Almeida, J.M.M.M., Saraiva, C. (2019). Evaluation of food labelling usefulness for consumers. *International Journal of Consumer Studies*, 43(4), 327–334.

Naturativ, (2018). Raport Slow Life w Polsce 2018, <https://www.naturativ.pl/raportslow/>.

Nawrot, K. (2020). Rola informacji na etykiecie w procesie wyboru produktu spożywczego. *Intercathedra*, 1(42), 33–40.

Nielsen. (2020). Nielsen: Pielęgnacja i higiena skóry – sprzedaż w obu kategoriach rośnie rok do roku, <https://www.wiadomoscikosmetyczne.pl/artykuly/nielsen-pielęgnacja-i-higiena-skory-sprzedaz-w-obu,64542/2>.

Orquin, J.L., Bagger, M.P., Lahm, E.S., Grunert, K.G., Scholderer, J. (2020). The visual ecology of product packaging and its effects on consumer attention. *Journal of Business Research*, 111, 187–195.

Regulation (EC) No 1223/2009 of The European Parliament and of The Council of 30 November 2009 on cosmetic products. OJ EU L 342/59.

Statista. (2019). Market value for natural and organic beauty worldwide 2018–2027, <https://www.statista.com/statistics/673641/global-market-value-for-natural-cosmetics/>.

Swasty, W., Mustikawan, A., Eridani, F. (2020). Visual perception of primary display panel of coffee packaging. *Journal Manajemen dan Kewirausahaan*, 20(1), 1–7.

Żuchowska-Grzywacz, M. (2019). Znakowanie produktów żywnościowych jako narzędzie gwarantujące prawidłową realizację konstytucyjnego prawa konsumenta do informacji. *Przegląd prawa konstytucyjnego*, 3(49), 229–243.

RECYCLER'S AUDIT WITHIN CIRCULAR ECONOMY APPROACH

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Abstract

The Circular Economy is now a very popular concept promoted by the EU authorities as well as by many companies around the world. Currently, the use of waste as raw materials is increasingly becoming a common practice that does not require the implementation of incentive legislative tools or building social awareness and awareness of market participants themselves. Circular economy has evolved to a level where recycling of material streams should be remembered already at the product design stage, not forgetting to reuse as much waste available on the market as possible. One of the elements to help to meet the requirements of the circular economy and, lead to greater transparency of the waste market is the audit of recyclers.

The purpose of this article is to present the statutory requirements for auditing packaging waste recyclers in the context of the circular economy concept. Based on the analysis of the available source materials, it is concluded that the audit of recyclers greatly facilitates the transformation of entrepreneurs from a linear economy to a circular economy. In addition, according to the authors, the effective implementation of the recycler audit process enables the fulfilment of individual requirements in the 9R circular economy concept.

Keywords: circular economy, recyclers audit, packaging waste, 9R concept.

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Introduction

Switching from the current linear model of economy to a circular one would not only bring savings of hundreds of billions Euro, but also significantly reduce the negative impact on the natural environment (Ellen MacArthur, 2015). The transition to the circular economy entails four fundamental building blocks—materials and product design, new business models, global reverse networks, and enabling conditions. Switching an economy to a circular one depends, on the one hand, on policymakers and their decisions; on the other hand, it depends on introducing circularity into their business models by business entities (Lewandowski, 2016). However, the transition to a more circular economy, where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste minimised, is an essential contribution to the EU's efforts to develop a sustainable, low carbon, resource efficient and competitive economy. This is supposed to be also a one of the key indicator for a more of a quality of life factors. Such transition is the opportunity to transform our economy and generate new and sustainable competitive advantages for Europe. The circular economy will boost the EU's competitiveness by protecting businesses against scarcity of resources and volatile prices, helping to create new business opportunities and innovative, more efficient ways of producing and consuming. It will create local jobs at all skills levels and opportunities for social integration and cohesion which also improve a life quality of the EU inhabitants (European Commission, 2015). At the same time, it will save energy and help avoid the irreversible damages caused by using up resources at a rate that exceeds the Earth's capacity to renew them in terms of climate and biodiversity, air, soil and water pollution. In the report Ellen McArthur also points at the wider benefits of the circular economy (Ellen MacArthur, 2015), including in lowering current carbon dioxide emissions levels. Action on the circular economy therefore ties in closely with key EU priorities, including jobs and growth, the investment agenda, climate and energy, the social agenda and industrial innovation, and with global efforts on sustainable development. Sustainability aims at addressing environmental and socio-economic issues in the long term. In general, the literature on sustainability has focused mainly on the environmental issues, whereas, more recently, a circular economy has been proposed as one of the latest concepts for addressing both the environmental and socio-economic issues. A Circular Economy aims at transforming waste into resources and on bridging production and consumption activities; however, there is still limited research focusing on these aspects (Witjes & Lozano, 2016).

One of the elements to help to meet the requirements of the circular economy and, at the same time, lead to greater transparency of the waste market is the audit of recyclers. Pursuant to the Act on the management of packaging and packaging waste, an obligatory audit of recyclers has been in force since 1 January

2016. The Act of 13 June 2013 on the management of packaging and packaging waste introduces the obligation to conduct an annual external audit, carried out by an accredited environmental verifier. This obligation applies to entrepreneurs who recycle or recover packaging waste other than recycling, processing more than 400 Mg of packaging waste per year, as well as entrepreneurs who export it or make intra-Community deliveries of this waste weighing more than 400 Mg per year.

The purpose of this article is to present the statutory requirements for auditing packaging waste recyclers in the context of the circular economy concept, that may fulfil the gap in the literature.

General basis on Circular Economy

The concept of the Circular Economy has been gaining momentum since the late 1970s (Ellen MacArthur Foundation, 2013). Several authors, like Andersen (Andersen, 2007), Ghisellini (Ghisellini, *et al.* 2016), and Su (Su, *et al.* 2013) attribute the introduction of the concept of circular economy to Segerson, Pearce and Turner (Segerson, *et al.* 2006) by describing how natural resources influence the economy by providing inputs for production and consumption as well as serving as a sink for outputs in the form of waste, they investigate the linear and open-ended characteristics of contemporary economic systems (Geissdoerfer, *et al.* 2017). The most renowned definition has been framed by the Ellen MacArthur Foundation, introducing the Circular Economy as “an industrial economy that is restorative or regenerative by intention and design” (Ellen MacArthur Foundation, 2013). Similarly, Geng and Doberstein (Geng & Doberstein, 2008), focusing on the Chinese implementation of the concept, describe the Circular Economy as the realization of a closed loop for material flow in the whole economic system. Webster adds that a circular economy is one that is restorative by design, and which aims to keep products, components and materials at their highest utility and value, at all times (Webster, 2017). Accordingly, Yuan state that the core of the Circular Economy is the circular (closed) flow of materials and the use of raw materials and energy through multiple phases (Yuan, *et al.* 2006). Bocken *et al.* categorise the characteristics of the Circular Economy by defining it as design and business model strategies that are slowing, closing, and narrowing resource loops (Bocken, *et al.* 2016; Geissdoerfer, *et al.* 2017).

According to the authors one of the most complex definition of the circular economy is one provided by Geissdoerfer, Savaget and others (Geissdoerfer, *et al.* 2017) that describes Circular Economy as a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing,

and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling.

Another important issue, that should be taken under consideration is the implementation of the Circular Economy Model. There are several aspects and factors that are determining its successful implementation. Circular Economy requires the compliance of three main principles, namely Reduce, Reuse and Recycle (i.e., 3R principles), which have to be embedded in production and consumption processes. Reduce is aimed at minimizing the input of raw materials, energy and waste by increasing the efficiency in production and consumption processes, for example by introducing simplified packaging or more compact products and household appliances. Reuse encompasses operations by which resources or components can be used again for the same purpose they were designed. It implies that products are used to their maximum potential in order to extend their life. Finally, Recycle relates to the possibility of reprocessing waste materials and components into production processes, thus resulting in a decrease of negative environmental consequences (Barbaritano, *et al.* 2019; Su, *et al.* 2013; Zhijun & Nailing, 2007). Some authors add the 4th principle – recover, where there is a discussion around incineration of materials with energy recovery (Kirchherr, *et al.* 2017). The 4R model corresponds directly with the model described in EU directive on waste (European Union, 2008). In the Table 1 there is a description of the 9R framework of CE proposed by J. Potting, *et al.* (Potting, *et al.* 2016) that is one of the most complex one and gives the idea of the possible change from the linear to circular economy. Other perspective of the CE principles is the waste hierarchy where an order or ranking of the various solutions indicate the more sustainable actions (Kirchherr, *et al.* 2017).

Furthermore there are also several other conditions that are required, and should be fulfilled for implementing the Circular Economy principles. In detail, economic and financial resources are needed for allowing the use of advanced technology (Wang, *et al.* 2008), sustaining the energy consumption required to carry out recycle activities (Allwood, 2014) and for promoting adequate waste disposal (Su, *et al.* 2013). Another authors Y. Geng and B. Doberstein (Geng & Doberstein, 2008) stressed the role of an efficient information system for planning and managing all activities related to resource reduction, reuse and recycle. Finally, given the critical role of consumers in Circular Economy (Gallaud & Laperche, 2016; Lieder & Rashid, 2016), the overall circular supply chains should also consider consumption processes in addition to production and distribution. Particularly, the degree of consumer awareness about environmental and sustainable issues could highly affect the practical implementation of a circular business model (Barbaritano, *et al.* 2019; Borrello, *et al.* 2017).

Table 1. The 9R Framework

Smarter product use and manufacture		R0. Refuse	Make product redundant by abandoning its function or by offering the same function with a radically different product
		R1. Rethink	Make product use more intensive (e.g. by sharing product)
		R2. Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials
Extend lifespan of product and its parts		R3. Reuse	Reuse by another consumer of discarded product which is still in good condition and fulfils its original function
		R4. Repair	Repair and maintenance of defective product so it can be used with its original function
		R5. Refurbish	Restore an old product and bring it up to date
		R6. Remanufacture	Use parts of discarded product in a new product with the same function
		R7. Repurpose	Use discarded product or its parts in a new product with a different function
Useful application of materials		R8. Recycle	Process materials to obtain the same (high grade) or lower (low grade) quality
		R9. Recover	Incineration of material with energy recovery

Source: Adapted from (Kirchherr, *et al.* 2017; Potting, *et al.* 2016).

Currently, the issue of the circular economy is gaining more and more attention. This model is characterized by designed renewability and reproducibility, and its goal is to constantly maintain the highest value and usability of products, components and materials in separate biological and technical cycles. At the heart of the circular economy is the assumption that it is a continuous cycle of development that preserves and enriches natural capital, optimizes raw material gains, and minimizes systemic risk by managing non-renewable and renewable material streams. This system works on every scale. Its essence is the final decoupling of economic development from the consumption of limited resources (Ellen MacArthur, 2015; Nowicki, *et al.* 2020). According to the all mentioned above, the development of circular economy is based on three principles so far, which are shown in Figure 1.

OUTLINE OF A CIRCULAR ECONOMY

PRINCIPLE

1

Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows.
ReSOLVE levers: regenerate, virtualise, exchange

PRINCIPLE

2

Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles.
ReSOLVE levers: regenerate, share, optimise, loop

PRINCIPLE

3

Foster system effectiveness by revealing and designing out negative externalities.
All ReSOLVE levers

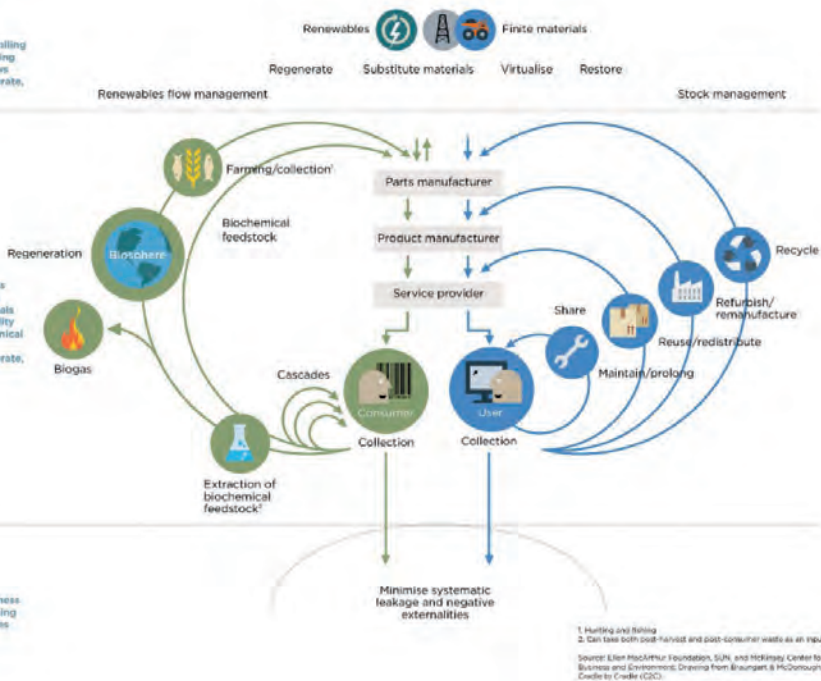


Figure 1. Circular economy diagram

Source: (Ellen MacArthur, 2015).

Recycler's audit

From 1 January 2016, entrepreneurs recycling packaging waste are obliged to carry out an annual external audit. The purpose of the audit is to organize the market, promote enterprises that ensure an appropriate organizational and technical level and meet legal requirements as well as to eliminate recyclers that pose risks to the recovery organization and the recovery system. The deadline for the performance of the statutory obligation is April 30 of the year following the calendar year to which it relates. Based on Article. 51 of the Act of 13 June 2013 on the management of packaging and packaging waste, and further the Regulation of the Minister of the Environment of 21 December 2015 on the annual external audit of entrepreneurs issuing DPO (document confirming recovery), DPR (document confirming recycling), EDPO (a document confirming the export or intra-Community delivery of packaging waste in order to subject it to a recovery process other than recycling, including the weight of this waste) or EDPR (a document confirming the export or intra-Community delivery of

packaging waste for recycling, including the weight of this waste) documents the obligation to conduct an audit applies to entrepreneurs:

- recycling or non-recycling process for the recovery of packaging waste, who issue DPO and DPR documents and have a processing permit, allowing the recovery of waste with a mass exceeding 400 Mg/year;
- exporting packaging waste and entrepreneurs making intra-Community deliveries of packaging waste, who issued EDPR documents or EDPO documents in a given calendar year, confirming the export of packaging waste or intra-Community delivery of packaging waste weighing more than 400 Mg /year;

The new regulations assume that the external audit is carried out by an accredited environmental verifier referred to in the provisions of Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009, i.e. only by certification bodies accredited by EMAS. The scope of the annual external audit includes (Dziennik Ustaw RP, 2015):

- checking the permits held under the Act on waste or the permits referred to in the Act – Environmental Protection Law;
- compliance assessment of the recycling process or non-recycling packaging waste recovery process with the permits or permits held and assigning this process to recycling or recovery process other than recycling in documents prepared for the purposes of waste records;
- assessment of the installations or devices owned by the entrepreneur in terms of technical possibilities to process the masses of waste indicated in the permits or permits held by the entrepreneur;
- assessment of the compliance of the masses and types of packaging waste indicated in the DPO and DPR documents with the annual capacity of the installations or devices indicated in the permits or permits and with the documents prepared for the purposes of waste records;
- assessment of the correctness of the packaging waste processing carried out by the entrepreneur in relation to the recovery processes indicated in the DPO and DPR documents;
- conformity assessment of the conducted recovery process as a result of which the waste ceased to be a waste pursuant to the provisions of Chapter 5 of the Act on waste;
- assessment of the compliance of the masses and types of packaging waste indicated in the EDPO and EDPR documents with the documents prepared for the purposes of waste records by an entrepreneur exporting packaging waste or an entrepreneur performing an intra-Community delivery of packaging waste;
- assessment of the compliance of the masses and types of packaging waste indicated in the documents drawn up for the purposes of waste records with financial documentation, in particular with VAT invoices, held by the

entrepreneur for the purchase of waste intended for recycling, for the calendar year to which the audit relates.

After carrying out the audit, the auditor prepares a draft report. The draft report is submitted to the audited entrepreneur. The audited entrepreneur, within 14 days from the date of receipt of the draft report, may submit in writing additional explanations or justified reservations regarding its content. The auditor, after receiving additional explanations or justified objections regarding the draft report from the audited entrepreneur, analyses them and, if necessary, undertakes additional checks in this regard. If the auditor finds that all or part of the additional explanations or justified reservations submitted by the audited entrepreneur are justified, the draft report is changed or supplemented. Additional explanations or substantiated reservations are included in the audit documentation. After the auditor considers additional explanations or justified objections, the draft report becomes an audit report. The audit report contains information on the causes and effects of the state of affairs, as well as findings and recommendations for the removal of deficiencies or the introduction of improvements. The auditor submits, by June 15 of the year following the calendar year to which the audit relates to the audit report, to the audited entrepreneur and a certified copy of the audit report:

- a) the voivodship marshal - competent for the place of residence or seat of the audited entrepreneur,
- b) the voivodeship environmental protection inspector – competent for the place of business of the audited entrepreneur.

Conclusions

Summarizing the descriptions of the circular economy and the legal requirements for conducting a recycler audit, it should be indicated that the obligatory audit process for recycling companies definitely brings closer and facilitates the transposition of their activities towards a circular economy. In many cases, this obligatory audit somehow forces entrepreneurs to properly comply with the provisions and at the same time care for the natural environment in which we operate. Among the elements included in the 9R framework there are many activities that simultaneously become tools for the functioning of circular economy. One of them is recycling, which, according to the authors, is a key element of the implementation of circular economy. For a circular economy it is essential to recycle materials from waste in order 'to close the loop'. Therefore, it can be concluded that just as the circular economy is much more than recycling, so recycling is more than separate collection of waste. We can distinguish activities related to upcycling, where a completely different product is created than the original one, without breaking it into elements, and with

downcycling, where the material decomposes - as a result, we can use it as a poorer material. In both cases, the main beneficiaries are both producers and consumers. The requirements for the audit of the recycler and the concept of circular economy are very complementary to the problems of today's world, where there is more and more waste that can be reused and must be dealt with in a way that does not burden the environment. Creating new requirements for entrepreneurs dealing with recycling, on the one hand, causes certain difficulties and generates additional costs and burdens employees with new obligations, but nevertheless provides many benefits that allow them to develop. By conducting an annual audit, the entrepreneur confirms its compliance in the field of recovery and recycling of packaging waste and verifies the correctness of the issued DPR, DPO, EDPR or EDPO documents. As a result, the entrepreneur gives credibility to his assessment of a reliable recycler in relation to public authorities, as well as to customers, suppliers and recovery organizations. For recyclers, recovery and leading exporters of waste, it also means increasing the chances for cooperation with organizations recovery and elimination of unfair competition.

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References

- Allwood, J.M. (2014). Squaring the Circular Economy: The Role of Recycling within a Hierarchy of Material Management Strategies. In: Handbook of Recycling: State-of-the-Art for Practitioners, Analysts, and Scientists, <https://doi.org/10.1016/B978-0-12-396459-5.00030-1>
- Andersen, M.S. (2007). An introductory note on the environmental economics of the circular economy. *Sustainability Science*, 2, 133–140, <https://doi.org/10.1007/s11625-006-0013-6>
- Barbaritano, M., Bravi, L., Savelli, E. (2019). *Sustainability and Quality Management in the Italian Luxury Furniture Sector: A Circular Economy Perspective*.
- Bocken, N.M.P., de Pauw, I., Bakker, C., van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial and Production Engineering*, <https://doi.org/10.1080/21681015.2016.1172124>
- Borrello, M., Caracciolo, F., Lombardi, A., Pascucci, S., Cembalo, L. (2017). *Consumers' perspective on circular economy strategy for reducing food waste*. Sustainability (Switzerland), <https://doi.org/10.3390/su9010141>

Dziennik Ustaw RP, 2015. ROZPORZĄDZENIE MINISTRA ŚRODOWISKA z dnia 21 grudnia 2015 r. w sprawie rocznego audytu zewnętrznego przedsiębiorców wystawiających dokumenty DPO, DPR, EDPO lub EDPR. Warszawa.

Ellen MacArthur Foundation, (2013). Towards the Circular Economy: Opportunities for the consumer goods sector. Towards the Circular Economy.

European Commission (2015). Communication from the commission to the European Parliament, the Council, the European economic and social committee and the committee of the regions. Closing the loop – an EU action plan for the circular economy. Com 614, 21, <https://doi.org/10.1017/CBO9781107415324.004>

European Union (2008). Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives. LexUriServ. do, <https://doi.org/2008/98/EC.; 32008L0098>

Gallaud, D., Laperche, B. (2016). *Circular economy, industrial ecology and short supply chain, Circular Economy, Industrial Ecology and Short Supply Chain*, <https://doi.org/10.1002/9781119307457>

Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Hultink, E.J. (2017). The Circular Economy – A new sustainability paradigm? *Journal of Cleaner Production*, 143, 757–768, <https://doi.org/10.1016/j.jclepro.2016.12.048>

Geng, Y., Doberstein, B. (2008). Developing the circular economy in China: Challenges and opportunities for achieving “leapfrog development.” *International Journal of Sustainable Development & World Ecology*, <https://doi.org/10.3843/SusDev.15.3:6>

Ghisellini, P., Cialani, C., Ulgiati, S. (2016). A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114, 11–32, <https://doi.org/10.1016/j.jclepro.2015.09.007>

Kirchherr, J., Reike, D., Hekkert, M. (2017). *Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling*, <https://doi.org/10.1016/j.resconrec.2017.09.005>

Lewandowski, M. (2016). *Designing the Business Models for Circular Economy — Towards the Conceptual Framework*, <https://doi.org/10.3390/su8010043>

Lieder, M., Rashid, A. (2016). Towards circular economy implementation: A comprehensive review in context of manufacturing industry. *Journal of Cleaner Production*, 115, 36–51, <https://doi.org/10.1016/j.jclepro.2015.12.042>

MacArthur, E. (2015). *Growth within: a circular economy vision for a competitive Europe*, Ellen MacArthur Foundation, <https://doi.org/Article>

Nowicki, P., Kafel, P., Balon, U., Wojnarowska, M. (2020). Circular economy's standardized management systems. Choosing the best practice. Evidence from Poland. *International Journal for Quality Research*, <https://doi.org/10.24874/IJQR14.04-08>

Potting, J., Hekkert, M., Worrell, E., Hanemaaijer, A. (2016). *Circular Economy: Measuring innovation in the product chain – Policy report*. PBL Netherlands Environmental Assessment Agency.

Segerson, K., Pearce, D.W., Turner, R.K. (2006). *Economics of Natural Resources and the Environment*. *Land Economics*, <https://doi.org/10.2307/3146419>

Su, B., Heshmati, A., Geng, Y., Yu, X. (2013). A review of the circular economy in China: Moving from rhetoric to implementation. *Journal of Cleaner Production*, 42, 215–227, <https://doi.org/10.1016/j.jclepro.2012.11.020>

Wang, G.H., Wang, Y.X., Zhao, T. (2008). *Analysis of interactions among the barriers to energy saving in China*. *Energy Policy*, <https://doi.org/10.1016/j.enpol.2008.02.006>

Webster, K. (2017). *The circular economy: A Wealth of Flows*, Ellen MacArthur oundation Publishing, <https://doi.org/10.1038/531435a>

Witjes, S., Lozano, R. (2016). *Towards a more Circular Economy: Proposing a framework linking sustainable public procurement and sustainable business models*. *Resources, Conservation and Recycling*, <https://doi.org/10.1016/j.resconrec.2016.04.015>

Yuan, Z., Bi, J., Moriguichi, Y. (2006). *The circular economy: A new development strategy in China*. *Journal of Industrial Ecology*, <https://doi.org/10.1162/108819806775545321>

Zhijun, F., Nailing, Y. (2007). Putting a circular economy into practice in China. *Sustainability Science*, <https://doi.org/10.1007/s11625-006-0018-1>

FOOD SAFETY MANAGEMENT SYSTEM AS A TOOL FOR REDUCING THE RISK RELATED TO THE ACTIVITY OF AN ORGANIZATION IN THE FOOD CHAIN

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Abstract

An integral element of Food Safety Management Systems (FSMS), based on the requirements of the ISO 22000:2018 standard, is risk management, which may have an impact on the effectiveness of the system and the results achieved in the area of ensuring food safety. Effective risk management enables organizations to meet food safety objectives in an effective and efficient way, achieve the set goals by FSMS, and ultimately achieve lasting success in a constantly changing environment.

The purpose of the article is to analyze the requirements for risk management specified in the ISO 22000:2018 standard and to present the possibility of using FSMS as a tool to reduce the risk associated with the activities of organizations belonging to the food chain.

As a result of the research that was carried out, it was found that FSMS is a tool that enables an organization to manage risk on two levels: operational, including risk management of the occurrence of food safety hazards, which could have a potentially negative impact on the health of consumers as well as business, including risk management that may have an impact on the ability of an organization to achieve the objectives related to food safety.

Keywords:

food safety, risk management, food safety management system

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Introduction

The functioning of any organization, regardless of its size or type of activity, is influenced by internal and external factors, which make it uncertain whether and when it will achieve its goals. The influence of such an uncertainty on goals is called risk. Organizations need to effectively manage risk to increase their ability to achieve their goals, and risk management is one of the tools that organizations can use to deal with the uncertainty and volatility of the economic environment in which they operate (Gołaś, Mazur & Misztal, 2016). The effectiveness of risk management is the main determinant of the quality of organization management, an integral part of the organization's strategy (Lisiecka, 2012).

The food chain is a field of the organization's activity where risk management is becoming increasingly important due to the possible threats to consumer safety (Szkiel, 2015). One of the tools that chain organizations can use to eliminate or reduce risk to an acceptable level is Food Safety Management System (FSMS) compliant with ISO 22000:2018 standard. Having an efficient FSMS is a prerequisite for the company in food chain to remain competitive (Monge-Mora, *et al.* 2020). The purpose of implementing this system is (Purwanto, Santoso & Asbari, 2020):

- ensuring the safety of food products and services,
- meeting the requirements of food law,
- meeting customer requirements related to food safety and demonstrating compliance with these requirements,
- communicating information related to food safety in the food chain,
- demonstrating compliance of the organization's activities with the adopted food safety policy.

The system approach to food safety management is a preventive measure related to the improvement of the organization's activities aimed at ensuring food safety, as well as minimizing undesirable situations related to the occurrence of hazards that may have a negative impact on consumer health. This approach indicates that FSMS, reflecting contemporary market trends, is part of the risk management trend. It is noticeable in the changes introduced in standardization in the area of management systems, including food safety management (Zapłata, 2012b).

An effective FSMS compliant with the ISO 22000:2018 standard enables the organization to achieve its goals. Organizations in the food chain should define and achieve, first and foremost, food safety objectives. However, they may also be goals related to other aspects of the organisation's functioning, e.g. compliance with food law and ensuring legality of products, relations with interested parties (e.g. clients, consumers, suppliers, official food control authorities), finances (achieving long-term profits), influence on the environment, occupational health and safety, social responsibility.

Companies nowadays operate in turbulent environment of very prominent producer competition and developed distribution channels. There is a significant increase in the uncertainty that brings significant risks with it, so that business entities are critical to managing its internal and external risks (Alheriani, *et al.* 2021). The variability and complexity of the environment in which the organizations belonging to the food chain operate, and thus the uncertainty and risk, determine all decision-making processes. Therefore, the model of a system approach to food safety management described in the ISO 22000:2018 standard is based on the concept of risk-based thinking. This concept implies that risk management, which can impact the achievement of goals, should be an integral part of the FSMS and the organisation's overall management system, as well as a pillar of the organisation's food safety culture. This enables the creation of an organization's ability to achieve and maintain its goals over time and thus achieve sustainable market success in a complex, demanding and ever-changing environment (ISO 9004:2018).

This is a review article. Its purpose is to analyze the requirements for risk management specified in the ISO 22000:2018 standard and to present the possibility of using FSMS as a tool to reduce the risk associated with the activities of organizations belonging to the food chain.

Updating the requirements of the ISO 22000:2018 standard

The need to harmonize the requirements for the food safety management system at the international level, adapted to the specific functioning of enterprises that belong to the food chain, led to the publication of the ISO 22000 by the International Organization for Standardization in 2005, an internationally recognized standard specifying the requirements for a system approach to food safety management (ISO 22000:2005).

In June 2018, the ISO 22000 standard was updated. The main purpose of this revision was to ensure that the ISO 22000:2018 standard would meet new growing food safety challenges [Chen, *et al.* 2020]. The amendment to the standard was a response to the needs of organizations operating in the food chain regarding the implementation of an organization management model, enabling the achievement of food safety objectives. It was also aimed to take into account the latest management trends and the best organization management practices, especially related to risk management affecting its functioning. In addition, the changes to the standard were aimed to increase the transparency of the requirements for FSMS and make it easier for organizations to understand and interpret them.

The revised standard has a structure in line with the High Level Structure concept, common to all standards for management systems developed by International Organization for Standardization. This concept is designed to improve alignment across management system standards, therefore facilitating an organization to integrate FSMS with other management systems to achieve comprehensive organizational protection (ISO 22000:2018a; Rosiak, 2020; Monge-Mora, *et al.* 2020; Chen, *et al.* 2020). In addition, the requirements of the 22000:2018 standard are based on seven universal principles of quality management, which are the basis of the quality management system model described in the ISO 9001:2015 standard and are now recognized as key principles in the implementation of any management system (ISO 22000:2018b; ISO 9001:2015).

One of the main barriers to the implementation of FSMS is a lack of top management commitment (Purwanto, Hutagalung, Yanthy, 2020). The management's approach to food safety behaviour could influence the food safety culture at work or the employees' food safety behavior (Sharman, Wallace & Jespersen, 2020). Therefore, the revised ISO 22000:2018 standard emphasized the importance of leadership and commitment of the senior management of the organization as an internal factor determining the effectiveness of FSMS (Monge-Mora, *et al.* 2020). The senior manager must be able to command and guide employees, as well as show responsibility to establish, implement and maintain food safety policy (Purwanto, Santoso & Asbari, 2019). This is to ensure that maintaining the system is primarily the responsibility of senior management.

One of the external factors that are the key to the successful implementation of FSMS is context in which the organization operates (Monge-Mora, *et al.* 2020). Therefore, the new requirements also include the requirement to analyze the context of the organization, that is, to determine the external and internal factors relevant to the implementation of the goals and strategy of the organization (ISO 22000:2018b). In addition, the standard introduced a requirement to adopt a process approach when developing, implementing and improving FSMS, previously used in quality management systems based on standards of ISO 9000 series. According to this approach, organizations should identify and manage the processes implemented in the system and their interrelationships in order to ensure that the processes achieve the assumed results. This approach is currently considered the most effective organizational management model.

Along with the revision of the standard, the requirements regarding FSMS documentation have been reduced. The organization is no longer required to develop documented procedures; the standard only indicates areas where documented information should be maintained. The introduction of a general term in the standard – documented information, which does not specify the type and name of mandatory documents, leaves a lot of freedom in the choice of the form and structure of documents of FSMS (Dzwolak, 2018b). The organization

should establish and maintain documented information for areas that are areas that are important to ensure that the processes are carried out as planned and to demonstrate the compliance of products and services with the requirements. The organization should still maintain documentation defining the principles of managing the organization's activities and the functioning of the FSMS, however, the amended standard places emphasis on the preparation of records that will provide evidence that the organization achieves the assumed results.

Another change introduced in the ISO 22000:2018 standard is the link between food safety management and the continuous improvement process. The requirements of the standard include two PDCA (plan, do, check, act) improvement cycles. The PDCA cycle was designed to enable organizations to ensure that their processes are adequately resourced and managed, and to identify opportunities for improvement and action (Chen, *et al.* 2020). The first cycle relates generally to the FSMS and is aimed to increase its effectiveness, while the second relates to operational activities and is aimed to improve the processes affecting food safety. These two PDCA cycles operate independently, and through mutual relations, they can maintain the synergy of cooperation and make food safety systems and food safety programs effective (Chen, *et al.* 2020). Therefore, ISO 22000 FSMS not only allows for the growth of food safety but also enables the improvement of key processes in the food supply chain, especially in production and control processes (Granja, *et al.* 2021).

Food safety objectives are a tool for continuous improvement; hence the standard specifies new requirements for monitoring, measuring, analyzing and evaluating the achievement of objectives. In addition, the requirements for operational control, contained in point 8 of the standard, were more closely related to the implementation stages of the HACCP system specified in the Codex Alimentarius, and were extended to include requirements for supervision over processes, products and services supplied from outside (Codex Alimentarius, 2020; Szkiel, 2020).

A significant change in the requirements for FSMS is also the extension of risk management requirements compared to the previous version of the standard (Dzwolak, 2018a). The requirements for identifying risk at the operational level, i.e. the risk of food safety hazards that may have a negative impact on the health of consumers at particular stages of the processes, remained unchanged. Additionally, new requirements have been introduced regarding the identification of risk at the organizational level, which may affect the ability of the organization and its FSMS to achieve the assumed results (ISO 22000:2018). This is a significant change from the point of view of the organization in the food chain; as such activities have not been standard practice in food safety management so far.

A risk-based approach as part of standardized management systems

While developing standards for management systems, the International Organization for Standardization is guided by the assumption that they should be adapted to the needs of organizations operating in a turbulent environment, as well as to current management trends. Nowadays, risk management is becoming more and more important for business. It has become an important element of enterprise management and the decision-making process. Therefore, it is important for companies to standardize risk management and take a systematic approach in this area by ensuring compliance with the standards, as this allows them to demonstrate their efforts in this field (Björnsdóttir, Jensson & Boer, 2021).

In order to meet the needs of enterprises, the concept of a risk-based approach has been included in the HLS concept that defines the structure of standards for management systems. As a result one of the most important requirements identified in all management systems standards is risk management, which should be part of all processes within an organization. A systems approach to risk management should be an integral part of managing the organization, as well as part of policy definition, strategic planning and change management (Alheriani, *et al.* 2021).

The basis of the risk-based approach is the identification and risk analysis that has an impact on the effectiveness of the management system. Risk is a complex concept and therefore it is difficult to define. Risk is most frequently described in relation to the uncertainty associated to the situation when the knowledge regarding future events is flawed. The definitions also associate risk with a potential impact for the organization, which can mean both losses and benefits. Therefore, risk can be perceived in relation to the results – in compliance with requirements, effectiveness or efficiency (Jedynak, 2017).

Similar approach to defining risk has also been adopted in standardized management systems. As defined in the ISO 31000:2018 standard, risk should be understood as the impact of uncertainty on objectives (ISO 31000:2018). Therefore, risk is an effect of uncertainty, which may have positive or negative effects on the achievement of goals and achieved results. Therefore, actions taken by organizations in relation to the identified risk that affect the effectiveness of the management system should be directed not only at the elimination of undesirable effects, but also at the use of potential opportunities appearing in the environment in which the organization operates, both internal and external. Risk is most often expressed by organizations in terms of risk source, potential events, their consequences and their likelihood (ISO 31000:2018).

As the existing risk is reflected in the results achieved by the organization, risk management should be an integral element of the management system. Risk

management should be understood as coordinated activities to direct and control with regard to risk (ISO 31000:2018). Risk management aims at increasing the probability of success (Rampini, Takia & Berssaneti, 2019). It improves performance, encourages innovation and supports the achievement of objectives (ISO 31000:2018). Organizational risk management has to be integrated into all decision-making processes that generate value for the organization (Demelo & Demedeiros, 2020).

The activities that constitute for risk management should include defining the organization's risk management policy, analyzing the context in which the organization operates, as well as establishing procedures that define: the principles of risk identification and evaluation, taking action in relation to risk, monitoring, risk, its documentation and reporting (Rampini, Takia & Berssaneti, 2019).

Risk management at the operational level

An integral element of FSMS compliant with the requirements of the ISO 22000:2018 standard is the HACCP system. The HACCP principles and the stages of its implementation, in accordance with Codex Alimentarius (Codex Alimentarius, 2020), have been included in the requirements of point 8 of the ISO 22000:2018 standard on operational activities. The implementation of these requirements enables the organization to manage operational risk, i.e. the risk of food safety hazards occurring at individual stages of the processes, which could potentially have a negative impact on the health of consumers. In this context, food safety risk is defined as a function of the probability of an adverse effect on the consumer's health, such as illness, and the severity of this effect when exposed to a specific hazard such as hospitalization, absenteeism, death (ISO 22000:2018b).

The organization should ensure the safety of products at all stages of the implemented processes, production, transport and storage. Hazard control activities, in line with the principles of the HACCP system and established prerequisite programs, aim to eliminate the risk of introducing non-compliant food products into the food chain (Rosiak, 2020). This is ensured by introducing mechanisms that will reduce the probability of exceeding the acceptable levels of hazards, such as, for example, the definition of risk control measures, the selection of process steps critical to ensure food safety, the definition of process parameters to be monitored with their limit values, monitoring of critical control points, or taking corrective actions after exceeding the established critical limits. The implementation of these mechanisms ensures that all food safety hazards that can be reasonably expected during the implementation of the processes are identified, assessed and controlled in such a way that the organization's products do not harm the consumer, directly or indirectly. The basic objective of operational

risk management in the food safety management system is therefore to ensure an appropriate level of consumer health protection.

An introduction to operational risk management is the identification of risks that should be subject to supervision. Each process within the scope of the FSMS should be considered in terms of its impact on food safety. Therefore, risk management at the operational level refers to the process approach to management and the related process perspective in understanding risk (Jedynak, 2017). In addition, all decisions of the organization that may directly or indirectly affect food safety should be made while taking into account the conducted risk analysis, i.e. the assessment of the severity of the consequences of the decision on the ability to achieve the assumed food safety objectives by the organization.

Properly conducted risk analysis is necessary for effective process management, as it enables ordering the knowledge required to establish an effective combination of supervision measures that will be used in individual processes. Operational risk management should cover both the current threats, included in the risk prevention plan, as well as new emerging threats that should be subject to supervision.

Operational risk management should also be an integral part of the design and implementation of changes to processes and products. The introduction of a new product, packaging, manufacturing method or process parameters, especially if it involves a risk to a group of vulnerable consumers, should be preceded by an assessment of the associated risk. Considering risk management at the design stage ensures that a potential new product will be manufactured in a way that ensures its safety, enables the elimination of hazards before the product is delivered to consumers, and the reduction of costs related to the occurrence of hazards.

On the basis of the conducted hazard and risk analysis, the organization should define its strategy that it will use to ensure the control of threats, and then establish and implement processes that will enable its implementation. In accordance with the requirements of the ISO 22000:2018 standard, the principles of operational risk management (its identification, assessment, monitoring and response in the event of exceeding the acceptable risk level), as well as its results, providing evidence of product compliance with the requirements and confirming their safety, must be documented by the organization.

Risk management at the organizational level

The updated ISO 22000:2018 standard requires organizations to use a risk-based approach when planning, implementing, maintaining and improving FSMS. Such an approach was considered necessary for the implementation of an effective

and efficient system, continuous improvement of the organization's performance and prevention of negative effects. Therefore, in addition to operational risk, the organization must also identify the business-level risk (at the organization-wide level) that may have an impact (positive or negative) on the ability of the organization and its FSMS to achieve the intended results (ISO 22000:2018b).

The risk-based approach is consistent with the general assumption of the revised ISO 22000:2018 standard, which places emphasis on achieving planned results and less on how to achieve them. This approach allows the organization to identify factors that could cause its processes in the food safety management system to deviate from the planned results and to introduce supervision to prevent or minimize negative effects. It also enables opportunities that may lead to the adoption of new practices, modification of processes or products, the use of new technologies, and the ability to meet the food safety needs of an organization or its customers (ISO 22000:2018b).

Organizational risk should be related to the identified expectations of interested parties and the defined scope of the FSMS (ISO 22000:2018b). It should also be related to the established context of the organization, especially those factors that shape the effectiveness of the system. The environment in which the organization operates and the related external threats, as well as internal factors specific to its activities, such as location, organizational structure, food safety culture, resources, and related internal threats should be taken into account.

According to the requirements of ISO 22000 standard, when planning FSMS, the organization should identify risks and opportunities that may affect the effectiveness of the system and the achieved results in the area of food safety. The standard also requires the organization to plan activities that will enable the elimination of the identified risk or its reduction to an acceptable level, as well as the use of opportunities to improve the performance of the system and improve its effectiveness (ISO 22000:2018b). When planning activities related to risks and opportunities, the organization should adapt them to the impact on food safety, compliance of products and services with customer requirements and the requirements of stakeholders in the food chain. When identifying actions in relation to risks and opportunities, the organization should also plan how it will evaluate their effectiveness. The results of this assessment should be subject to management reviews by the management (ISO 22000:2018b).

The ISO 22000:2018 standard does not define detailed requirements for the methodology of identifying and assessing organizational risk. The organization is also not required to document its risk management process. However, the formalization of this process enables the organization to take a systemic approach to identifying and assessing risks, as well as planning and implementing actions in relation to risk. It is necessary to ensure a stable level of food safety and to

maximize the results in various areas of the organization's activities. Only a systematic and properly documented risk management process provides access to reliable information on risk and enables appropriate risk response (Dembicka & Mołas, 2019).

The organization may identify risk that affects its FSMS, e.g. during strategic meetings, management reviews, internal audits, meetings devoted to food safety issues, activities related to the design and development of new products or the design of production processes. An organization may use a number of different methods to analyze the factors that have an impact on FSMS effectiveness and the associated risk. The most important and widely used methods include the PESTLE method (including the analysis of political, economic, social, technological, legal and environmental factors) and the SWOT method (analysis of the organization's strengths and weaknesses, as well as threats and opportunities) (Monge-Mora, *et al.* 2020).

While planning activities that relate to the identified risk, the organization should take into consideration their impact on:

- health safety of products and services and their compliance with the requirements of customers and other interested parties,
- the organization's ability to meet food safety requirements (e.g. customers, official food control bodies or those resulting from food law),
- results of other processes carried out in the system,
- achievement by the organization of the assumed food safety objectives.

An organizational risk assessment methodology that an organization can use may be based on the risk assessment used in the HACCP system. Such a solution will ensure consistency and standardization of the approach to operational and organizational risk management. However, the organization may adopt any other methodology, such as that described in the ISO 31000:2018 standard. It is important that the approach taken by the organization is understood by the organization's personnel involved in the risk management process and will ensure the effectiveness of the FSMS. In small organizations, a simplified assessment of the impact of actions, e.g. changes in the composition or packaging of a product, on its safety may be sufficient (Dzwolak, 2018a). However, it should be remembered that oversimplification of the procedure may lead to the overlooked or underestimation of serious risks, resulting in ineffective system (Wiśniewski & Grudzień, 2017).

When formalizing the principles of risk management, the organization should define (Kleniewski, 2015):

- the degrees of threats used in the assessment (e.g. low, medium, significant),
- probability degree definitions,

- definition of degree of consistency,
- definitions of acceptable risk,
- rules for determining and documenting the flow of information about priorities in taking actions relating to the identified risk,
- description of how to deal with the highest risk identified (decision path).

Risk mitigation areas in FSMS

In accordance with the new approach adopted in the ISO 22000:2018 standard, the foundation of an effective FSMS is the context of the organization, i.e. external and external factors, both positive and negative, which are relevant to the purpose of its operation and affect its ability to achieve the intended results of the system (ISO 22000:2018b). Any change in the organization's environment may be a source of risk. An important element of the context of the organization's operation are the needs and expectations of its interested parties, e.g. clients, consumers, official food control bodies, suppliers, certification entities, owners, business partners. The standard requires the organization to continuously identify, monitor, review and update information regarding its stakeholder requirements in order to select those that are relevant to its FSMS and therefore become requirements for the organization (ISO 22000:2018b). Relevant stakeholders are those that pose a risk to the system if their needs and expectations are not met. So these are the stakeholders on whom the organization's success and the effectiveness of its FSMS depend (Szkiel, 2020).

The requirements of interested parties should be taken into account by the organization when planning and implementing activities relating to the identified risks and opportunities (ISO 22000:2018b). Correct and comprehensive determination of the risk related to the needs and expectations of interested parties is a prerequisite for organizations to achieve sustainable market success (Dembicka & Mołas, 2019). Therefore, the standard adopts a holistic approach to the analysis of the organization's stakeholders, aimed at reducing the risk of omitting the parties important from the point of view of their activities by organizations, as well as omitting their essential requirements. The needs and expectations of interested parties may refer not only to the safety of products and services, but also to their broadly understood quality (organoleptic features, nutritional values and functional properties) and delivery conditions, e.g. timeliness, flexibility or quality of service (Jedynak, 2015; Wieteska, 2012). While operational risk management in accordance with the HACCP principles is aimed to ensure that food will be safe and will not harm consumers, organizational risk management is aimed to obtain broadly understood customer satisfaction with the quality of products and services. The introduction of the requirements for the analysis of the context of the organization in the ISO 22000:2018 standard,

including the analysis of the requirements of interested parties, is therefore aimed to enable organizations in the food chain to reduce the risk related to non-compliance with these requirements, and thus reduce the risk related to loss of reputation and loss of customers (current and potential customers).

Communication plays an important role in building relationships with interested parties. Each organization in the food chain should demonstrate that it has relevant and up-to-date information, compiled from comprehensive sources, on food safety. This is to use a solid basis, including scientific one, when managing risk related to product safety. Therefore, organizations should collect information on food safety hazards from suppliers, contractors, consumers, official food control entities, databases, external experts, as well as all stakeholders who have an impact on the risk related to the achievement of the organization's food safety objectives that might bear its consequences (Szkiel, 2015). Effective communication, both internal and external, reduces the risk of a lack of flow of information relevant to food safety throughout the food chain. In addition, it enables the organization to build awareness of food safety issues and a sense of product responsibility among all participants in the chain (Wieteska, 2012).

In the light of the applicable food law, the organization producing or marketing the food is responsible for ensuring food safety, because it is responsible for any damage and harm to the health of consumers caused by food that does not meet the requirements. The implementation of the FSMS enables the organization to demonstrate that it performed due diligence in the implementation of food-related processes in order to ensure its compliance with the requirements of food law. Ensuring the legality of products, understood as their compliance with applicable legal requirements, is the basis of the organization's food safety policy. As part of the implemented FSMS, the organization provides evidence that it has a full picture of the legal regulations applicable to its products and services, systematically assesses compliance with regulations, monitors changes in these regulations and takes them into account when updating the system. In addition, the organization ensures knowledge of legal regulations throughout the structure of organization, takes into account the requirements when defining specifications for products, establishing prerequisite programs, identifying hazards and determining their acceptable levels in products. Therefore, the implementation of the ISO 22000:2018 standard requirements minimizes the risk of non-compliance by the organization with legal regulations and reduces its effects, such as the need to pay compensation to consumers for damage to health, financial sanctions imposed by official food control authorities, issuing a decision by the supervisory entity to temporarily suspend production or permanent closure of the organization.

The processes of monitoring, verification, validation, auditing and reviews of system suitability, adequacy and effectiveness play an important role in risk management

under FSMS. This is because they enable the organization to collect information on an ongoing basis about the degree of fulfillment of the requirements relating to both the products and services of the organization and its FSMS. Thanks to information about possible non-conformities, the organization can quickly react to emerging threats. System assessment processes influence the risk reduction by identifying problems, non-conformities and the causes of the occurring adverse events (Wieteska, 2012). Assessment processes and subsequent improvement actions significantly affect the effectiveness of FSMS, and thus reduce the risk of losing the system certificate, which may be a negative factor affecting the competitiveness of the organization.

All organizations in the food chain are interconnected, because each of them is on the one hand a supplier of its finished products, and on the other hand, a buyer (of raw materials, semi-finished products, services). The concept of a systemic approach to food safety management assumes that the safety of products and services provided to end consumers must be ensured as a result of the combined efforts of all organizations participating in the chain. The occurrence of food safety threats may take place at any stage of this chain (ISO 22000:2018b). As the safety of an organisation's finished products is significantly influenced by raw materials, semi-finished products, additives and packaging provided by suppliers with whom the organization cooperates, as well as processes outsourced by it (e.g. transport services, cleaning services, infrastructure maintenance), the organization must focus your activities on building lasting relationships with suppliers. The implementation of FSMS enables the organization to mitigate the risks associated with the purchasing process and outsourced processes that may affect the organization's ability to meet food safety objectives (Szkiel, 2015). This is because the ISO 22000:2018 standard requires that processes, products or services provided externally do not adversely affect the organization's ability to consistently meet FSMS requirements. By ensuring supervision over suppliers, the organization reduces the risk related to deliveries, such as the risk of delivering products that do not meet the requirements relating to their safety, purchase of adulterated products, delayed deliveries, ineffective control of deliveries, as well as the risk of crisis situations in the organization resulting from supplier errors. The implementation of FSMS also enables limiting the risk of ineffective communication with suppliers, e.g. related to the failure to provide suppliers with the organization's requirements relating to the safety of the purchased products or failure to provide them with feedback on the identified threats related to the delivered products.

One of the areas of the ISO 22000:2018 standard requirements are the requirements for defining and ensuring the necessary competences of the personnel, as well as their awareness of the impact of performed tasks on food safety (ISO 22000:2018b). Meeting these requirements enables the organization

to reduce the risk of errors made by employees, which may result, for example, from a lack of knowledge or deliberate omission of established rules of conduct. Where personnel fail to adhere to the procedures which control the hazards identified in the HACCP plan, consumers are put at risk, which may lead to recalls or foodborne illness. Thus, FSMS enables an organization to create a food safety culture in which employees are willing to engage in behaviours that collectively contribute to the organization's compliance (Sharman, Wallace & Jespersen, 2020). The key to reduce such risk is to ensure the competence of people who carry out work directly affecting food safety, as well as people important for the effectiveness of FSMS – responsible for monitoring hazards, supervising critical control points and taking corrective actions. The implementation of the system also enables limiting the risk related to the personnel by defining and enforcing the requirements concerning the hygiene of the personnel, as well as the risk of improper organization of work by defining the scopes of tasks, responsibilities and authorizations of the personnel, as well as describing the rules of conduct in the process implementation in the system documentation.

The requirements of the ISO 22000:2018 standard focusing on the process implementation environment and on prerequisite programs minimize the risk associated with these areas and prevent the introduction of threats to food production from the production environment. In addition, the requirements for supervision over the infrastructure ensure that the infrastructure will not pose a threat to the safety of finished products, enable the reduction of the risk of failure of machines, devices, IT systems, as well as the risk of their negative impact on food safety. Such situations lead not only lack of food safety, which cannot be used in further stages of production processes and introduced into the food chain, but also to delays in the execution of orders for customers, interruptions in business continuity and reputation problems (Wieteska, 2012).

The food safety management system also reduces the risk of emergencies and crises related to food safety, such as fire, failure of the water supply network, lack of energy supply, infrastructure failures, sabotage (deliberate food contamination). A proper approach to this issue can protect organizations from economic, image and legal consequences, which would undoubtedly be large if it was necessary to initiate actions related to recalling the product from the market and paying compensation to consumers for damages (Łańcucki, 2019). In the event of a crisis situation, the organization is prepared to take actions related to the protection of its activities, minimizing the effects of the crisis. Preparing for crisis situations allows for a systemic approach, and thus minimizes the risk of taking ill-considered and disorderly actions in the event of being surprised by a crisis situation (Zapłata, 2012a). Taking action to prevent the occurrence of crisis situations, as well as skillful handling in such situations reduces the risk of losing the reputation of the organization (Wieteska, 2017).

Thus, the implementation of FSMS increases the organization's ability to effectively respond to crises occurring in the food chain and reduce the image of crises related to their occurrence, as well as financial losses (e.g. related to re-evaluation of products to confirm their safety, loss of customers, withdrawal of products from the market, their disposal). On the occasion of emergencies, the organization identifies new threats, which are taken into account during the FSMS update. In this way, the organization reduces the level of risk of the same emergencies in the future.

An important element of the FSMS, reducing the risk related to crisis situations, is a mechanism enabling effective communication to interested parties of information related to a crisis situation, as well as supporting the withdrawal from the market of products that do not meet the requirements relating to their safety and, as a result, endanger the health of consumers. Requirements for the implementation of an effective traceability system that support product recall processes and reduce losses, both for the organization and its customers, related to the delivery of a non-compliant product are also important. From a public health point of view, an effective traceability system reduces the risk of unsafe food being introduced on market. In addition, it allows you to identify potential causes of risk and minimize the occurrence of the same risk in the future (Walaśczyk, 2016).

One of the key problems of the 21st century for the food chain and the modern world is food wastage (Granja, *et al.* 2021). Therefore all actors in the food chain have a responsibility for food waste, as well as the obligation to take action to reduce it. A food safety management system enables an organization to reduce the level of risk associated with food waste. As already mentioned, by supervising suppliers, preparing specifications for purchased raw materials, passing them on to suppliers and enforcing them, the organization reduces the risk of waste resulting from cooperation with inappropriate suppliers, e.g. waste related to the disposal of non-compliant raw materials. The organization also reduces economic (financial), social and economic losses related to food waste thanks to appropriate planning of production processes. Moreover, by following the rules described in the FSMS documentation, it is possible to reduce the level of risk and losses related to the production of non-compliant products that must be disposed, and therefore wasted (Kołożyn-Krajewska, *et al.* 2014).

Conclusions

Based on the analysis of the ISO 22000:2018 standard, it can be concluded that thanks to the risk management requirements specified in it and the inclusion in a risk-based approach to the food safety management system, this system can be an effective tool for reducing the risk associated with the functioning of the food chain organization. The inclusion in the standard of risk management

requirements, not only operational, but also organizational, makes it possible to eliminate the risk related to the organization's activities, not only in terms of food safety, but also in other areas influencing their success on the market. This can contribute to the improvement of results achieved by organizations and increase of their competitiveness.

The requirements for risk management at the operational level are detailed in the standard as they are based on proven Codex Alimentarius solutions that have been successfully used by organizations in the food chain for years to effectively manage food safety risk. On the other hand, the risk management-related requirements at the organizational level may be insufficient for the organization in order to ensure effective identification and evaluation of business risk, as well as taking actions targeted at its reduction. These requirements were specified in the standard too generally – without indicating detailed solutions that relate to the methodology of risk identification and the criteria for its estimation, as well as documenting activities in this field. For this reason, for effective organizational risk management, it is necessary for organizations to apply not only the requirements of the ISO 22000:2018 standard, but to supplement them with guidelines regarding a systemic approach to risk management (e.g. specified in the ISO 31000: 2018 standard) or to use the available methods of risk identification and evaluation. Too general definition of organizational risk management requirements may also result in difficulties in evaluating the solutions adopted by the organization during audits of food safety management systems conducted by certification bodies, due to the lack of precise evaluation criteria.

The above-mentioned difficulties with the practical implementation of organizational risk management, as well as the evaluation of its effectiveness, indicate the need to provide additional details regarding the requirements of ISO 22000:2018 standard in this respect in order to adapt it to the needs of the organization in the food chain.

References

- Björnsdóttir, S.H., Jensson, P., de Boer, R.J. Thorsteinsson, R.J. (2021). The Importance of Risk Management: What is Missing in ISO Standards?. *Risk Analysis*, Vol. 0, No. 0, 1–33, doi: 10.1111/risa.13803.
- Alheriani, N.M.S., Brkić, V.K., Persić, M.B., Alsharif, A.M. (2021). Integrated Risk Management Model Implementation's Contextual Dependence on Company Size. *Tehnika – Menadžment*, 71, 361–366, doi: 10.5937/tehnika2103361A.
- Chen, H., Liu, S., Chen, Y., Chen, C., Yang, H., Chen, Y. (2020). Food safety management systems based on ISO 22000:2018 methodology of hazard analysis compared to ISO 22000:2005. *Accreditation and Quality Assurance*, 25(1), 23–37, doi: doi.org/10.1007/s00769-019-01409-4.

- Codex Alimentarius. General Principles of Food Hygiene (CAC/ RCP 1-1969), Rev. 5-2020.
- Dembicka, A., Mołas, K. (2019). The theory of fuzzy sets in risk management as a utilitarian tool of a quality management system. *Problemy Jakości*, 3, 9–14, doi: 10.15199/46.2019.3.2.
- Dzwolak, W. (2018a). ISO 22000:2018 requirements – Part 1. Context of the organization, leaderships and planning. *Przegląd Mleczarski*, 10, 8–13.
- Dzwolak, W. (2018b). ISO 22000:2018 requirements – Part 2. Support. *Przegląd Mleczarski*, 11, 42–46.
- Gołaś, H., Mazur, A., Misztal, A. (2016). Model of organization improvement by risk management in accordance with ISO 9001:2015. *Problemy Jakości*, 10, 9–14, doi: 10.15199/47.2016.10.2.
- Granja, N., Domingues, P., Cabecinhas, M., Zimom M., Sampaio, P. (2021). ISO 22000 Certification: Diffusion in Europe. *Resources*, 10, 100, 1–16, doi: .org/10.3390/resources10100100.
- Jedynak, P. (2015). Relations of the organization with the environment. The perspective of standardized management systems. In: T. Sikora, P. Rogala, P. Skowron (Ed.), *Zrównoważony rozwój organizacji – odpowiedzialne zarządzanie*. Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu nr 376. Wrocław: Wydawnictwo Akademii Ekonomicznej im. Oskara Langego we Wrocławiu, doi: 10.15611/pn.2015.376.23.
- Jedynak, P. (2017). *Znormalizowane systemy zarządzania a ryzyko działalności organizacji*. Kraków: Wydawnictwo Uniwersytetu Jagiellońskiego.
- Kleniewski, A. (2015). Zarządzanie ryzykiem w systemie zarządzania jakością. *Problemy Jakości*, 2, 20–25, doi: 10.15199/46.2015.2.4.
- Kołożyn-Krajewska, D., Wrzosek, M., Bilka, B., Krajewski, K. (2014). Ryzyko powstawania strat i marnotrawstwa żywności a możliwość ich ograniczenia. In: T. Tarko, A. Duda-Chodak, M. Witczak, D. Najgebauer-Lejko (Ed.), *Technologia produkcji i bezpieczeństwo żywności* (15–30). Kraków: Polskie Towarzystwo Technologów Żywności.
- Lisiecka, K. (2012), Risk management and quality of enterprise management. *Zarządzanie i finanse*, 10(3/1), 557–573.
- Łańcucki, J. (red.) 2019. *Systemy zarządzania w znormalizowanym świecie*. Poznań: Uniwersytet Ekonomiczny.
- Monge-Mora, P.M., Oliveira, D.L.G., Shevchenko, K., Cabecinhas, M., Domingues, P. (2020). Critical success factors during the implementation of ISO 22000:2018. Proceedings Book of ICQEM 2020 – 4th International Conference on Quality Engineering and Management. Braga, Portugal, Sep 21–22, 350–362, 2020.
- ISO 22000:2005 Food safety management systems. Requirements for any organization in the food chain.
- ISO 22000:2018a Food Safety management systems. A practical guide.
- ISO 22000:2018b Food safety management systems. Requirements for any organization in the food chain.

ISO 9001:2018 Quality management systems. Requirements.

ISO 9004:2018 Quality management. Quality of an organization. Guidance to achieve sustained success.

ISO 31000:2018 Risk management. Guidelines.

Purwanto, A., Hutagalung, L., Yanthy E. (2020). Food safety management leadership style: transformational or transactional? *Jurnal Ekonomi dan Manajemen*, 14(1), 170–182.

Purwanto, A., Santoso, P.B., Asbari M. (2020). Effect of integrated management system of ISO 9001:2015 and ISO 22000:2018 implementation to packaging industries quality performance in banten. *Jurnal Ilmiah MEA (Manajemen, Ekonomi & Akuntansi)*, 4(1), 17–29.

Rampini, G.H.S., Takia, H., Berssaneti, F.T. (2019). Critical Success Factors of Risk Management with the Advent of ISO 31000 2018 – Descriptive and Content Analyses. *Procedia Manufacturing*, 39, 894–903, doi: 10.1016/j.promfg.2020.01.400.

Rosiak, E. (2020). Zarządzanie bezpieczeństwem w łańcuchu żywnościowym wg PN-EN ISO 22000:2018. *Przemysł Spożywczy*, 7(74), 8–13, doi: 10.15199/65.2020.7.2.

Sharman, N., Wallace, C.A., Jespersen, L. (2020), Terminology and the understanding of culture, climate, and behavioural change – Impact of organisational and human factors on food safety management. *Trends in Food Science & Technology*, 96, 13–20.

Szkiel, A. (2020). Analyzing the context of an organization in food safety management system. In: G. Rosa, A. Smalec (Ed.), *Strategie zarządzania przedsiębiorstwem i środowiskiem naturalnym* (27–41). Szczecin: Wydawnictwo Naukowe Uniwersytetu Szczecińskiego.

Szkiel, A. (2015). The usage of risk management principles according to ISO 31000:2012 standard in food safety management systems. In: P. Kafel, T. Sikora (Ed.), *Zarządzanie jakością – osiągnięcia i wyzwania*. Kraków: Uniwersytet Ekonomiczny w Krakowie.

Walaszczyk, A. (2016). *Wdrażanie standardów zarządzania bezpieczeństwem żywności w teorii i praktyce*. Łódź: Politechnika Łódzka.

Wieteska, G. (2012). Systemy zarządzania jakością i ich rola w zarządzaniu ryzykiem pojawiającym się w łańcuchu dostaw. *Problemy Zarządzania* 2(37), 139–159. DOI 10.7172.1644-9584.37.9.

Wieteska, G. (2017). Supply chain risk management – the directions of enterprise risk management – Part 1. *Problemy Jakości*, 10, 24–30, doi: 10.15199/48.2017.10.4.

Wiśniewski, M., Grudzień, Ł. (2017). Metodyka oceny ryzyka w świetle wymagań normy ISO 9001:2015. In: R. Knosala (Ed.), *Innowacje w zarządzaniu i inżynierii produkcji*. Opole: Oficyna Wydawnicza Polskiego Towarzystwa Zarządzania Produkcją.

Zapłata, S. (2012a). Business continuity management in organization – the role of normalized management systems. *Studia Ekonomiczne Regionu Łódzkiego. Rozwój organizacji w teorii i w praktyce zarządzania*, VII. Łódź: Polskie Towarzystwo Ekonomiczne Oddział w Łodzi.

Zapłata, S. (2012b). Normalised management systems – aspect of risk management. In: T. Sikora, M. Giemza (Ed.), *Praktyka zarządzania jakością w XXI wieku*. Kraków: Uniwersytet Ekonomiczny w Krakowie.

THE USE OF THE ISO 14063 STANDARD IN COMMUNICATION PROCESSES WITHIN THE OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM

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Abstract

One of the key factors determining the effectiveness of an occupational safety and health (OHS) management system and the ability to achieve the results intended by an organization is to ensure effective communication. An organization shall establish, implement and maintain the processes necessary for internal and external communication that are relevant to the OHS management system. A particularly important element in the OHS management system is ensuring participation and consultation with employees, which implies two-way internal communication including a dialogue and an exchange of information.

The aim of the paper is to present the importance of communication in improving the effectiveness of the OHS management system, as well as to present the possibility of using the guidelines of ISO 14063 standard to build an effective communication process within this system. In the first part of the paper the author discusses the requirements of the PN-ISO 45001:2018 standard related to communication and the interested parties of an organization participating in the communication process. Then, the methods used in organizations to communicate in the field of the occupational safety and health management system are presented, as well as the possibilities of using the guidelines of ISO 14063 standard to establish the communication process.

Keywords: OHS management system, communication, ISO 45001, ISO 14063

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Introduction

The objective of the OHS system management is to ensure an acceptable level of protection of health and life against the occupational hazards as well as to facilitate creation of healthy and safe workplaces. We can therefore assume that the efficiency assessment of the OHS management system compliant with PN-ISO 45001:2018 should be based on the final safety factors, such as workplace accident or injury rates (Niziołek & Boczkowska, 2020).

The implementation of the OHS management system in a given organization is both a strategic and an operational decision. Its success is reliant on the engagement of all the services on all the organizational levels, especially the top management, as well as on the wide inclusion of the employees on the stage of planning, implementation and maintenance of all elements of such a system. In addition, efficient OHS management is tightly connected with the strategic actions aimed at the development of the competitive edge of the organization. Compliance with PN-ISO 45001 can thus be used by the organization to demonstrate to the interested parties that it uses a properly implemented and maintained OHS management system. Therefore, to facilitate the efficiency and effectiveness of the OHS management system it is necessary to provide a proper internal and external communication (PN-ISO 45001, 2018). In other words, organizations improving their OHS management systems need to pay a particular attention to the communication processes.

Studies addressing various elements of OHS management systems are being conducted in the field of OHS management systems. Pacana (2016) in his work presented a model for implementing an occupational health and safety management system. Organizational practices for learning with work accidents throughout their information cycle in Portugal were researched by Silva, *et al.* (2017). Research on employers' awareness regarding the use of motivational tools for promoting OHS compliance was conducted by Gołembski, Sobański & Wojtkowiak (2016), while research in OHS leadership and management processes was carried out by Sweepers & Mbohwa (2015) and Skład (2018). Meanwhile, the issues related to improving the effectiveness of adverse events reporting systems and the fair treatment culture in the context of ISO 45001:2018 standard were undertaken by Ewertowski (2018).

Aspects involving communication within the OHS management system are also analysed and researched, especially in terms of employee participation. According to Tyszkiewicz (2019), open and sincere OHS communication is based on communicating with other employees in the organization, persuading, teaching, listening, speaking, reaching a compromise or consensus. Bienias, Czerniak, & Ewertowski (2019) highlight the opportunities to improve communication offered by today's technological solutions. Walters & Wadsworth (2020), on the other

hand, discuss the experience of worker representation in occupational safety and health in the European Union, using findings from an extensive qualitative study of practices in 143 companies in seven member states. However, the most extensive research on OHS management system communication is conducted by Pawłowska (2015, 2016, 2017).

This paper is a review article and it is aimed at presenting the importance of internal and external communication in the improvement of the OHS management system efficiency, as well as at the demonstrating the utilization of the ISO 14063 environmental communication guidelines for improvement of the communication related to the OHS management system.

PN-ISO 45001:2018 communication-related requirements

PN-ISO 45001:2018 standard contains requirements for the OHS management system to allow the organization to maintain a full compliance with the legal requirements related to the OHS, control OHS risks and increase of efficiency related to the latter (PN-ISO 45001, 2018). Model of the OHS management system presented in PN-ISO 45001:2018 is based on the idea of continual improvement and virtually mirrors quality management system or environmental management system. One of the distinct differences is the fact that the hub of the OHS management system includes not only the top management but also the employees (Pawłowska, 2017), which has been addressed in the Chapter 5 of the standard. This stresses the crucial role performed by the employees in the OHS management system, which is related to the proper internal communication. The structure of the PN-ISO 45001:2018 standard is presented in the Table 1 along with an indication of the areas related to communication.

Basic requirements of the PN-ISO 45001:2018 standard related to the communication are included in the Chapter 7 that contains all requirements concerning the support of the OHS management system. According to the PN-ISO 45001:2018 requirements, the organization needs to create, implement and maintain adequate processes of the internal and external communication, and provide the detailed information on the following (PN-ISO 45001, 2018; Pawłowska & PęciŃo, 2018):

- what needs to be communicated,
- when does it have to be communicated,
- to whom should it be addressed, including various organizational tiers and functions, as well as contractors, workplace visitors and other interested parties,
- how the communication should look like.

Table 1. Structure of the PN-ISO 45001:2018 standard

No	Section Name	Subsection name
1	Scope	–
2	Normative references	–
3	Terms and definitions	–
4	Context of the organization	4.1. Understanding the organization and its context 4.2. Understanding the needs and expectations of workers and other interested parties 4.3. Determining the scope of the OHS management system 4.4. OHS management system
5	Leadership and worker participation	5.1. Leadership and commitment 5.2. OHS policy 5.3. Organizational roles, responsibilities and authorities 5.4. Consultation and participation of workers
6	Planning	6.1. Actions to address risks and opportunities 6.2. OHS objectives and planning to achieve them
7	Support	7.1. Resources 7.2. Competence 7.3. Awareness 7.4. Communication 7.5. Documented information
8	Operation	8.1. Operational planning and control 8.2. Emergency preparedness and response
9	Performance evaluation	9.1. Monitoring, measurement, analysis and performance evaluation 9.2. Internal audit 9.3. Management review
10	Improvement	10.1. General 10.2. Incident, nonconformity and corrective action 10.3. Continual improvement

Source: based on: (PN-ISO 45001, 2018).

Considering its communication needs, the organization should address the aspects of diversity (e.g. gender, language, culture, ability to read and write, disabilities). In addition, during the creation of the communication processes, the organization needs to ensure that (PN-ISO 45001, 2018):

- it will take into account the input of the involved external parties,
- it will take into account all relevant legal provisions and other requirements,
- transmitted information is consistent and reliable.

Organization should respond to the vital messages related to its OHS management system and store documented information as proof of such communication, if relevant (PN-ISO 45001, 2018; Pawłowska & Pęciłło, 2018).

PN-ISO 45001:2018 requirements concerning internal communication presented in Chapter 7 state that the organization should (PN-ISO 45001, 2018):

- transmit important information related to the OHS management system, including the information about changes within the OHS management system itself between different levels and functions within the organization (if appropriate),
- ensure that the communication processes facilitate continual improvement among employees (PN-ISO 45001, 2018).

In addition, requirements related to internal communication are delineated in other Chapters of the PN-ISO 45001:2018 standard. The top management should inform all other members of the organization about the following:

- the importance of the efficient OHS management and compliance with the requirements of the OHS management system (Chapter 5.1),
- OHS policy (Chapter 5.2),
- responsibilities and authorizations of people performing important functions within the OHS management system (Chapter 5.3),
- OHS objectives (Chapter 6.2.1),
- monitoring and measurement results (Chapter 9.1.1),
- the output data of the management review (Chapter 9.3),
- continual improvement results (Chapter 10.3).

In addition, employees, visitors, emergency services, administration authorities and local community should be informed about the prevention, readiness and response measures taken by the organization in case of an emergency (Chapter 8.2). Communication processes are inextricably linked with the consultation and ensuring the employees' participation, as presented in Chapter 5.4 of PN-ISO 45001:2018.

Now, for the external communication, compliance with PN-ISO 45001:2018 requires organization to present the information concerning the OHS management system established in the communication processes and in accordance with applicable legal requirements. PN-ISO 45001:2018 also states that the OHS policy developed by the top management and consulted with the employees should be available for all the interested parties. It is important that the organization should define essential needs and expectations of the interested parties and determine, which of these needs and expectations are or can become requirements of legal or common nature that the organization will be bound to meet (PN-ISO 45001, 2018). This implies securing a proper and efficient communication with

the external interested parties, which should be a subject of the analysis of management reviews carried out by the top management.

Communication processes should allow acquisition, storage, update and dissemination of the relevant information related to the OHS management system in both internal and external contexts. Internal and external communication of the organization is a process of information exchange, in which all participants exert mutual influence. Such a process requires usage of the messages (signals) to present clear and consistent content (Grabosz, 2014).

Internal communication in the OHS management system

One of the most important elements of the OHS management system is the internal communication that should be maintained in both directions by:

- managers informing the employees about various aspects of the OHS management system,
- employees informing their superiors about the safety and hygiene in the workplace.

Basic rules for communication related to the OHS in a workplace are determined by the legal regulations that require informing employees about all the issues related to their safety and health in the workplace, including the information about the following (Accounting Act of June 26, 1974):

- hazards to the health and life that are present in the workplace, on the specific workstations and during specific tasks,
- protective and preventive actions taken to eliminate or diminish dangers,
- occupational risk related to the specific job and the rules concerning protection from the threats inherent to the latter,
- OHS rules and regulations related to the tasks performed,
- rules concerning behaviour during the emergency and other situations related to the health and life dangers in the workplace,
- employees designated to administer first aid, perform tasks related to the fire protection and oversee the emergency evacuation of the employees.

Pursuant to the legal regulations, employees should also inform their superiors of the safety and hygiene in the workplace, especially when the information concerns potential dangers and all noticed defects or damage to the equipment (Accounting Act of June 26, 1974; Pawłowska & PęciŃo, 2018).

In the OHS management system employees are considered the most interested party and their needs and expectations should be addressed and met by the organization. The organization should also determine needs and expectations of

the employees in managerial and non-managerial positions, as well as those of the representatives of employees or the employee associations (labour unions), who can influence the OHS management system. From the perspective of OHS management system, requirements of the employees can include (Pawłowska & Pęciłło, 2018):

- communication of the decisions and objectives,
- informing about duties and responsibilities,
- ensuring safety in the workplace,
- provision of resources (infrastructure, equipment),
- provision of the effective protective measures,
- ability to influence the decisions and participation in the activities related to OHS,
- support of the top management.

According to Bodak & Gableta (2015), important expectations of the employees include stability of employment and the manner in which it is provided, but also the conditions facilitating the feeling of importance among employees and the agency of the employees, which entails their participation in the decision-making processes, including those related to OHS. Within the OHS management system compliant with PN-ISO 45001:2018, cooperation of the employees, as well as the leadership of the top management is considered a basic condition for a system to function properly (Pawłowska, 2017). The most recent version of the standard defines cooperation as the participation of the employees in the decision-making process, Consultation is defined as listening to the employees' opinions before making decisions. Organization should establish, implement and maintain employee consultancy and cooperation processes during development, planning, implementation, result assessment and improvement of the OHS management system on all relevant levels, in relation to all applicable functions, and with the participation of the employees' representatives where applicable (PN-ISO 45001, 2018).

PN-ISO 45001:2018 draws particular attention to the participation of the employees holding non-managerial positions and indicates that the participation of these people is especially important in the case of consulting related to (PN-ISO 45001, 2018):

- determining the needs and expectations of the interested parties,
- establishing the OHS policy,
- assigning roles, responsibilities and authorizations within the organization,
- determining the manner in which the requirements (legal or otherwise) will be satisfied,
- setting objectives and plans to meet them,
- determining rules concerning supervision of the goods and service suppliers,
- determining what should be monitored, measured and assessed,

- planning, implementation and maintenance of the auditing programs,
- continual improvement process.

Consultation implies bidirectional communication including dialogue and information exchange. To make consultations efficient, it is necessary to provide employees with required information in a timely manner and acquire feedback that needs to be taken into account by the management before decisions are made.

In addition, OHS management system should ensure cooperation of the employees that hold non-managerial positions in the activities such as (PN-ISO 45001, 2018):

- determining mechanisms of consultation and participation,
- identification of dangers, risk and chance assessment,
- determining actions directed at the elimination of the dangers and decreasing related risk,
- identification of the necessary competencies, training needs and education assessments,
- determining the scope of the transmitted information and the form of transmission,
- investigation of the incidents and non-compliance issues, and determination of the corrective actions.

Participation allows employees to be involved in the decision-making processes regarding the assessments of the actions connected to the OHS and all proposed changes. Feedback concerning the OHS management system is reliant on the employees' participation. Organization management is advised to ensure that employees on all levels are encouraged to report all dangerous situations, so that it is possible to introduce preventive measures and undertake corrective actions. Employees should never be afraid that they might be a subject to termination, disciplinary actions or other repressive measures for making suggestions or reporting dangerous situations (PN-ISO 45001, 2018).

A whole variety of information subject to internal communication is often divided into separate groups depending on the objectives it serves (Pawłowska, 2015). Such information can be communicated via different methods. The basic methods of communication in the OHS include (Pawłowska & Pęciłło, 2018):

- traditional oral communication methods, such as:
 - formal meetings (meetings of all employees, managerial and directorial meetings, meetings of the working teams),
 - training,
 - informal meetings and discussions (directors and managers visiting the workstations, direct conversations between employees or between employees and managers),

- traditional written communication methods, such as:
 - memos, documented procedures and instructions,
 - rules concerning OHS, written orders,
 - posters, notice boards, internal bulletins, magazines etc.,
- electronic methods, such as e-mail, Intranet, webpage, newsletter or social media.

In general, one information is transmitted via several different methods to increase the efficiency of the message.

External communication in the OHS management system

External communication in the OHS management system chiefly encompasses information exchange between the organization and the external interested parties. PN-ISO 45001:2018 standard suggests the need to determine external and internal factors that are important for the organization's objectives and that influence organization's ability to achieve set objectives of the OHS management system. Internal and external factors can be positive or negative and include conditions, traits or transient circumstances that can influence the OHS management system. One of the most important external factors is the organization's relation with the external interested parties. The organization should identify interested parties that can influence or be affected by its decisions or actions. The following entities are usually described as potential external interested parties in the OHS management system (PN-ISO 45001, 2018):

- legal and regulatory bodies (local, regional, central or international),
- parent organizations,
- suppliers, contractors and subcontractors,
- employees' associations (labour unions) and employers' associations,
- owners, shareholders, customers, visitors, local communities, neighbours and general population,
- customers, medical services and other communal services, media, academic organizations, business associations and non-governmental organizations,
- OHS organizations and specialists.

The organization should determine the needs and expectations of the interested parties and state which of them will be met. Needs and expectations of the separate interested parties can differ, may conflict with those of other parties or be prone to frequent changes. Organizations should meet the needs of the interested parties that have the greatest adverse impact on the organization's objectives if they are not met. Some of the needs and expectations are mandatory, such as those that are a part of the legal system. Activities of the organizations performed with regard to the interested parties can take very different forms,

Table 2. Examples of the interested parties in the OHS management system and of the communicated information

Interested party	Communicated information
Supervision and inspection authorities for the workplace conditions (PIP, SIP, UDT)	Interpretation of the labour and OHS law, Results of the inspections within the organization, Actions taken by the organization in response to the decisions and recommendations following the inspection, Identified dangers and results of the occupation risk assessment, Actions taken by the organization in response to the incidents and emergency situations, Documentation required by the OHS regulations
Suppliers, contractors and subcontractors	OHS policies and objectives of the organization, Information concerning dangers related to the organization activities, Information concerning OHS requirements of the organization and the rules of conduct, Safety rules enforced in the workplace (identification, movement, mandatory and forbidden actions, rules of work supervision and coordination), Information concerning the evacuation routes, medical stations, Specification of the purchased products that include the OHS regulations, Rules of suppliers supervision, criteria and frequency of the suppliers assessment, methods of the purchased products verification, approval criteria of suppliers and supplied goods
Customers, guests of the organization	OHS policies and objectives of the organization, Information concerning dangers related to the organization activities, Information concerning OHS requirements of the organization and the rules of conduct, Safety rules for the visitors to the workplace (identification, movement, mandatory and forbidden actions), Information concerning the evacuation routes, medical stations
Local community, neighbours of the organization and general population	OHS policies and objectives of the organization, Informing of the emergency situations that might impact the safety
Parent organizations	Implementation of the requirements resulting from the OHS rules and OHS management system, Timely reporting of the safety indicators
External emergency services, fire protection units	Identified situations that can potentially lead to emergency, Plans of the periodical testing and training related to the emergency response with the participation of the external emergency services
Certifying body	OHS management system certification scope, OHS management system documents, Audit arrangements, Audit results, Actions taken in response to audit results

Source: personal study.

including cooperation, joint operation, negotiations, outsourcing or conclusion of operation. Needs and expectations of the interested parties become mandatory for an organization when said organization agrees to accept them. Once adopted by an organization, they become the requirements and should be taken into account during the planning and implementation of the OHS management system.

Each of the interested parties can determine different requirements concerning the type of the information transmitted and forms of communication used by the organization. This is why the organization should determine the type of information that will be transmitted to each of the interested parties. Examples of the interested parties and types of information used in the communication process are presented in Table 2.

Depending on the influences that the interested parties have on the OHS management system and also on the level of interest in the transmitted information expressed by the relevant parties, communication can run the gamut between the limited and full participation of the interested parties. (PN-ISO 14063, 2020).

Development of the communication process in the OHS management system based on the ISO 14063 guidelines

PN-ISO 45001:2018 determines the requirements of the efficient communication between the organization and the interested parties. However, this document does not include detailed requirements related to the formalization of this process, and does not determine the operational requirements connected with the usage of the specific communication tools by the organization.

Guidelines for the implementation of the efficient external communication process within the management system used by the organization can be found in the ISO 14063. Said guidelines are focused on the environmental communication meant to inform the interested parties of the pro-environmental activities of the organization and related results in this area, but they are nevertheless universal and can be adjusted to various communication needs of the organization. Therefore, they can also be used by organizations that have already implemented a OHS management system for the communication process related to the OHS issues.

A key factors influencing efficiency of the communication with interested parties is the engagement of the organization leaders. The leaders should be engaged in the communication process by making personnel responsible for the collection and analysis of the information linked to the communication with the interested parties, motivating and recognizing the employees engaged in the communication

process and encouraging them to share the results of such communication with all employees (PN-ISO 14063, 2020).

An effective communication with the interested parties should be based on the established communication policy that has been developed and approved by the organization leaders, and is compliant with the general OHS policy of the organization. The objective of the communication policy is to determine the obligations of the organization related to the engagement with the interested parties to discuss the issues important for the OHS, to inform the interested parties about the safety rules, identified dangers and emergency situations or incidents that can impact safety of the employees. Communication policy should be presented to both the organization and interested parties, to stress the importance of the communication concerning OHS issues (PN-ISO 14063, 2020).

Once the communication policy related to the OHS issues is determined, organization leaders should develop and approve a communication strategy that will serve as a baseline for all the actions related to the communication with the interested parties. This strategy should include the following (PN-ISO 14063, 2020):

1. Communication objectives that are compliant with the OHS policy, and also take into account the perspective, needs and expectations of the interested parties.
2. Identification of the interested parties to whom organization will communicate issues related to OHS.
3. Establishment of the type of information related to OHS that might be useful to the interested parties, as well as the form and frequency of its communication.
4. Allocation of the resources (human, technological or financial) necessary to implement communication process.
5. Determination of the responsibilities and authorizations concerning communication process.

The strategy determined by the organization should ensure engagement of the interested parties by the organization to express opinions concerning adequacy and effectiveness of the actions of the organization and also make sure that the latter understands the perspective of other interested parties.

While planning the actions concerning the communication related to OHS, the organization should take into account all the communication tools that have been used up to this point, assessment of their efficiency, expectation of the interested parties concerning the communication, and the consciousness and OHS-related knowledge of the interested parties. Planned scope and type of the communication activities should also take into account the potential costs and ramification of the lack of communication with the interested parties (PN-ISO 14063, 2020).

Organization should also develop the implementation program for the communication objectives related to the OHS, determining the tasks necessary for its completion. These tasks should be measurable, achievable and scheduled. This allows the organization to determine whether the communication objectives have been achieved (PN-ISO 14063, 2020).

Another important element of the communication with the interested parties is the communication during the incidents and emergency situations that influence safety of the employees and interested parties. Organization should determine the rules of communication with the interested parties in an event of the aforementioned situations. Effectiveness of the communication during the incidents and emergency situation can influence the following (PN-ISO 14063, 2020):

- Keeping the interested parties continuously informed about dangers to health or life,
- effective and quick departure during the emergency situation,
- ensuring the positive opinion and trust of the interested parties.

For the communication to be conducted in a formalized manner, its rules should be collected in the OHS management system documentation. It is recommended that such documents include the records of the communication results, which can be necessary for:

- reconstruction of the history of the communication with the interested parties,
- improvement of the communication efficiency.

Assessment of the reactions of the interested parties to the OHS-related information and the analysis of the received feedback allows the organization to verify how well the information is understood by the interested parties. This can, in turn, influence the assessment of the actions related to communication and identify the need for improvements, which also includes the communication tools or the form of the transmitted information as presented in (PN-ISO 14063, 2020).

To identify the needs and possibilities of the OHS-related communication process improvement, the organization should subject this process to periodical reviews and assess its effectiveness. Such assessment should include (PN-ISO 14063, 2020):

- topicality and adequacy of the communication policy,
- the level of implementation of communication goals,
- transparency and understanding of the communication rules by the personnel, and the level of their implementation,
- quality of the information transmitted to the interested parties,
- degree of understanding of the objectives and content of the OHS-related communication by the interested parties,

- degree to which the needs of the interested parties concerning the communication with the organization are met,
- The interested parties' perception on the degree of utilization of the input provided by said parties as part of the communication,
- effectiveness of the actions taken by the organization in response to the information provided by the interested parties.

Assessment of the degree to which the OHS-related communication is implemented may be conducted with the use of the communication factors. The results of the reviews and efficiency assessment of the communication process should form the baseline for the decisions made by the leaders of the organization and related to the update of the OHS communication and resulting communication objectives. In addition, the organization leaders should use the assessment results to identify the opportunities of improvement and need for changes in the communication process. These changes can be connected with (PN-ISO 14063, 2020):

- resources used in the communication process,
- communication process and the information provided to the interested parties,
- rules of collection and documenting of the communicated information.

In the decision-making process related to the changes of the OHS communication policy, the organization needs to take into account how the interested parties might react to the changes and communicate the rationale for said changes.

Conclusions

Organization management cannot be separated from the communication with other people. Lack of adequate communication causes many resources to be either untapped or used only to a fraction of a possible efficiency. This includes also the area of OHS, because the communication is one of the most crucial requirements for the effective and efficient management of the occupational safety and health.

Results obtained by Pawłowska indicate that the implementation of the formalized OHS management system is accompanied by the development of the internal communication related to the OHS. This increases the level of the direct participation of all employees who also more often take part in the consultations and decision-making processes related to OHS (Pawłowska, 2016). Current PN-ISO 45001:2018 requirements even more profoundly stress the importance of the rules concerning consultations and employee participation in the OHS management system procedures. Improvement of the communication methods used in the OHS area should be one of the main objectives of any organization. Efficient flow of the information in both directions and analysis of this information

significantly contribute to the better safety of the employees and increased efficiency of the OHS management systems.

In order to improve the external communication within the OHS management system, organizations can adopt the PN-ISO 14063:2020 guidelines. General rules related to the development of the communication with external parties can also be used by the organization to improve the process of communication with the employees, taking into account the specificity and complexity of this process.

References

Bienias, M., Czerniak, K., Ewertowski, T. (2019). Preparation of an enterprise for emergency situations and their better communication. *Informatyka Ekonomiczna*, 3(53), 9–22.

Bodak, A., Gableta, M. (2015). Employee expectations of safety in the workplace. *Zeszyty Naukowe Politechniki Śląskiej. Seria: Organizacja i Zarządzanie*, 83, 45–54.

Dz.U. 2020, poz. 1320, 2021, poz. 1162 (t.j.), Ustawa z dnia 26.06.1974 Kodeks pracy.

Ewertowski, T. (2018). Adverse events reporting system improvements in organisations in the context of ISO 45001:2018 standard – implementation. *Zeszyty Naukowe Politechniki Poznańskiej. Organizacja i Zarządzanie*, 78, 19–34, doi: 10.21008/j.0239-9415.2018.078.02.

Gołembski M., Sobański P., Wojtkowiak G. (2016). Employee Motivations in Maintaining Occupational Health and Safety (OHS) Compliance: Research on Nine Construction Firms in Poland. *Global Management Journal*, 1(8), 94–100.

Grabosz, J. (2014). Audyt komunikacji wewnętrznej w przedsiębiorstwie: propozycja narzędzia diagnostycznego. In: B. A. Basińska, I. Garnik (Ed.), *Zarządzanie informacyjnym środowiskiem pracy*. Gdańsk: Wydział Zarządzania i Ekonomii Politechniki Gdańskiej.

Niziołek, S., Boczkowska, K. (2020). Znormalizowane systemy zarządzania w świetle partycytacji pracowników w zakresie bhp – wyniki badań. In: E. Sońta-Drączkowska, I. Bednarska-Wnuk (Ed.), *Wybrane aspekty zarządzania procesami, projektami i ryzykiem w przedsiębiorstwach*. Łódź: Wydawnictwo Uniwersytetu Łódzkiego.

Pacana, A. (2016). *Synteza systemowego zarządzania bezpieczeństwem i higieną pracy*. Rzeszów: Oficyna Wydawnicza Politechniki Rzeszowskiej.

Pawłowska, Z. (2015). Electronic and classical communication channels in OSH management. *Zarządzanie i Ekonomia*, 5, 11–13.

Pawłowska, Z. (2016). Methods used for communicating OSH – related issues in companies. *Zeszyty Naukowe Małopolskiej Wyższej Szkoły Ekonomicznej w Tarnowie*, 4(32), 45–58.

Pawłowska, Z., Pęciłło, M. (2018). *Doskonalenie zarządzania bezpieczeństwem i higieną pracy z uwzględnieniem wymagań i wytycznych normy międzynarodowej ISO 45001*. Warszawa: Centralny Instytut Ochrony Pracy – Państwowy Instytut Badawczy.

Pawłowska, Z., Skład, A. (2017). OSH Management Systems adjustment towards requirements of the ISO/DIS 45001.2 standards. *Zarządzanie i Ekonomia*, 11, 13–15, doi: 10.5604/01.3001.0010.5789.

PN-ISO 14063 (2020). *Environmental management – Environmental communication – Guidelines and examples*.

PN-ISO 45001 (2018). *Occupational health and safety management systems – Requirements with guidance for use*.

Silva, S. A., Oliveira, M. J., Carvalho, H., Jacinto, C., Fialho, T., Guedes Soares, C. (2017). Organizational practices for learning with work accidents throughout their information cycle. *Safety Science*, 99, part A, 102–114, doi: 10.1016/j.ssci.2016.12.016.

Skeepers, N. C., Mbohwa, C. (2015). A study on the leadership behaviour, safety leadership and safety performance in the construction industry in South Africa. *Procedia Manufacturing*, 4, 10–16. DOI:10.1016/j.promfg.2015.11.008.

Skład, A. (2018). Processes in the occupational health and safety management system and the safety performance of the enterprises. *Prace Naukowe Akademii im. Jana Długosza w Częstochowie. Technika, Informatyka, Inżynieria Bezpieczeństwa*, 6, 307–326, doi: 10.16926/tiib.2018.06.22.

Tyszkiewicz, R. (2019). The importance of a work safety culture in a management system. *Quality Production Improvement*, 2(11), 94–101, doi: 10.30657/qpi.2019.11.08.

Walters, D., Wadsworth, E. (2020). Participation in safety and health in European workplaces: Framing the capture of representation. *European Journal of Industrial Relations*, 26(1), 75–90, doi: 10.1177/0959680119835670.

HOW BIG DATA IS CHANGING THE FOOD INDUSTRY: THE REAL EXAMPLES

Krzysztof Wójcicki¹

Abstract

A huge volume of data is being produced worldwide in nearly all sectors of the society including manufacturing, business, government, health care, and research disciplines such as: natural sciences, social sciences, life sciences, engineering and humanities. As more and more of this Big Data become available, it can be used to enable new insights, improve decision-making, and enhance the quality of products and services.

Today, industrial manufacturers are leveraging Big Data to transform their processes, their organizations and, in some cases, entire industries. The food industry is one of the largest and most important industries in the world. It covers everything from manufacturers and shipping companies to grocery stores and restaurants. Therefore, more and more often the food industry uses the same Big Data services as financial companies and marketing departments in order to better understand consumers, increase efficiency and even create new products. Big Data applications, although to varying extents, can be found in all steps of the food supply chain from farm to fork to optimize production while maintaining safety and quality standards.

This study conducted an overview of the recent developments in Big Data applications in food sector

Keywords: Big Data, Industry 4.0, Food Industry

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Introduction

Current global trends have seen the focus on production and manufacturing shifting towards technologies related to the Fourth Industrial Revolution. In its complexity and high potential, Industrial Revolution 4.0 harnesses together cyber physical systems, internet of things, cloud computing and cognitive computing that allows production and manufacturing systems to be flexible, customizable and robust. This, in turn, allows efficient utilization of resources, reducing waste, provision of traceability and increasing productivity.

Big Data offers a technological breakthrough that may provide a means for translating “good” practices into generalizations that consumers can trust and be willing to pay for and, at the other end of the supply chain, firms could use for monitoring and evaluation of alternative solutions to providing sustainably produced and safe food (Ahearn, *et al.* 2016). According to Ahearn, *et al.* (2016) even though consumers would be the ultimate beneficiaries, it is the intermediaries in the food supply chain who must identify and develop or adapt existing data sources needed to operationalize best practices. Successfully capturing the data which being created in the production process and creating the tools to analyze those data, requires new analytics adapted to the particular issues involved (Ahearn, *et al.* 2016).

The purpose of this article is to present the selected examples how Big Data is changing the food industry. We begin by defining Industry 4.0 and its application in food sector. Next chapters demonstrated the definition of Big Data and the possibilities of using it in the food industry.

Industry 4.0 and food sector

The world economy is on the verge of accelerated digital transformation, and that includes also food processing. The global industrial automation market is anticipated to be worth \$297 billion by 2026, with food and beverage applications making up 11% of the market (Statista, 2020). Internet of Things (IoT) technologies, such as sensors, simulations, artificial intelligence-based autonomous systems, additive manufacturing, cloud systems, and blockchain, are projected to have the huge impact on the food industry by enabling integration of physical processes, computation, and networking in cyber-physical systems (Institute of Food Technologists).

Industry 4.0 is known as the data exchange and automation process used in manufacturing technologies. This is very useful in the successful running of a standard and efficient food production and manufacturing from the beginning of its supply chain until it gets to the consumers table. This is achievable because the food manufacturing supply and demand systems are being digitalised to

reduce waste and promote sustainability [Berttram & Schrauf, 2018]. Most of the processes of food production have to do with good logistics to accurately control the food supply chain which requires an up-to-date equipment and logistics planning. Logistics can be seen as part of supply chain management because it involves the coordination and movement of goods and services (Beske, Land & Seuring, 2014). Some of the equipment needed to achieve this controlled sustainable supply chain system are components of Industry 4.0 (Ojo, *et al.* 2018).

Food processing operations have benefitted from Industry 4.0 concepts by improving traceability, monitoring, and control of food quality; improving safety, manufacturing, automation, and training; predicting sensory and consumer preferences; and reducing loss and waste. The good example is Siemens which employs several IoT components and digitalization tools for various processes, including brewing, sugar production, dairy processing, baking, and agricultural production (Siemens, 2016). Another example could be a multi-sensor system that uses ultraviolet fluorescence imaging and acoustic sensors to assess fouling in chocolate spread production as part of the clean-in-place systems decision-making (Institute of Food Technologists). The cheese manufacturer from a United States use the machine learning correlation models which were trained with six months of historical data on 29 different processing variables, including the amount of starter culture, mixing times, and raw milk composition, to classify impacts on the final moisture content. As a result of the optimization study, the manufacturer was able to reliably increase average moisture content by up to 0.6% within regulatory compliance limits, corresponding to more than \$1 million in savings in one year (Institute of Food Technologists).

Industrial robots which were integrated with a high-tech image processing system are becoming smart, able to see and react to different situations based on the clearly defined parameters. On the same processing line the identification of food products is possible and subsequently perform different tasks in the blink of an eye. According to Buckenhueskes (2015) and Hasnan & Yusoff (2018) the use of a camera or other visioning with the inspection system or integrated into robots is particularly beneficial for food quality inspection such as to verify labeling accuracy, colors, height or volume. The complete system can be used to control and inspect the entire manufacturing processes or only for sub-process at individual equipment.

Based on Costa, *et al.* (2013) traceability is defined as the ability to locate an animal, commodity, food product or ingredient and to follow its history in the supply chain forward (from source to consumer table) or backward (from consumer to source) by means of recorded identifications. The traceability process becomes costly and inefficient as the complexity of the value chain increases. For this reason the complexity could be linked into the unique characteristics of the food materials that undergo a dynamic transformation from the bulk raw material to individual

food products in the manufacturing processes. The Quick Response (QR) code and Radio Frequency Identification (RFID) have been adopted in food supply chain as to automate the identification and tracking of food materials (Ilie-Zudar, *et al.* 2011).

According to Hasnan & Yusoff (2018) the great example of RFID application could be the chicken meat, whereby the system is applied through the complete chain from the farm, through slaughterhouse and processing factory, to the retailer. The traceability data is gathered and registered by the RFID readers, and when sent to the central database. At specific places, there are devices which can be use by a consumer to read data from the central database and get the required information about the chicken meat. Other foods that have been applied with RFID system are dairy, bakery, beverages, sushi, pasta and coffee (Costa, *et al.* 2013). The information of some of these products can be read using the RFID readers provided by the resellers and/or retailers, by the web (browser personal computer) and smartphone applications (APP) when the RFID tag code is inserted (Hasnan & Yusoff, 2018).

Besides the manufacturing sector, the use of robots gave a great potential in the gastronomy. For example in Japan robot can serve rice in just the right predetermined portions for a range of meals, from curries to rice bowl dishes (Hasnan & Yusoff, 2018). Another example could be the Chef Robot which is able to learn and reproduce the cooking movement of a human chef as captured on a 3D camera and registered to the computer, when required to make meals (Hasnan & Yusoff, 2018).

As shown various types of sources can be distinguished that may contain or generate information useful for food sector. These large volumes of different types of data is called Big Data.

Big Data

Many definitions of Big Data exist. One of the most cited definitions is that included in the Gartner report from 2001. The Gartner report makes no mention of the phrase “Big Data” and predates the current trend. However, the report has since been coopted as a key definition. Author proposed a threefold definition encompassing the “three Vs”: Volume, Velocity, Variety (Laney, 2001)

Gartner (2012) defined the Big Data as a: “high volume, high velocity, and high variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization.”

Based on Ward & Baker (2013) “Big Data is a term describing the storage and analysis of large and or complex data sets using a series of techniques including, but not limited to: NoSQL, MapReduce and machine learning.”

The European Commission (EC) has issued a similar definition (EC, 2014), referencing the three Vs of Volume, Velocity and Variety: “Big Data refers to large amounts of different types of data produced with high velocity from a high number of various types of sources. Handling today’s highly variable and real-time data sets requires new tools and methods, such as powerful processors, software and algorithms.”

According to De Mauro, Greco & Grimaldi (2015) “Big Data represents the information assets characterized by such a High Volume, Velocity and Variety to require specific technology and analytical methods for its transformation into Value.”

In all presented definitions volume refers to the amount of data, velocity is the speed of information generated and how fast the data is processed, and variety represents the variation in data formats (e.g., structured and unstructured data). Structured data refers to a variety of data formats and types that can be fitted neatly into rows and columns (traditional text/numeric information). Unstructured data is information that is not organized for example Twitter tweets, and other social media postings. Value is referred to as the costs of data generation and its intrinsic value as well as the transformation of Big Data into valuable new insights, solutions or decisions that otherwise have remained undiscovered and unknown (Marvin, *et al.* 2017).

Big Data as described in the definitions has become a reality in many sectors and the ability to tackle the challenges related to handling and integrating huge amounts of data will provide opportunities to increase competitive advantages.

Big Data in food sector

Nowadays the Food industry is on a whole new level because of the Big Data science. The new technologies, like data science and analytics, allows the food sector to improve the capacity of insights from data, marketing campaigns, creating an innovative product, and more interactive development.

Internet is a huge source of information and may be exploited to assist risk managers and or risk assessors in maintaining food safety. Web crawling systems have been developed to search in the internet for publications on food safety related reports. A typical example of such system is MedISys which is part of the European Media Monitor (EMM) developed by the joint Research Centre (JRC) of the European Commission (Steinberger, *et al.* 2009). MedISys is a fully automatic surveillance system that collects reports from the internet on human and animal infectious diseases (Steinberger, Pouliquen & Van Der Goot, 2009). This system has been also adapted to collect food safety related publications (Rortais, *et al.* 2010). Analysis of that system showed that it can be used as an early warning system for the detection of food and feed-borne hazards (Rortais, *et al.* 2010).

The use of mobile phones is widespread in modern world. This is the reason why new applications appear rapidly, including food safety and health related applications (Marvin, *et al.* 2017). Smartphones in combinations with other handheld devices could be used to measure for example:

- Mercury contamination in water (Wei, *et al.* 2014),
- Ochratoxin A contamination in beer (Bueno, Munoz & Marty, 2016),
- allergens in a variety of food products (Coskun, *et al.* 2013),
- microbial contamination (*Escherichia coli*) in water and food samples (Zhu, Sikora & Ozcan, 2012).

Collected data can be processed on the phone or via a Wi-Fi connected computer for own purpose but may also be transferred to data clouds or other data centers.

Social media such as Facebook, Twitter and YouTube are already used by food safety agencies and food associated organizations to communicate with the general public on food safety related issues (Marvin, *et al.* 2017). By monitoring users conversations on social media, food agencies will better understand their audience and may detect new issues.

According to Jin, *et al.* (2020) satellite imagery data can be used to detect crop growth, forest crop harvest and improve agriculture monitoring systems, thereby helping to improve the quality of agriculture products.

The application of blockchain technology in food safety is limited to traceability but issues such as data integrity and tampering still needs attention. Kumar & Iyinengar (2017) proposed a system implementation using blockchain to enable full traceability to combat food fraud. Their system aims to provide a complete history across all five steps in the rice supply chain and automate it using smart contracts.

More and more companies are intensively applying food-tech innovations, such as Big Data-powered solutions, as they realize it can significantly change their whole business and streamline profit. Below we listed some examples of successful implementation of Big Data in food sector (byteant.com):

- The Yield company has developed the solution to monitor planting beds and the whole agricultural ecosystem and foresee any arising issues.
- The all-known restaurant KFC uses Big Data to analyze customer feedback and food preferences, which comes up with better customer experience and sales.
- The Cheesecake Factory utilizes a Big Data-driven software to process and analyze enormous data sets from 175 locations in the U.S.
- FreshDirect uses sensors, processing, and analyzing data to monitor product status and environmental conditions during transportation.
- Connecterra has designed a predictive analytics-based tool to aid farmers in determining cattle health problems.
- Foodpairing is one of the largest online food and ingredient databases in the

world, which leverages machine learning to recommend new food and drink combinations to chefs and bartenders and help food companies determine which flavor they should launch next.

It is clear that food sector can benefit from the features that Big Data tools can offer, there are a number of challenges that should be addressed to take full advantage of it. According to most experts, the biggest challenges with the data generated along food supply chain are related to issues of data fairness, data quality and lack of standardization (Jin, *et al.* 2020). According to Bouzembrak, *et al.* (2019) one of the challenges that may have caused the limited uptake of the use of IoT technology in food safety is that the data produced today by IoT devices can be difficult to be interpreted, communicated, and shared because of lack of standardized communication protocol. According to Jin, *et al.* (2020) handling Big Data issues are challenging and time consuming that requires a large computational infrastructure to ensure successful data processing and analysis in reasonable time. Overall, the results showed great potentials of Big Data analysis to predict, monitor and control food safety from “farm to table”.

Conclusions

This paper presents some of the application areas of Industry 4.0 technologies which are relevant to the food sector. Without a doubt, the fourth wave of technological revolution has already paved its way throughout the sector. In this new era, sensors, machines, workpieces, and IT systems are linked along the value chain beyond a single organization.

The food industry is one of the most profitable sectors globally. Big Data is critical in helping the food industry meet the challenges of growing world population, climate change, and urbanization. Currently, only limited numbers of tools developed within the Big Data domain are applied in food safety. The trend to make data from public funded research projects available on internet opens new opportunities for stakeholders dealing with food safety to address issues not possible before. But, to exploit this full potential of Big Data, technical, social, and health and sustainable development issues require further research.

Overall, the results showed great potentials of this technology and successful applications have been reported to predict, monitor and control food safety in the food supply chain. Big Data is really the future of businesses because it is not only generate insights, but also has a positive impact on the society, economy, and the workforce. The use of Big Data will lead to more jobs, new standards and regulatory structures, etc. By properly taking advantage of these possibilities that Big Data brings, organizations can reduce costs, enhance or even automate processes, simplify operations and increase business value, plus, be a pioneer in their industry.

References

- Ahearn, M.B., Armbruster, W., Young, R. (2016). Big Data's potential to improve food supply chain environmental sustainability and food safety. *International Food and Agribusiness Management Review*, Vol. 19, Issue A, 155–172.
- Bertram, P., Schrauf, S. (2018). Industry 4.0: How digitization makes the supply chain more efficient, agile, and customer-focused. *Strategyand.pwc.com*
- Beske, P., Land, A., Seuring, S. (2014). Sustainable supply chain management practices and dynamic capabilities in the food industry: A critical analysis of the literature. *International Journal of Production Economics*, vol. 152, 131–143, 2014.
- Bouzembrak, Y, Kluche, M, Gavai, A, Marvin, H.J.P., (2019). Internet of Things in food safety: Literature review and a bibliometric analysis. *Trends in Food Science & Technology*, 94, 54–64.
- Bueno, D., Munoz, R., Marty, J.L. (2016). Fluorescence analyzer based on smartphone camera and wireless for detection of Ochratoxin A. *Sensors Actuators B: Chem.* 232, 462–468.
- Buckenhueskes, H.J. (2015). Quality improvement and fermentation control in vegetables. *Advances in Fermented Foods and Beverages*, 515–539.
- ByteAnt. (2020). <https://www.byteant.com/blog/how-big-data-is-boosting-food-industry-the-best-examples/> [23.11.2021].
- Costa, C., Antonucci, F., Pallottino, F., Aguzzi, J., Sarriá, D., Menesatti, P. (2013). A review on agri-food supply chain traceability by means of RFID technology. *Food and Bioprocess Technology*, 6(2), 353–366.
- Coskun, A.F., Wong, J., Khodadadi, D., Nagi, R., Tey, A. Ozcan, A. (2013). A personalized food allergen testing platform on a cellphone. *Lab Chip*, 13, 636–640.
- De Mauro, A., Greco, M., Grimaldi, M. (2015). What is Big Data? A consensual definition and a review of key research topics. In *International Conference on Integrated Information (IC-ININFO 2014) AIP Conf. Proc.* 1644 (97–104). Madrid, Spain: AIP Publishing LLC. <http://doi.org/10.1063/1.490782>
- EC, European Commission (2014). Towards a thriving data-driven economy. Brussels: Communication from the Commission to the European Parliament, the Council, the European Economic and social committee and the committee of the regions.
- Gartner (2012). The importance of 'Big Data': A definition. Available on the website: <https://www.gartner.com/doc/2057415/importance-big-data-definition>
- Hasnan, N.N.Z., Yusoff, Y.M. (2018). Short review: Application Areas of Industry 4.0 Technologies in Food Processing Sector. *2018 IEEE Student Conference on Research and Development (SCORED)*, 1–6, doi: 10.1109/SCORED.2018.8711184.
- Ilie-Zudor, E., Kemény, Z., Van Blommestein, F., Monostori, L., Van Der Meulen, A. (2011). A survey of applications and requirements of unique identification systems and RFID techniques. *Computers in Industry*, 62(3), 227–252.

Institute of Food Technology. (2021), <https://www.ift.org/events/event-listing/2021/jun/big-data-the-internet-of-things-iot-in-the-food-industry-are-we-there-yet>.

Jin, C., Bouzembrak, Y., Zhou, J., Liang, Q., van den Bulk, L.M., Gavai, A., Liu, N., van den Heuvel, L.J., Hoenderdaal W., Marvin, H.J.P. (2020). Big Data in food safety – A review, *Current Opinion in Food Science*, 36, 24–32, ISSN 2214–7993, <https://doi.org/10.1016/j.cofs.2020.11.006>.

Kumar, M., Narayana, I.N.Ch.S. (2017). A Framework for Blockchain Technology in Rice Supply Chain Management Plantation. *Conference: Future Generation Communication and Networking 2017*, 125–130, 10.14257/astl.2017.146.22.

Laney, D., (2001). 3D Data Management: Controlling data volume, velocity and variety. *Gartner*. Retrieved, 6.

Linge, J.S., Steinberger, R., Weber, T.P., Yangarber, R., van der Goot, E., Al Khudhairy, D.H., Stilianakis, N.I. (2009). Internet surveillance systems for early alerting of health threats. *Euro Surveill*, 14(13): pii = 19162, <https://doi.org/10.2807/ese.14.13.19162-en>.

Marvin, H.J.P, Janssen, E.M., Bouzembrak, Y., Hendriksen, P.J.M & Staats, M. (2017) Big Data in food safety: An overview, *Critical Reviews in Food Science and Nutrition*, 57:11, 2286–2295.

Ojo, O.O., Shah, S., Coutroubis, A., Jiménez, M.T., Munoz Ocana, Y. (2018). Potential Impact of Industry 4.0 in Sustainable Food Supply Chain Environment. *2018 IEEE International Conference on Technology Management, Operations and Decisions (ICTMOD)*, 172–177, doi: 10.1109/ITMC.2018.8691223.

Rortais, A., Belyaeva, J., Gemo, M., van der Goot, E. and Linge, J.P. (2010). MedISys: An early-warning system for the detection of (re-)emerging food- and feed-borne hazards. *Food Res. Int*, 43:1553–1556.

Shan, L.C., Panagiotopoulos, P., Regan, A., De Brun, A., Barnett J., Wall P., McConnon, A. (2014). Interactive communication with the public: Qualitative exploration of the use of social media by food and health organizations. *J. Nutr. Educ. Behav.* 47, 104–108.

Siemens. (2016). Virtually brewing, <https://www.siemens.com/customer-magazine/en/home/industry/process-industry/paulaner-virtually-brewing.html>.

Statista. (2020). Industrial automation worldwide. ([statista.com/study/87398/industrial-automation-worldwide](https://www.statista.com/study/87398/industrial-automation-worldwide)) [23.11.2021].

Steinberger, R., Pouliquen, B., Van Der Goot, E. (2009). An Introduction to the Europe Media Monitor Family of Applications. In Conference Proceedings: Fredric Gey, Noriko Kando and Jussi Karlgren, editors. *Information Access in a Multilingual World – Proceedings of the SIGIR 2009 workshop*. Boston (United States of America): ACM-SIGIR (Association for Computing Machinery – Special Interest Group on Information Retrieval), 1–8. JRC52936.

Wei, Q., Nagi R., Sadeghi, K., Feng, S., Yan, E., Ki, S.J., Caire, R., Tseng, D., Ozcan, A. (2014). Detection and spatial mapping of mercury contamination in water samples using a smart-phone. *ACS Nano*, 8, 1121–1129.

Zhu, H., Sikora, U., Ozcan, A. (2012). Quantum dot enabled detection of *Escherichia coli* using a cell-phone. *Analyst*, 137, 2541–2544.

INNOVATIONS IN BEEKEEPING AS A PART OF PRODUCT MANAGEMENT – IN OPINION OF POLISH BEEKEEPERS

Natalia Żak¹

Abstract

The definition of natural honey and apiculture products states that no raw material modifications are possible. Therefore, it has become important to identify the possibility of increasing the range of products on the beekeeping market with the use of product management elements.

The aim of the study was to determine the possibilities and nature of innovation as an element of product management in the opinion of beekeepers from Poland. The scope of the research included a direct interview with beekeepers from all over Poland.

The analysis showed that there is a need to manage the product by implementing innovations only in the product planning sector. Especially in terms of creating its image, promotion, distribution and marketing without interfering with the production sphere. In addition, beekeepers indicated that they treat it more as an option to increase the range of their products on the market than innovation. The term innovation in the case of bee products is very difficult to define due to the traditional approach of consumers to the nature of apitherapy and the legal definition of the scope of the definition of natural honey and bee products.

Keywords: honey, apitherapy, product management, innovations

Introduction

Product management is an element of enterprise management, which combines the possibilities resulting from the use of new technologies with the expectations

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of consumers throughout the product life cycle (from the design, implementation and disposal phase). The main goal of shaping the product is, first of all, adapting it to the requirements of a selected group of recipients, in order to increase the company's profits and gain competitiveness on the market (Urban, 2001; Krajewski, 2010).

In the case of an enterprise with a specific form of activity, such as a beekeeping farm, the form of such product management is a challenge. A beekeeping farm selling its products on the market of food products is a kind of production enterprise. However, they are distinguished from other enterprises operating on the market by several elements, such as: different seasonal specificity of labor production, dependence on climatic conditions, but also on the living organisms used in the production, and above all, the lack of coverage of the work process with the production process (Karliński, 2015; Szymański, 2015).

The definition of natural honey and bee products specifies that no raw material modifications are possible during their production (RMRIW, 2015). These are food products considered by many to be natural remedies for immunity, and natural honey is also considered a tasty natural sweetener. In addition to supporting the treatment of colds and strengthening the body's immune system, natural honey has a nourishing and antibacterial effect, lowers blood pressure and is also a rich source of energy (Stangaciu & Hartenstein, 2007; De Silva, *et al.* 2016; Dač, *et al.* 2017; ed. Tikhonow, 2017; Jagiełło, *et al.* 2018).

Honey is offered for sale in many varieties, characterized by various sensory characteristics, from the delicate taste of phacelia, rape, lime to a stronger taste of buckwheat or honeydew. The same applies to products from bee production, their unique features depend primarily on the use for which they arise (RMRIW, 2015; ed. Tikhonow, 2017).

Therefore, it has become important to identify the possibility of increasing the range of products on the beekeeping market with the use of product management elements, such as: offer planning (wide range, target group, competitive planning) (Karliński, 2015; Szymański, 2015).

An important element of product management, influencing the efficiency and competitive advantage of an enterprise operating in the field of agri-food processing, is the very popular process of searching for and implementing a number of innovations (Kowalczyk, 2009). Which can relate to four important areas:

- 1) product innovations (understood as introducing a new product or significantly improving them with regard to features or purpose (including a significant improvement in terms of technical specifications, components and materials as well as functional features),

- 2) process innovations, which include the introduction of new production or delivery methods or their significant improvement (including changes in technology, equipment),
- 3) market (marketing) innovations, including the introduction of new methods of conducting marketing activities, including significant changes in the product packaging and its positioning, methods of promotion and methods of setting prices,
- 4) organizational innovations – defined as the introduction of new ways of organizing the company's operations, organizing the workplace or shaping relations with the environment (Semkiw & Skubida, 2006; Kowalczyk, 2009; Lipińska, 2015).

The process of implementing such solutions should always bring measurable effects, such as: increasing market share and reducing direct costs and, consequently, increasing revenues (Urban, 2009; Karliński, 2015; Szymański, 2015).

From the point of view of beekeeping marketing, it is important to sell not only honey, but also other bee products, and defining the target group can be a challenge. It can be presumed that they are people who eat honey and consider bee products to be healthy. In this case, customers can be attracted by interesting innovations that have so far been introduced by honey producers and beekeepers. The basis for such decisions was probably the knowledge used in the sale of products from various market segments. For example, customers are always affected by the following phrases: new, unique, innovative, one-of-a-kind, this has not happened yet. This is information for the recipient that the product they are buying is different, unique, and implicitly better (Mruk & Mruk, 2005; Urban, 2009; Celińska, 2019).

Both the product and the form of its distribution can be an innovation in beekeeping marketing. Producers, who want to encourage the purchase of traditional honeys, sell them in various packages, and also conduct marketing in social media in order to get acquainted with their activities (e.g. creating vlogs, videos from apiary life and widely understood production) (Kowalczyk, 2009; Goryńska-Goldmann & Gazdecki, 2016; Celińska, 2019).

An innovative beekeeping product is, for example, unique or rare honey (for example raspberry, chestnut, phacelia) and products produced during its production: propolis, pollen, bee feathers.

Herbal honey, which is just beginning to gain popularity among consumers, can also enjoy great interest in the innovation category. They combine the advantages of herbs and honeys, and in promoting their sale, emphasizing their health and nutritional properties is of the greatest importance. They are also produced by bees

in accordance with the traditional honey production procedure. However, instead of nectar, they are fed with herbal extract or herbal syrup, such as chokeberry or aloe leaves. For example, blueberry and hawthorn support the cardiovascular system, are expectorant and are recommended during colds (Juszczak, *et al.* 2009; Noskowicz-Bieronowa, 2009; Wilczyńska, 2012; Isidorov, *et al.* 2015).

Another product that can arouse great interest in the category of new honeys is honeys enriched with additives – these are mostly creamed honeys (they are created, among others, by long-term mixing of fresh liquid honey, they are characterized by a thick, homogeneous consistency, giving them spreading properties) (Dżugan, Sowa & Wesołowska 2016), the composition of which has been enriched in order to increase the pro-health value of honey. Additions can be: herbs and spices (e.g. lavender, ginger, cinnamon, cocoa), bee products (the propolis, pollen, bee feathers), fruits such as raspberries, currants, cherries, elderberry (RMRiRW, 2015; Dżugan, Sowa & Wesołowska, 2016).

The third method of product innovation in the group of honeys is the introduction of filtered honeys – these are honeys from which organic and inorganic substances (e.g. contamination with yeast cells) as well as pollen, dyes, air bubbles have been removed through a filtration process. The main task of filtration is to stop the crystallization process and remove impurities, e.g. yeast cells. Compared to unfiltered honeys, these honeys are characterized by: lighter color, better clarity, less intense, waxy aroma, and a more intense sweet smell. Filtration also stops the crystallization process, thanks to which these honeys are liquid longer (Root & Root, 2005; Beckmann, *et al.* 2010; Wilczyńska, 2012, 2014).

The above variants of honey also include honey hydrolyzate in the form of a powder. Its use is widespread in baking. In Poland, there is still a problem with the purchase of this type of product, and its production is long and quite expensive (Samorska, 2019).

The last aspect of product innovation is the use of bee products in a different form, also in the form of an additive, for example, candies with honey or the propolis, cosmetics (creams, shampoos, masks, etc.) and medicines, for example, a sore throat spray with the propolis, etc. (Stangaciu & Hartenstein, 2007; De Silva, *et al.* 2016).

Hive air is quite an interesting innovation that has a chance to increase sales as promotion and popularity increase. Until recently, the idea of selling air from a hive grew in the minds of some beekeepers with a more business-like approach. Today, the product is already available on the market in the form of devices that spray the propolis capsules in the room (Woś & Bień, 2013).

Innovations in beekeeping marketing may attract new groups of recipients – those whose traditional marketing and ordinary honeys, available in every apiary, have so far not encouraged the purchase of bee products. First of all, people who do not like standard, traditional bee products and their taste or smell (Celińska, 2019).

Due to the fact that there are a number of scientific reports that describe the presence and impact of the implementation of innovations in the development of enterprises from various sectors of the economy (Jokel & Marciszewska, 2002; Juchniewicz, 2011; Wasilewska & Wasilewski, 2016), however, there was no treatment of the above issue concerning farms beekeepers. The aim of the study was to determine the nature and possibilities of using innovation as an element of product management in the opinion of beekeepers from Poland.

Research methodology

The research was carried out by means of a direct interview, ultimately targeted at a given research group – beekeepers. The questionnaires were sent to beekeepers and were completed during visits to beekeepers. The research was conducted in the first quarter of 2021. The main objective of the study was to determine the possibilities and the nature of introducing innovations in beekeeping farms in the opinion of beekeepers. Beekeepers answered multiple choice questions.

Statistical analysis included methods of descriptive statistics and statistical inference. In order to assess the dependence, the χ^2 test of independence was used at the significance level $p = 0.05$.

Characteristics of the studied population

A face-to-face interview was conducted with 150 owners of apiaries, selected randomly from all over Poland. Beekeepers were owners of apiaries offering a wide range of products, sizes, sales and production. However, these factors did not affect the obtained responses. There were no statistically significant differences ($\chi^2 = 7.4230$; $p = 0.12$). Therefore, this dependence is low – there is practically no correlation. Apiaries had: less than 11 trunks – 12%, from 11 to 20 trunks – 52%, 21-50 families – 30%, and over 80 families – 6%.

Results and discussion

Statistically significant differences were found regarding the importance of innovation in beekeeping ($\chi^2 = 8.4374$; $p = 0.16$). Therefore, this dependence is low – there is practically no correlation. According to the vast majority of beekeepers, innovations in beekeeping are a way to increase the range (41%) and obtain increased profits (45%). Some beekeepers associate innovation with introducing a new packaging (39%) or a new product (38%). Innovation was indicated by 32% of beekeepers as an element of product management. In the case of the production

process, beekeepers rarely indicated the possibility of implementing innovations – about 20% of beekeepers. The data is presented in Figure 1.

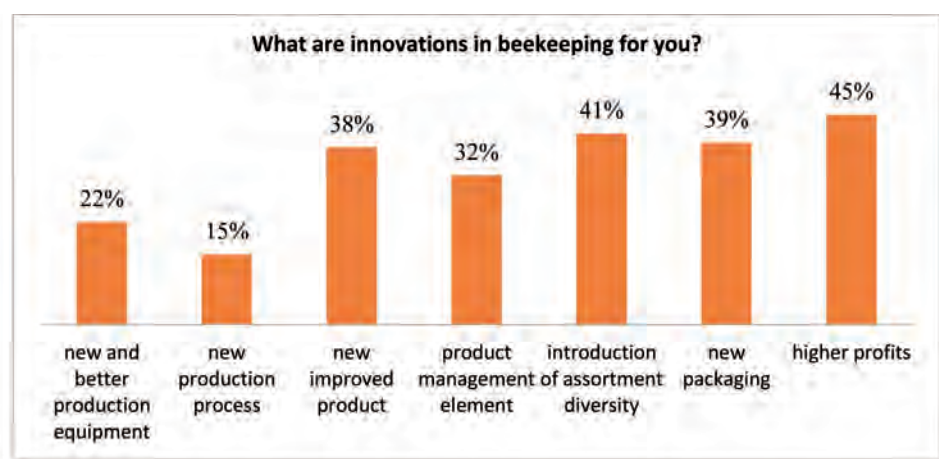


Figure 1. Innovations in beekeeping

Source: own research.

The implementation of innovations in an apiary is a process of changing beekeepers’ thinking about innovation as an element of product management. Statistically significant differences were found regarding the implementation of innovations in apiaries run by the surveyed beekeepers ($\chi^2 = 7.4374$; $p = 0.18$). Therefore, this dependence is low – there is practically no correlation.

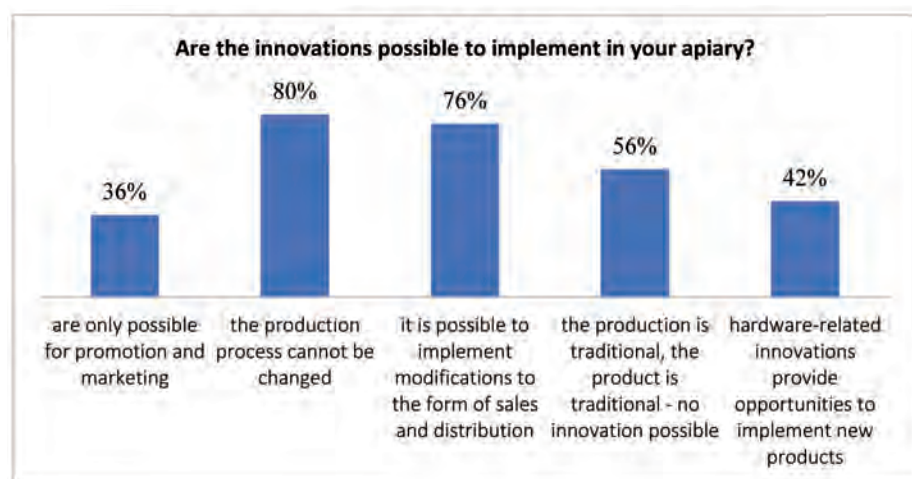


Figure 2. Innovations in the tested apiary

Source: own research.

The production process is an element that, according to 80% of beekeepers, cannot be changed in their apiary. However, according to 76% of them, innovations in their apiary are possible only in the form of sale and distribution. Half of the respondents (56%) also believe that innovation is not possible in the case of a traditional product and production process. Only 36% of respondents indicated the possibility of implementing innovation as an element of promotion and marketing. The data is presented in Figure 2.

According to the respondents, the use of innovations in beekeeping brings benefits not only related to the expansion of the range of traditional products (62%), but also the possibility of acquiring new customers (49%). For 36% of beekeepers, implementing an innovation in an apiary does not bring any visible benefits (Figure 3). Statistically significant differences were found regarding the benefits of implementing innovations in apiaries run by the surveyed beekeepers ($\chi^2 = 8.6102$; $p = 0.13$). Therefore, this dependence is low – there is practically no correlation.

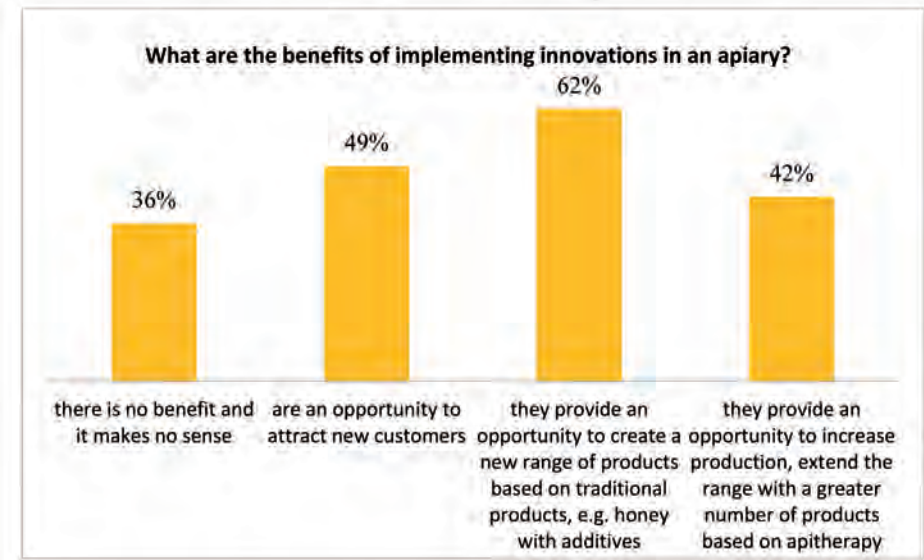


Figure 3. The benefits of implementing innovations in an apiary

Source: own research.

It can be observed that the vast majority of beekeepers use innovation as part of product management in their apiaries. These differences were statistically significant ($\chi^2 = 7.6237$; $p = 0.13$). Therefore, this dependence is low – there is practically no correlation. This applies to the use of innovations in the form of promotion, distribution and marketing (73%) and in any other aspect apart from modifying their products (78%). Only 3% of beekeepers take advantage of

the possibility of innovation in every aspect of their apiary activity. 41% of the respondents declare that the innovations do not concern their apiary (Figure 4).

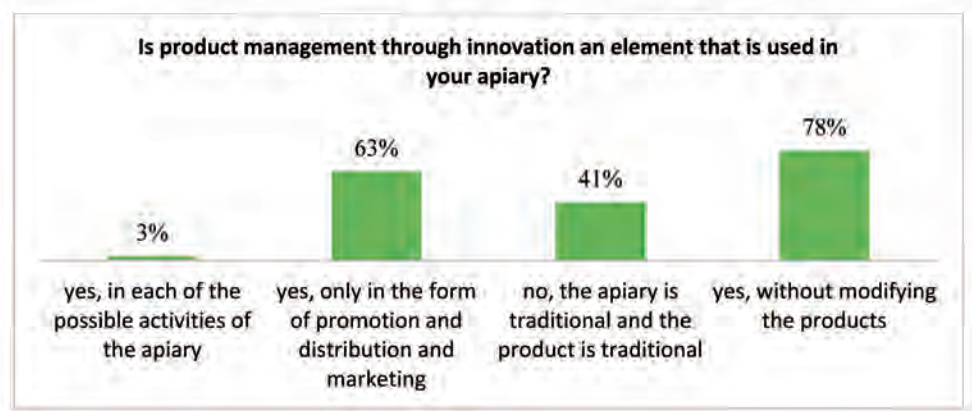


Figure 4. Product management as an element of innovation in an apiary

Source: own research.

Finally, the respondents were asked whether, in the event of the possibility of implementing new solutions, they would use such a possibility. 64% of the respondents would benefit if it was subsidized and it would bring financial profit for their activities. On the other hand, 40% of respondents believe that a traditional product and a beekeeping farm do not need any innovation in their production or distribution. The data is presented in Figure 5.



Figure 5. The desire to implement innovations in the apiary

Source: own research.

The analysis of the literature shows that the implementation of innovations in the production of traditional products is quite a difficult issue (Gutkowska,

Zakowska-Biemans & Sajdakowska, 2009; Szul, 2016; Bortnowska, 2017; Goryńska-Goldmann & Gazdecki, 2017). Firstly, the production process itself is an element that should not be changed, and in addition, the question remains whether product innovations will leave the product the same, consistent with its original definition. This applies, for example, to honey, the definition of which clearly indicates that there is no possibility of interfering with the composition of the product (RMRiRW, 2015).

It can be observed that there is a trend of implementing new solutions in the field of promotion, marketing and the process of functioning of enterprises, because they bring visible profits and do not interfere with the production process, this applies to apiaries, i.e. beekeeping enterprises (Goryńska-Goldmann & Gazdecki, 2017; Dziadkiewicz, 2018).

Conclusions

The analysis of the nature and possibilities of using innovation as an element of product management in beekeeping farms showed that there is a need to manage the product through the implementation of innovations, only in the product planning sector. Especially in terms of creating its image, promotion, distribution and marketing without interfering with the production sphere. Innovations are treated as a form of increasing not only profit, but also the range offered by the apiary. Beekeepers are concerned about the implementation of innovations in the production process, they only allow modifications to the equipment while maintaining the tradition associated with the production process. It can be noticed that beekeepers are divided into two groups: I – traditionalists who do not care about product management, II – willing to try changes and novelties in product and beekeeping management.

References

- Beckmann, K., Beckh, G., Luellmann, C., Speer, K. (2010). Characterization of filtered honey by electrophoresis of enzyme fractions [online], *Apidologie*, www.apidologie.com <http://dx.doi.org/10.1051/apido/2010036> [03.07.2021].
- Bortnowska, G. (2017). Innowacje w żywności tradycyjnej – oczekiwaniem współczesnego konsumenta, *Innovations in traditional foods – expectations of a contemporary consumer* *Probl Hig Epidemiol*, 98(4), 321–324.
- Celińska, A. (2019). *Marketing pszczelarski w praktyce*. https://www.portalpszczelarski.pl/artykul/144/marketing_pszczelarski_w_praktyce__promocja.html [03.07.2021].

Da Silva, P.M., Gauche, C., Gonzaga, L.V., Costa, A.C.O. (2016). Honey: Chemical composition, stability and authenticity. *Food Chem*, 196, 309–323.

Dağ, B., Sirali S., Tarakçı, Z. (2017). Investigation of some properties of chestnut honey produced in black sea region of Turkey. *Batman University Journal of Life Sciences*, Volume 7, Issue 2/2, 118–123.

Dziadkiewicz, A. (2018). Koncepcja rozwoju nowego produktu a dyfuzja innowacji. *Zarządzanie i Finanse Journal of Management and Finance*, Vol. 16, No. 3(3), 109–120.

Dżugan, M., Sowa, P., Wesołowska, M. (2016). *Aktywność antyoksydacyjna miodów kremowanych z dodatkami*, Żywność a innowacje – komunikaty. Kraków: Oddział Małopolski Polskiego Towarzystwa Technologów Żywności.

Goryńska-Goldmann, E., Gazdecki, M. (2016). Kryteria wyboru jako podstawa innowacyjności na rynku produktów regionalnych i tradycyjnych. *Roczniki Naukowe*, tom XVIII, zeszyt 6, 35–41.

Gutkowska, K., Zakowska-Biemans, S., Sajdakowska, M. (2009). Preferencje konsumentów w zakresie możliwych do zastosowania innowacji w produktach tradycyjnych. *Żywność Nauka Technologia Jakość*, 16(3), 115–125.

Isidorov, V.A., Bagan, R., Bakier, S., Swiecicka, I. (2015). Chemical Composition and Antimicrobial Activity of Polish Herbhoney. *Food Chemistry*, 171, 84–88.

Jagiello, J., (2018). Bursztynowe źródło zdrowia – zastosowanie miodu we współczesnej medycynie. *Med. Rodz.*, 21(1), 64–69.

Jokić, G., Marciszewska, A. (2002). Innowacje w małych i średnich przedsiębiorstwach branży spożywczej Dolnego Śląska w przededniu integracji z Unią Europejską. *Prace Naukowe Akademii Ekonomicznej we Wrocławiu. Zmiana warunkiem sukcesu: integracja, globalizacja, regionalizacja – wyzwania dla przedsiębiorstw*, 963, 162–173.

Juchniewicz, M. (2011). Innowacje nietechnologiczne w przemyśle spożywczym. *Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu*, 13(2), 159–164.

Juszczak, L., Socha, R., Rożnowski, J., Fortuna, T., Nalepka, K., (2009). Physicochemical properties and quality parameters of herbhoney. *Food Chemistry*, 113(2), 538–542.

Karliński, S. (2015). Podnoszenie rentowności w gospodarstwie pasiecznym. *Gospodarka w praktyce i teorii*, 3(40), 39–64.

Kowalczyk, I. (2009). Innowacyjność produktowa przedsiębiorstw branży spożywczej. *Zeszyty Naukowe SGGW w Warszawie. Ekonomia i Organizacja Gospodarki Żywnościowej*, 75, 63–77.

Krajewski, K. (2010). Zarządzanie produktem żywnościowym w kanałach dystrybucji – aspekty komunikacji rynkowej. *Zeszyty Naukowe Uniwersytetu Ekonomicznego w Poznaniu*, 153, 100–108.

Lipińska, I. (2015). Ryzyko innowacyjne w produkcji żywności – aspekty prawne i ekonomiczne. *Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu*, 17(1), 129–134.

Mruk, H., Mruk, J. (2005). Strategie marketingowe na rynku pszczelarskim. *Pszczelarstwo*, 56(9), 8–11.

Noskowicz-Bieronowa, H. (2009). *Co może miód?*, Kraków: Emilia.

Root, I.E., Root, E.R. (2005). *The ABC of bee culture*. Kessinger Publishing.

Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 29 maja 2015 r. zmieniające rozporządzenie w sprawie szczegółowych wymagań w zakresie jakości handlowej miodu (Dz.U. 2015, poz. 850).

Samborska, K. (2019). Powdered honey – drying methods and parameters, types of carriers and drying aids, physicochemical properties and storage stability. *Trends in Food Science & Technology*, 88, 133–142.

Semkiw, P., Skubida, P. (2006). Innowacje motorem postępu gospodarstw pasiecznych. *Pszczelarstwo*, 57/07, 8–9.

Stangaciu, S., Hartenstein, E. (2007). *Leki z pszczelej apteki – Miodolecznictwo dla każdego*. Warszawa: Pozkał.

Szul, E. (2016). Konsumenci wobec innowacyjnych produktów. *Nierówności Społeczne a Wzrost Gospodarczy*, 46, 226–236.

Szymański, E. M. (2015). Problematyka rozwoju i stabilizacji gospodarstw pasiecznych – studium przypadku. *Studia i Prace WNEiZ US*. 40/1, 263–274.

Urban, S. (2001). Zarządzanie produktem jako istotne podejście marketingowe. *Management*, 5, 2. 91–101.

Tichonow, A.I. (Ed.). Bondarenko, L.A., Jarnych, T.G., Szpyszczak, O.S., Kowal, W.M., Skrypnik-Tichonow, R.I. (2017). *Miód naturalny w medycynie i farmacji*, Gospodarstwo Pasieczne „Sądecki Bartnik” Sp. z o.o., Stóże.

Wasilewska, A., Wasilewski, A. (2016). *Stan, kierunki i efektywność innowacji w przedsiębiorstwach przetwórstwa rolno-spożywczego*. Warszawa: Wydawnictwo SGGW.

Wilczyńska, A. (2012). Analiza rynku ziołomiodów – uwarunkowania produkcji i sprzedaży. *Zeszyty Naukowe Akademii Morskiej w Gdyni*, 72, s. 37–45.

Wilczyńska, A. (2014). Effect of Filtration on Colour, Antioxidant Activity and Total Phenolics of Honey. *LWT – Food Science and Technology*, 57(2), s. 767–774.

Woś, B., Bień, W. (2013). Apiturystyka jako forma turystyki zrównoważonej. *Zeszyty Naukowe. Turystyka i Rekreacja*, 1(11), 83–90.

PERCEIVED INFLUENCE OF PRODUCT DESIGN AWARDS ON COMPANY PERFORMANCE

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Abstract

Design is increasingly taking on a new role, becoming a competitive advantage and a differentiating factor. As part of the innovation process, it has the potential to significantly contribute to improving the brand image, increasing sales and the company's profitability. It is important to increase the level of public awareness of design and its added value for products and services. Design awards are one of the design promotion activities that give companies a reputation and publicity. The National Design Award is a prestigious award organized by the Slovak Design Center since 1993. The aim of the paper is to examine the perception of the impact of awards in the product design category by the designers and producers of the awarded products. Through a qualitative survey, we found that the cooperation between the producer and the professional designer is mutually beneficial. Producers of award-winning products perceive an improvement in the company's reputation, increased sales of award-winning products and a better competitive position. Award-winning designers see the benefits of making it easier to obtain offers for further cooperation and are better suited to the international design environment.

Keywords: product design, The National Design Award, competitive advantage

Introduction

Intense competition in domestic and international markets, more demanding customers and rapid advances in technology are putting great pressure on companies to look for ways to achieve a lasting competitive advantage.

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In an era of globalization, every company is aware of its competitive advantage if it is prepared for radical changes and the application of innovative design to its products, which will enable it to create a sustainable competitive advantage. According to Blazeska & Ristovska (2016), we can compare the sources of competitive advantage with the foundations of the house. If we can say that a house is safe only if it has a good foundation, we can say that a competitive advantage can be maintained only if its resources are stable, unique, and difficult to imitate.

Differentiation as a competitive advantage

Competitive advantage is the basis of the success of any company in a competitive market. Many companies have been competing dynamically with domestic and global competition for decades. The competitive advantage is the company's ability to make its offer more attractive in the eyes of consumers over the competition. According to the definition of Porter (1985), a competitive advantage is the company's ability to create an advantage over the competition. Porter's generic strategies might assist the business to manage to gain and sustain the competitive advantage and be better than other businesses in the industry.

According to this theory, cost leadership, differentiation and concentration can be an advantage. Companies that want to serve a wide market, develop, and grow benefits at a lower cost use a cost leadership strategy. Companies that seek to benefit from uniqueness use a differentiation strategy. According to Anderson, Palma & Thisse (1992) differentiate product – in packaging, quality, design, color and style – has an important influence on consumer choice. Product differentiation is a competitive business strategy by which firms seek to gain a competitive advantage by increasing the perceived value of their products and services compared to the perceived value of other companies' products and services (Rahman, 2011). Dirisu, Iyiola & Ibiidunni (2013) state that although there are many ways to differentiate brands, identifying meaningful product differences can be particularly useful in gaining and maintaining a competitive advantage.

A product can bring news to the market in several ways, and the aesthetic appearance of a product is just one of those ways to meet customer needs (Dell'Era & Verganti, 2007). Design deals with the meanings that people give to a product, as well as the language of the products that can be designed to express that meaning (Verganti, 2008). Designers make sense of products by using a specific design language that refers to a set of signs, symbols, and icons to convey a message (Verganti, 2008) and to harmonize the user's sociocultural models (Dell'Era & Verganti, 2007).

An increasing number of companies are integrating product design into the process of developing their products in order to gain a competitive advantage in the market. A study by Gemser & Leenders (2001) suggests that design budgets in European and American companies are growing by 8 to 20% per year. Companies currently focusing on product or industrial design can be found in a wide range of industries, from traditional design-intensive industries such as furniture and lighting to modern industries such as personal computers and consumer electronics.

The design transforms thoughts and ideas into practical and attractive propositions for users and consumers and represents a powerful tool of differentiation for companies in the competition. Borja de Mozota (2006) introduced the concept of four design tasks: (1) design as a differentiator – a source of competitive advantage in the market through brand value, customer loyalty, price setting and customer orientation, (2) design as an integrator – environment-dock to improve the development processes of new products and services (eg shortening time to market), (3) design as a transformer – a means of creating new business opportunities, to improve the company's ability to cope with change and also as a tool for better interpretation of society and market, (4) design as a good business – a source of increased sales and higher margins, greater brand value, greater market share, better return on investment.

Product design is defined as a set of features that affect the look, feel, and operation of a product. A well-designed product offers consumers functional and aesthetic benefits that could become an important source of differentiation (Kotler & Keller, 2007). Thus, product design will always help the consumer to make a purchase choice amongst products of the same brands and categories. A well-designed product can also be a market gap that helps the consumer to accept through ease of use, durability, reliability or packaging; serve as a source of competitive advantage (Dirisu, Iyiola & Ibidunni, 2013).

Design promotion activities

For the term design promotion, it is difficult to find a single definition that would explain the nature and main activities. There are different perspectives on design promotion because it involves different activities that have slightly different goals. Promotion is one of the four elements of the marketing mix, the 4P model (product, price, people, and promotion). In marketing, promotion refers to all means of communication (advertising, public relations, point of sale, etc.) that a trader can use to increase sales in the market.

Design promotion is divided into two main functions: design awareness and design support. Design awareness refers to activities aimed at raising awareness of

design and its value, such as design exhibitions, good design awards, international exchanges, national design festivals and the publication of design-related materials. Design support concerns activities that help designers and industries develop their skills and competitiveness (for example, providing financial support to SMEs, programs that help industries to use design more efficiently). Design awareness focuses mainly on the public sector, while design support focuses on the business sector. The impact of design support can be seen in the short term; however, the impact of design awareness usually appears in the long run (Sung, *et al.* 2007).

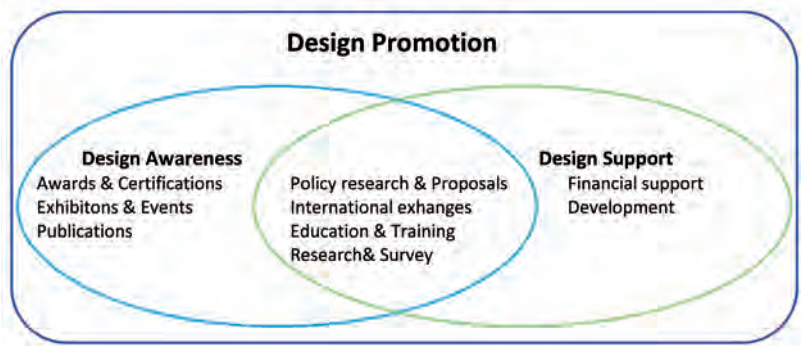


Figure 1. Design promotion activities

Source: Adapted from (Sung, *et al.* 2007).

Raulik-Murphy (2010) cite design education, design support, and design promotion as design policy activities. Support programs focus mainly on businesses, while promotional activities are aimed at the general public, in order to raise awareness of the benefits of design through activities such as exhibitions, awards, conferences, seminars and publications.

Methods

The aim of the paper is to examine the perception of the impact of awards in the product design category by the designers and producers of the awarded products.

The National Design Award is a prestigious award organized by the Slovak Design Center since 1993. The announcers of the competition are the Ministry of Culture of the Slovak Republic and Slovak Design Center. The award of the National Design Prize is the highest form of award and presentation in the field of design in Slovakia. The organization of the competition has changed several times since 1993, until it has stabilized in its current form. Currently, the competition is announced annually with the alternation of 2 categories – product design category and communication design category.

The aim of the competition is: (1) to support the professional work of authors of Slovak design and entities cooperating with designers, (2) to support the application of Slovak designers, entities cooperating with designers and other professionals working in the field of design in the international environment, especially within the European Union, (3) to present to the general public the current work of designers in its broadest form, (4) to motivate subjects in Slovakia to continuously cooperate with professional designers, (5) to promote design that takes into account the ideas of sustainability and responsibility of designers and their clients, (6) to support the development of design theory and professional journalism in the field, (7) to map, document and present the development of Slovak design (Slovak Design Center).

The Slovak Design Center publishes a full-color catalog of awarded products for the competition, and the public can get acquainted with the results of the competition through an exhibition.

We focused our pilot qualitative survey on the winners of the last 3 years of the National Design Award competition in the category – product design. As the product and communication design categories have alternated in the competition since 2015, we focused on the years 2015, 2017 and 2019. In the product design category, it is possible to submit an original domestic product developed in the last two years. Products that entered the competition were from the fields of mechanical engineering, furniture design, dental and gastronomic equipment, in a smaller number of devices, utility glass, textiles and leather goods. We have divided our short qualitative survey on the perception of the benefits of winning the National Design Award into 2 parts. Part 1 of the survey was attended by 10 designers from the last years of the competition. Using an online questionnaire form, we asked them 4 closed questions about the perceived impact of the award on their further professional work and mutual cooperation with the producer. At the same time, the designers had the opportunity to express their attitudes and opinions on the issue. In the second part of the online questionnaire survey, we addressed 10 producers of awarded products. Their task was to answer 5 closed questions concerning their perception of the impact of the awarded product on their economic results and further development of the company and evaluation of mutual cooperation with the designer. At the same time, producers were given the opportunity to openly express their attitudes and opinions on the topic.

Result

The popularity and reputation of the competition is evidenced by the number of submitted applications to the competition, which has an increasing trend. In 2020, after further organizational changes and the division of nominations into several categories, a record number of applications was submitted (Figure 2).

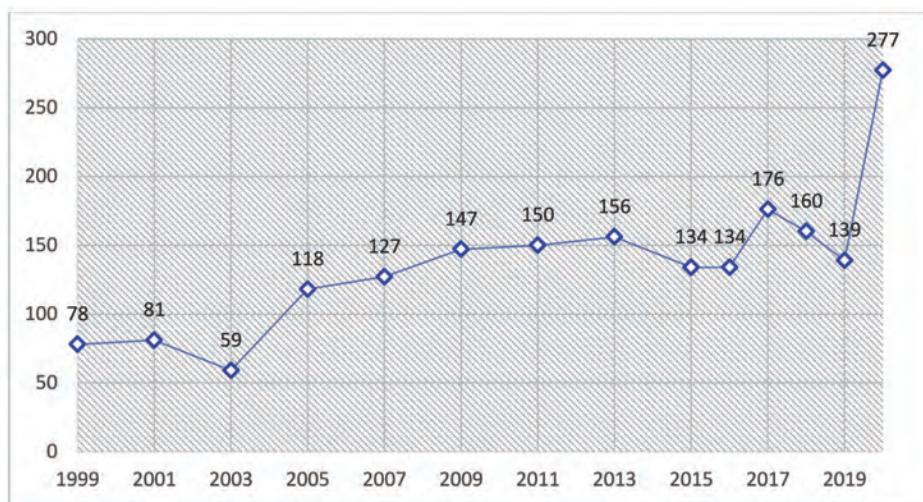


Figure 2. Number of submitted applications for the competition

Source: own processing.

The first question in our survey was to find out how designers perceive the benefits of the award. Half of the designers who answered our questions said that they had not noticed any change in their design profession. We can explain this fact by weaker activities in the field of design promotion. The National Design Award is recognized among professionals, but promotion aimed at the general public is lacking. On the other hand, the remaining half of the designers who answered our questions mentioned many of the positives that the award brought them. It was mainly an agreement on long-term cooperation with the producer, obtaining new contracts for cooperation with other producers, establishing cooperation abroad, raising awareness of the design company and the results of its work. Designers also perceive the award as *“prestigious that can move them in the professional field at the national level.”* Many designers have stated that they have also won international awards for their designs, such as the Red dot design award in Germany, the BIG SEE award in Slovenia, or their design is protected by industrial designs in many countries. Successful product design requires a deep understanding of the available technologies and manufacturing process from the designer. For this reason, we focused on mutual cooperation and understanding between the designer and the producer. All designers who answered our questions assessed the cooperation with the producer as very beneficial. Producers accepted their product designs without change or with only minimal changes. Designers see the problem in the uncertainty of Slovak producers when contacting the designer during product development, *“many companies are afraid or think that they do not need a designer or do not have the money for it.”* The lack of knowledge and

information about the possibilities and potential benefits of design hinders the effective use of design as a key factor for successful innovation.

The producers of the awarded products themselves perceived the various benefits obtained by the award. According to the producers, *“the awareness of the company and the awarded product has increased, people are looking for the product more”*. The producers stated that they perceive the benefits of the award in increasing customer satisfaction, improving the company’s image as well as increasing sales of the awarded product compared to other products.

The producer evaluated the collaboration with the designer as very beneficial, even though it was the first collaboration with an external design studio. Based on the positive experience, the producer considers the contribution of the designer in creating product innovation to be significant and cooperation with the designer as necessary. The award confirmed *“that the cooperation of the development department with the designer is justified and only in this way is it possible to achieve success.”*

Conclusion

The aim of the paper was to examine the perception of the impact of awards in the product design category by the designers and producers of the awarded products. Through a short qualitative survey, we outlined a perception of the impact of this award and stimulated discussion about the possibilities of design support and promotion. The results of the survey indicate a positive perception of the impact of the award on the further professional activity of the designer as well as on the producer of the awarded product. Based on the answers obtained, we can state that the benefits of the award are perceived mainly by the producers of the awarded products. Some designers did not feel any changes in their design work after receiving the award. In our opinion, their name was overshadowed by the “product” itself, which benefited from the award. It is important to raise awareness of the benefits of design work for the general public and to encourage collaboration between designers and industry.

Different views and perceptions of the impact of the awarded product on the part of producers and designers leave room for further investigation of the impact of the award on consumer behavior and purchasing decisions.

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References

- Anderson, S.P., de Palma, A., Thisse J. (1992). *Discrete Choice Theory of Product Differentiation*. Cambridge, MA: MIT Press.
- Blazeska, D., Ristovska, N. (2016). The product design as a significant element of differentiation for achieving market competitiveness. *Economic Development*, 18 (1/2), 41–58.
- Borja de Mozota, B. (2006). The Four Powers of Design: A Value Model in Design Management. *Design Management Review*, Spring, 44–53. Retrieved May 25, 2021, from: <https://bura.brunel.ac.uk/bitstream/2438/1388/1/Four%20Powers%20of%20Design.pdf>.
- Dell'era, C., Verganti, R. (2007). Strategies of innovation and imitation of product languages. *Journal of Product Innovation Management*, 24, 580–599.
- Dirisu, I.J., Iyiola, O., Ibidunni, O.S. (2013). Product differentiation: A tool of competitive advantage and optimal organizational performance. *European Scientific Journal*, 9(34).
- Gemser, G., Leenders, M A.A.M. (2001). How Industrial Design in the Product Development Process Impacts on Company Performance. *Journal of Product Innovation Management*, 18(1), 28–38.
- Kotler, Ph., Keller, K.L. (2007). *Marketing Management*. Praha: Grada, 788, ISBN 978-80-247-1359-5
- Porter, M.E. (1985). *Competitive Advantage: Creating and Sustaining Superior Performance*. Harper Collins Publishers, ISBN: 0684841460
- Rahman, M. (2011). *Differentiation of services to achieve competitive advantage: airlines meeting the needs of the physically challenged persons*. Theses, Southern Cross University. Lismore.
- Raulik-Murphy, G. (2010). *A comparative analysis of strategies for design promotion in different national contexts*. Doctoral dissertation, University of Wales.
- Slovak Design Center (2021). Retrieved May 23, 2021, from <https://www.scd.sk/>.
- Sung, W.O., Song, M.J., Park, J., Chung, K.W. (2007). Changing roles of design promotion organizations in the global context and a new theoretical model for a design promotion system. *Proceedings of International Association of Societies of Design Research*, Hong Kong, 32–39, 12–15 November 2007.
- Verganti, R. (2008). Design, meanings and radical innovation: A meta-model and a research agenda. *Journal of Product Innovation Management*, 25, 436–456.

ANALYSIS OF THE INFLUENCE OF THE EXTERNAL ENVIRONMENT ON THE PRODUCTION OF TRADITIONAL BULGARIAN SMILYANSKI BOB (SMILYAN BEANS)

Sabka Pashova¹

Abstract

Traditional Bulgarian Smilyan beans are available to consumers on the national market. They have specific composition and properties for the region on which they are cultivated. The aim of the article is to present types of traditional Smilyan beans and to analyse the influence of the external environment on the production of Smilyan beans. Accordingly, the main objective is to identify the key elements determining the possibility to develop production of Smilyan beans in the upper areas of Arda river basin. The main factors of the external environment of Smilyan bean production are subject to review in this research. For that purpose the PESTLE analysis was applied. The obtained results indicate that economic, socio-cultural and ecological factors are the key for the development of production of Smilyan beans. Considering the context defined by the PESTLE analysis, potential opportunities and threats associated with their implementation within beans production were indicated. Based on the derived features, were: provided a list of opportunities and threats; outlined the main factors that influence production of beans.

Keywords:

Smilyan beans, production, key factors, PESTLE analysis

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Introduction

Traditional Bulgarian foods date back from ancient times, and have consistently expanded and enriched over the years. They represent an important element of culture, identity, heritage and are characterized by both historical and geographical dimensions (Galli, 2018). The registered Bulgarian protected products are 8. Fille Elena, Lukanka Panagursk, Rolle Trapesitsa, Kaizerovan crop Trakia, Cattle Pastarma, Sudjuk Gornoorjahovski are registered as a food with Traditional Specialty Guaranteed (TSG). Another Bulgarian protected product is the Bulgarian rose oil and the Strandzhanski manov med (honey)/Manov med of Strandzha. The Bulgarian rose oil had an EU logo for the PGI from the summer of 2014 and Strandzhanski manov med had an EU logo for the PDO from the spring of 2019 (Pashova, 2020b). It was found in our research that consumers preferred traditional protected Bulgaria foods instead of foreign ones and find them easy in the supermarkets in our country (Pashova, 2020a).

The bean (*Phaseolus vulgaris*) is a plant species of the *Fabaceae* family. Smilyan beans is one of the few Bulgarian foods, protected by a patent for a word mark concerning its cultivation in the area of the upper valley of the river Arda. Tradition of beans production in the area dated back more than 250 years ago (Pashova, 2019).

The village of Smilyan is one of the oldest settled regions in the Rhodopes. It is 820-850 m above sea level and is cut in half by the swift-flowing Arda River. The name of the village was given by a Slavic tribe. Smilyan is best known for its particularly tasty beans, the main ingredient in many traditional dishes. The traditional livelihood of Smilyantsi is the cultivation and processing of beans, and they are especially famous for the production of large salad beans. Its production is done manually, and fertilization is done only with natural manure. The locals also call the Smilyan beans *fasuljovitsa* (Bulgaria travel, 2021). Smilyan beans are the seeds obtained from the bean plant with the same name (Fig 1). The specific soil conditions, the high humidity due to the proximity of the Arda River, the temperature and the water quality, typical for the area are suitable for growing this beans variety. Smilyan beans have an unique taste and are known both in Bulgaria and abroad. The method of cultivation has traditionally been preserved and passed down from generation to generation. The traditional way of growing beans guarantees the specific taste properties – density, fat and high protein content.

There are two main varieties of Smilyan beans: *large* (Fasuljovitsa-Smilyan large beans); *small* (Smilyanski beans) – the grains are smaller than the previous one, with light brown colour, dark brown and almost black stripes predominating. Both types of beans differ from all others in the unique patterns on the surface (Stoyanova, 2020). Smilyan beans are one of the few Bulgarian traditional

foods, protected by a *patent for word mark and geographical origin* since 2007, concerning its cultivation in the upper areas of Arda river basin and with extended protection until 2024. There are six varieties in the scope of registration – three of the small beans and three of the large salad beans. All the varieties of beans are offered with a special developed label (Figure 2).



Figure 1. Smilyan Beans

Source: Smilyan Beans, 2021.



Figure 2. Specially developed label SMILIAN BEAN *Fasulovitsa*

Source: Smilian Bean Fasulovitsa, 2020.

Smilyan beans are protected by a patent, but this unfortunately cannot prevent it from the appearance of fakes. The manufacturers of the product hope that the counterfeits will stop in the near future. For this purpose, they rely on the financial support of Slow food, of which Smilyan is a member as the homeland of the tasty and

healthy plant. The international movement is expected to allocate funds for the opening of a packaging plant for beans in the village, where the product of local producers will be subjected to quality control. Each package of Smilyan beans will be marked with a holographic sign for a trademark and the corresponding logo of Slow food. Thus, the product will become clearly recognizable on the Bulgarian market. It can be stated that the production of Smilyan beans is *a boutique one*, as no more than 20–40 tons of beans are produced annually. This is the reason why manufacturers do not target international markets. The main goal is to strengthen the position on the Bulgarian market (Smilyanski beans, 2010).

Every year since 2003, the village of Smilyan had held a festival. The Smilyan Bean Festival is organized on the last Saturday of October, when the inhabitants of the Smolyan village have already harvested the beans. With this event the village honors the tradition of growing the emblematic for the village agricultural crop – Smilyan beans. The beginning of the festival is marked by the cannon blast of a bean ball from an authentic Smilyan cannon and includes several traditional competitions: the most attractively arranged stands of bean producers; pano made of Smilyan beans; the most original dish of Smilyan beans; etc. (Figure 3). All guests of the holiday are able to taste bean soup and other traditional dishes, prepared from Smilyan beans, donated by the villagers (Fest BG, 2019).



Figure 3. Pano and dishes of Smilyan beans

Source: Angelov, 2017; Bulgarian Holidays/Sabori BG, 2021.

The purpose of this study is to make a brief and reasoned analysis of the external environment on production of Smilyan beans. The main objective was to identify the elements determining the possibility to increase beans' production. As part of this the elements that have the impact on the production were identified and the most important ones were presented. For this purpose, the PESTLE analysis was used. Its application pointed out the factors that are the driving force for the development of beans production. In addition, based on the current state of knowledge in the area of beans production, its strengths and weaknesses were

described. Considering the context defined by the PESTLE analysis, potential opportunities and threats associated with beans production were outlined.

Material and methods

The PESTLE analysis (political, economic, social, technological, legal, environmental) was applied to identify the main problems facing the production of Smilyan beans. The main prerequisite for using PESTLE analysis is to evaluate the factors of external environment that influence production of Smilyan beans – its future development and to suggest a way to solve existing problems. Taking into account the context identified by the PESTLE analysis, potential opportunities and threats related to bean production are identified. The obtained results allow better use of the opportunities and to overcome the threats that exist and affect production of Smilyan beans (Rialland & Wolf, 2009). This analysis is also used to create a context for further research (Kordana, *et al.* 2019; Zahari & Romli, 2018).

The first stage of the analysis was to identify the issues that influence production of Smilyan beans and to classify them into groups. It was found that production of bean is influenced by the following five groups of factors of the external macro environment: political-legal; technological; economic; socio-cultural; ecological. The evaluation of these groups of factors was performed on the basis of a 5-point scale, the meanings are as follows: -2 (severely unfavorable impact); -1 (adverse impact); 0 (neutral impact); +1 (favorable impact) +2 (highly favorable impact) (Table 1). This stage was based on a detailed analysis of the theory knowledge on beans production and the authors' decisions. Subsequently, a constant number of elements, that were considered as the most important for beans production were distinguished in each group. Considering the context determined by the PESTLE analysis, potential opportunities and threats associated with beans production were indicate.

Analysis of the external environment on production of Smilyan beans

The external environment of each business unit consists of two sub-fields – external microenvironment and external macroenvironment. *External macroeconomic factors* have the same impact on all companies in a given national economy. Their influence can be defined as indirect. *External microenvironment factors* have a direct impact on the specific business. Their manifestation is the same for all manufacturers in a given branch (Kotter & Schlesinger, 1991; Johnson & Scholes, 1993; Mukher, 2011).

PEST is popular as the four sources of change: political, economic, social, and technological (Thompson & Martin, 2010; Rothaermel, 2012), and is widely used tool for analyzing the strategic risk of certain business. It establishes the influence of the external macroenvironment on a company's competitive position (Sammut-Bonnici & Galea, 2015). PESTLE analysis describes the macroenvironmental factors used as a component of strategic management and production of goods. It's advantages are: to outline the different macroenvironmental factors which must be taken into consideration; to understand market growth or decline, business position, potential for the development of certain production (Wallis, 2017; Frue, 2020). PESTLE analysis is usually used for business development assessment and for decision-making (Wisconsin, 2004). By analyzing the macroenvironment, are found the factors that might affect and influence the organization's supply, demand levels and costs. According to Johnson PESTLE framework can be used to identify how future trends on the certain environment might impose on a given business/company (Johnson, Scholes & Whittington, 2008). All these are used to mark opportunities and also to make list of the possible threats when planning strategy for the future development of a sustainable business (Cooper, 2000).

Production of Smilyan bean is influenced by the following groups of factors of the external macro environment: political-legal; technological; economic; socio-cultural; ecological. Detailed information on the impact of external macroeconomic factors on the particular production of Smilyan beans is presented on Table 1. Along with an assessment of the current impact of the external macroenvironment, the table also provides estimates for a future period. Therefore, with "N" is indicated the influence at present moment (now), and with "F" – the future prognosis for this influence (future).

In general, we can summarize and report a relatively favorable impact of the external macro environment on the business climate in the country and in particular on the studied production. The positive impact of the *political and legal environment* is expressed primarily by the factors "availability of food legislation", "cooperation with producers in other countries on the Balkans" in the field of food production and the effective work of institutions. The influence of these factors is expected to be even more favorable in the future. Rather, the impact of the factor "efficiency of judicial system" is negative, but this trend is expected to diminish in the future.

The *economic environment* has a positive impact mainly with the factors of "economic growth", relatively low interest rates, which allows producers to secure financing and a relatively relaxed tax system. The region is characterized by high number of unemployed people, and this leads to stimulation of entrepreneurship and reorientation of the population towards agriculture, and respectively production of traditional product for the region – Smilyan beans.

Table 1. Analysis and evaluation of the external environment of Smilyan bean production

№	FACTOR	-2	-1	0	+1	+2
	Politic – law environment					
1	Politic stability			N, F		
2	Legislation in food area				N, F	
3	External contracts and cooperation				N	F
4	Effectiveness of the Judiciary			N, F		
5	Effectiveness of institutions working in the food sector				N	F
	Economic environment					
6	Economy grow				N, F	
7	Inflation			N, F		
8	Unemployment				N	F
9	Interest rates		N	F		
10	Tax level		N	F		
	Technological environment					
11	Presence of new technologies			N, F		
12	Access to new technologies			N, F		
13	Productivity of existing technologies			N	F	
	Socio-cultural environment					
14	Standard of life		N	F		
15	Availability of qualified workers				N, F	
16	Access to education					N, F
17	Quality in education		N		F	
18	Intercultural differences			N, F		
	Ecological environment					
19	Ecological production				N, F	
20	Waste recovery				N	F

Source: own research.

The *technological environment* does not affect the production, as the region area is mountainous with broken relief and the use of equipment is rather impossible. The low standard of living and the lack of education of the local population stimulates the entrepreneurial spirit and encourages the local citizens population to turn to the traditional agriculture of the region. Opportunities for access to quality education could have both positive and negative effects on the respective business (production of Smilyan beans).

The positive influence of the factors of the *socio-cultural environment* is manifested mainly in the fact that higher knowledge in the field could optimize production, but at the same time it would take young people out of the area and orient them to larger industrial centers. This, in turn, will be a major risk to the continuity (exchange of skills among the generations) of this traditional production for the region.

There is a positive trend in terms of *ecologisation (greening)* of production and the ability producers to use waste from their production efficiently, which would significantly increase their competitiveness. Another important moment which must be outline is the specific soil and climate conditions for the cultivation of Smilyan beans (grown in the area of the village of Smilyan, as well as the neighboring Mogilitza and Arda). The region is characterized by a mountain climate, in which the autumn-winter season is relatively mild and the summer is cool. Other factors that determine the good quality of Smilyan beans are altitude (of 820 to 875 m), humidity of the air, the moderate temperatures.

Based on the derived features, we provided a summary list of opportunities and threats, presented by the external macroenvironment (Table 2).

Table 2. Opportunities and threats, presented by the external macroenvironment of Smilyan bean production

OPPORTUNITIES	THREATS
Existence of legislation in the field of food External contracts and cooperation Efficiency of food institutions Economic growth Availability of skilled labor Access to education Low living standard Ecological production Waste recovery	Increasing standard of life, education and qualification Interest rate Level of taxes

Source: own research.

Table 3. Threat Matrix

		Threat Seriousness	
		Low	High
Likelihood of occurrence	Low	1	2, 3
	High		

Source: own research.

Since these factors influence the general business climate in our country, to derive those that are most important for the specific production, for the subject

of our study, we used a matrix of threats (Table 3) and a matrix of opportunities (Table 4).

Table 4. Matrix of Opportunities

		Attractiveness of the production	
		Low	High
Likelihood of occurrence	Low	1, 2, 3, 4	
	High	5, 6, 7	8, 9

Source: own research.

After the application of the two matrixes, the opportunities and threats are reduced in order to bring out those of them that have the most significant role in the development of beans production. *The main threats* are connected with the increasing standard of life, education and qualification of young people. This will take young people out of the region and orient them to larger industrial centers. This, in turn, will be a major risk to the continuity (exchange of skills among the generations) of the production of this traditional for the region product. Other threats are interest rate and level of taxes. They directly affect the production of Smilyan beans, as they do not have available funds and have to use loans and this affects the possibility of improving and modernizing beans production and last but not least the price of the final product. The higher price of Smilyan beans makes it uncompetitive on the market, and this directly affects the sales and income of producers.

The possibilities for overcoming the threats connected with production of the traditional for Bulgaria Smilyan beans can be summarized in the following directions: availability and periodic updating of the normative base and effective work of institutions; development of cooperation with other producers, with the aim to exchange experience, participation in seminars and trainings, aimed at improvement and development of production of Smilyan beans; introduction of new resource-saving and environmentally friendly technologies; improving the access of Smilyan bean producers to farmers’ markets all over the country.

Conclusions

Based on the made analyzes, the following conclusions and summaries are drawn from the conducted research and evaluation of the external environment of Smilyan bean production:

First: The main factors of the external environment that influence production and future development of Smilyan beans are economic, socio-cultural and

ecological. Based on the derived features, are outlined lists of opportunities and threats, presented by the external macroenvironment.;

Second: Development and improvement of Smilyan beans production, is possible through: use of legislation in the field; external cooperation among the producers; availability of skilled labor; ecological production and waste recovery. This will influence on the number of employees in the region, area under cultivation, quantity and quality of produced beans.;

Third: The main threads associated with Smilyan beans production are: *lack of sufficient labor and opportunities to improve the technology of cultivation and production of beans*, as the area is mountainous and the land where the plants are grown, are fragmented and decomposed along the Arda River; *increasing standard of life, education and qualification* of young people who live in the village, this will take young people out of the region and orient them to larger industrial centers; *high interest rate and level of taxes* affect the ability of producers to improve and modernize beans production.;

Fourth: Through the annual Smilyan Bean Festival the traditional product will be advertised outside the borders of Bulgaria, and this will favor the development of rural tourism and economic growth of the region.

References

- Angelov, M. (2017). The Smilyan beans holiday opened a market for producers. Retrieved 28.06.2021 from <https://agronovinite.com/praznikat-na-smilyanskiya-fasul-otvori-pazar-za-proizvoditelite/>
- Bulgarian Holidays/Sabori BG (2021). Smilyanski Beans Holidays. Retrieved 25.06.2021 from: <https://www.sabori.bg/ob-smolian/view.html?oid=9300>
- Bulgaria Travel (2021). The Village of Smilyan. Retrieved 20.06.2021 from: <https://bulgariatravel.org/the-village-of-smilyan/>
- Cooper, L. (2000). Strategic marketing planning for radically new products. *Journal of Marketing*, 64 (1), 1–15.
- Fest BG (2019). XVII Smilyan Bean holiday. Retrieved 27.06.2021 from: <https://fest-bg.com/event/празник-на-смилянския-боб-2018/>
- Frue, K. (2020). PEST Analysis Ultimate Guide: Definition, Template, Examples. Retrieved 30.06.2021 from: <https://pestleanalysis.com/pest-analysis/>
- Galli, F. (2018). Chapter 1 – *Traditional Food: Definitions and Nuances*. Case Studies in the Traditional Food Sector, A volume in the Consumer Science and Strategic Marketing series, Woodhead Publishing Series in Food Science, Technology and Nutrition, 3–24.
- Johnson, G., Scholes, K., Whittington, R. (2008). *Exploring Corporate Strategy*, 8th Edition, Prentice-Hall, Pearson Education.
- Johnson, G., Scholes, K. (1993). *Exploring Corporate Strategy*, 3rd Edition Prentice Hall.

Kordana, S., Pochwat, K., Słyś, D., Starzec, M. (2019). Opportunities and Threats of Implementing Drain Water Heat Recovery Units in Poland. *Resources*, 8(2), 88. MDPI AG. Retrieved 01.07.2021 from <http://dx.doi.org/10.3390/resources8020088>

Kotter, J., Schlesinger, L. (1991). Choosing Strategies for Change. Management of Change. Harvard Business Review. Harvard Business School Publishing Division. Boston, U.S.A.

Mukher, S. (2011). Business Environment Types (External Micro and External Macro). Retrieved 29.06.2021 from: <http://www.economicsdiscussion.net/business-environment/business-environment-types-external-micro-and-external-macro/10095>

Pashova, S. (2020a). Consumers` Attitude Towards Traditional Bulgarian Food. *Economics and Computer Science*, Varna: Knowledge and Business, 2, 14–26.

Pashova, S. (2020b). Protected Bulgarian Traditional Foods. Desire. Design and Research in Business: *Proceedings of the International Scientific Conference*, 22 November 2019, Bratislava, Slovakia, Bratislava: University of Economics in Bratislava, 2020, 84–94.

Pashova, S. (2019). Traditional Bulgarian Plant Species. *Journal of Mountain Agriculture on the Balkans* [JMAB], Trojan: Research Institute of Mountain Stockbreeding and Agriculture, 22(1), 238–258.

Rialland, A., Wolf, K. (2009). Future Studies, Foresight and Scenarios as Basis for Better Strategic Decisions (IGLO-MP2020 working paper, Trondheim).

Rothaermel, F. (2012). *Strategic Management: Concepts and Cases*. McGraw-Hill/Irwin.

Sammut-Bonnici, T., Galea, D. (2015). PEST analysis, Wiley Encyclopedia of Management. Publisher: John Wiley & Sons, Ltd, DOI: 10.1002/9781118785317.weom120113.

Smilyan Beans (2021). Retrieved 25.06.2021 from: https://www.google.com/search?q=смилянски+боб&client=opera&hs=KJ5&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjF17mms-nsAhWSDewKHdHuAlsQ_AUoAXoECAwQAw&biw=1326&bih=658#imgrc=S4Ksp8YVoZKBoM&imgdii=CdUk1KS4JgKuuM

Smilian Bean Fasulovitsa (2020). Retrieved 26.06.2021 from: <https://www.facebook.com/photo/?fbid=1807275555969193&set=pcb.1807278555968893>

Smilyanski beans. (2010). *Active consumers*, Retrieved 10.07.2021 from: <https://aktivnipotrebiteli.bg/statia/41/Smilyanski-bob>).

Stoyanova, R. (2020). Smolyansky Bean. Retrieved 10.07.2021 from: https://gotvach.bg/n7-39587-Смилянски_боб

Thompson, J., Martin, F. (2010). *Strategic Management: Awareness & Change*. 6th ed. Cengage Learning EMEA.

Wallis, G. (2017). *Pestle Analysis Jump Start*. Create Space Independent Publishing Platform.

Zahari, A.R., & Romli, F.I. (2019). Analysis of suborbital flight operation using PESTLE. *Journal of Atmospheric and Solar-Terrestrial Physics*, 192, 104901. <https://doi.org/10.1016/j.jastp.2018.08.006>.

INCREASE THE EFFICIENCY AND LIFE EXPECTANCY OF PORTABLE ELECTRICAL STORAGE DEVICES

Jacek Czerniak¹, Anna Gacek¹

Abstract

The concept of sustainable use of energy banks seems understandable, but the precise definition and interpretation of what sustainable use is requires both a technical and a practical explanation. The appropriate and sustainable use of portable energy storage, commonly known as power banks, is a compromise between the amount of energy accumulated during the charging cycle and the life of this product. Manufacturers of most power banks provide them with LED indicators that inform about the power bank's charge status. According to the literature a battery can be considered fully charged if the current stabilizes at a certain level and its and cannot go down further. The research was based on this understanding of capacity, and the capacity of the power bank was defined in two charging scenarios. One of them was the observation of optical indicators placed on the device and the end of the charging process when the last marker was activated. In the second case, a device monitoring the power consumption was connected to the power bank and its indications determined the moment of ending the charging process. The results of power bank capacity tests in both charging scenarios showed differences. Accordingly, the method of charging determines the service life of the battery and its maximum capacity.

Keywords: power bank, sustainable use, quality

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Introduction

The parameters of smartphones currently available on the market, equipped with very large displays, modern communication interfaces and other elements such as GPS navigation, cause that the battery life does not allow for long use. In urban agglomerations, you can easily find places to replenish the energy level of mobile device batteries. In larger cities, even in public transportation, there are USB ports available, so you can charge while you commute. It's not that easy to recharge in the outdoors and off the electric grid. Nowadays it is common to use devices equipped with a GPS module instead of traditional maps, even on mountain trails. They allow you to determine your geographical position with high accuracy. Very often smartphones are such devices, however their batteries can prove insufficient. Therefore the use of portable power banks is necessary.

The prediction of smartphone battery lifetime has been investigated by various researchers (Kang, Seo & Won-Ki Hong, 2011; Krintz, Wen & Wolski, 2004; Pandey, Verma & Kumar, 2019). This research focuses on power banks. Power banks allow you to recharge smartphones, e-book readers or even laptops. Currently, there are many companies on the market offering a very large selection of these types of devices. In 2018 the global mobile traffic was 3–4 times higher than it had been just 3 years earlier, and still led to year-over-year growth figures in the 90 percent range (Ericsson Mobility Report, 2021). The items on offer differentiate not only in design, number and types of charging ports but most importantly the capacity. The declared capacities refer to the capacity of cells built into the power bank and differ from the actual (empirically achieved) capacity (Czerniak, Gacek & Szopa, 2021). These differences result from the necessity to adjust the output voltage to the USB standard and the so-called fast charging standard offered in many devices. It is worth noting that the voltage of the batteries in the power bank is usually ca. 3.6–3.7 V and the capacity declared by the manufacturer is related to these batteries (*The basics of the six staple lithium chemistries*, 2018). The necessity to ensure the USB standard output voltage of 5V, requires the use of devices that increase the voltage, so-called STEP UP converters. They increase the output voltage at the expense of increased current consumption. Hence the differences in the declared and achievable capacity of power banks. The reduction in capacity will also be visible when using the so-called fast charging as it increases the voltage (Czerniak, Gacek & Szopa, 2021; Gao, *et al.* 2022; Finegan, *et al.* 2020; Rodrigues, *et al.* 2021) up to 9V, 12V or even 24V. This voltage step up is achieved by increasing energy consumption. In addition to the described losses resulting from voltage conversion, the charging method has a large impact on the capacity of this type of devices.

Most power banks have built-in LED charge level indicators. There are two possible ways of charging such devices. The first is to keep them plugged in until all charge

level indicators light up. The second is to monitor the charging current until it stabilizes at a constant low level. Logically the users will follow the first way and use the built-in indicator, but quite often the charging pattern follows the second scenario. To finish charging once all charge indicators light up would require a constant monitoring of the charging process, especially in its final stage. In order to check whether both of the presented scenarios result in differences in the amount of energy stored in the tested power banks, this study was carried out. As the market is dominated by power banks equipped with batteries of two chemical systems, apart from the two charging scenarios, power banks with lithium-ion and lithium-polymer cells were tested.

In power banks equipped with lithium-ion batteries, during the charging process, lithium migrates to the graphite anode and the voltage potential changes. Removing the lithium again during discharge does not wholly restore the chemical original state (Paul, *et al.* 2019; Yao, *et al.* 2019). A film called solid electrolyte interface (SEI) consisting of lithium atoms forms on the surface of the anode. Composed of lithium oxide and lithium carbonate, the SEI layer grows as the battery cycles. After many charge cycles this layer becomes thick enough to form a barrier that obstructs interaction with graphite (Finegan, *et al.* 2020). Studies have shown that the amount of lithium ions responsible for the transfer of electric charge between the electrodes ultimately decreases and settles on the anode (Chauhan & Chauhan, 2019). It also causes an irreversible process of reducing the amount of lithium on the cathode. Consequently the capacity of the power banks built-in cells is reduced. In order to charge the cells embedded in the power banks structure, they must be connected to an electromotive force and supplied with a voltage higher than the nominal voltage on the cell during its discharge. However it is very important not to exceed the voltage of 4.10 V per cell during charging, as this is harmful to the battery (Jing, *et al.* 2018). Such exceed causes the electrolyte to oxidize at the cathode, which degrades the batteries. Cells charged with lower voltages, in turn, lose their capacity due to the formation of a SEI layer on the anode.

The lithium-ion battery is fully charged once the battery reaches the voltage threshold and the current decreases to approximately 3% of the rated current or the current stabilizes and will not drop any further. Increasing the charge current does not reduce charging time. For CC-CV (Constant Current – Constant Voltage) charging method the increase of current excels the first stage (constant current) but the saturation in the second stage (constant voltage) requires more time. In everyday use it is not advised to fully charge the battery as higher voltage puts additional load on it. Selecting a lower constant voltage threshold during charging in stage two or eliminating this stage altogether extends battery life, but reduces operating time (Guo, *et al.* 2015; Keil & Jossen, 2016; Min, *et al.* 2017; Zheng, *et al.* 2017). Overcharging the battery is also not advisable. Once fully charged,

the current must be cut off. Continuous sustained charging would result in the deposition of a lithium metal layer.

Power banks equipped with lithium-polymer batteries, unlike lithium-ion batteries, must be equipped with a control system to prevent deep discharge as well as overcharging (Indra, *et al.* 2013). This is extremely important because if too much voltage is reached (overcharging) it could very easily damage the battery or even cause an explosion. With deep discharging, the battery can also be damaged and thus its capacity drastically reduced. During charging, the electronic system must supervise the whole process and limit the charging current and then cut it off at the right moment (Tanboonjit & Fuengwarodsakul, 2014). This action must be performed as soon detecting that any of the cells have reached fully charged state.

Both electrochemical systems of power banks are subject to the adverse consequences of improper use. The power banks users are aware of the problem of limited battery lifetime of the device. However the users do not have adequate knowledge of the power consumption characteristics and capabilities of the device (Rahmati, Qian & Zhong, 2007). Therefore, there is a need to have a system that can take care of the power optimization without much user intervention. In both Li-po and Li-ion batteries, it is important not to use a charging current that is higher than that required for the device. Although this reduces charging time, it also reduces battery life. The conventional CC-CV technique used in almost every commercial charger is efficient, but the Li-Po battery requires additional protection e.g. in the event of an overvoltage, and this protection is enforced by the battery management system. Undoubtedly, manufacturers of power banks ensure that they are safe to use, and the built-in electronic systems ensure that the batteries function properly. Otherwise, they would not have been approved for commercial use, so this aspect was not tested in this paper. This research focused on the influence of two charging scenarios on the working capacity of power banks.

Research design

Prior to the technical research of power banks, a survey of 167 respondents of two genders was carried out. The survey asked about the most important features of the power bank, when making a purchase decision. The surveyed age group was 20-35 years old, as this group is proven to be frequent users of power banks. Eight brand new power banks, for which the manufacturers declared a capacity of 10000 mAh, were used as test material. Power banks used in this tests were divided into two groups based on the type of chemical structure of cells used for storing electric energy. The first group consisted of power banks equipped

with lithium-ion cells and the second one with lithium-polymer cells. The next step was to check the actual capacity of the power bank against that declared by the manufacturer. In order to carry out the tests, an apparatus using elements of modern electronics and automation was constructed.

The figure (Figure 1) shows the schematic of the measuring apparatus, which consists of a climatic chamber, ensuring identical environmental conditions for all tested power banks and two measuring circuits. The first circuit consists of devices that charge and monitor the charge level of the power bank. The charge level can be monitored by measuring the current drawn during charging or by using indicators mounted on the power banks housing. Once the power bank is fully charged the charging process is automatically terminated and a second circuit, which allows the tested power bank to be discharged, is initiated. The charging was performed with the voltage of 5V. It was possible to current draw up to 3A, but the maximum recorded was 2.5A. The whole process was supervised by a PC running a program controlling a single-chip microcomputer equipped with appropriate sensors and archiving data. The charging and discharging parameters together with the time needed to complete both processes were recorded at two-second intervals.

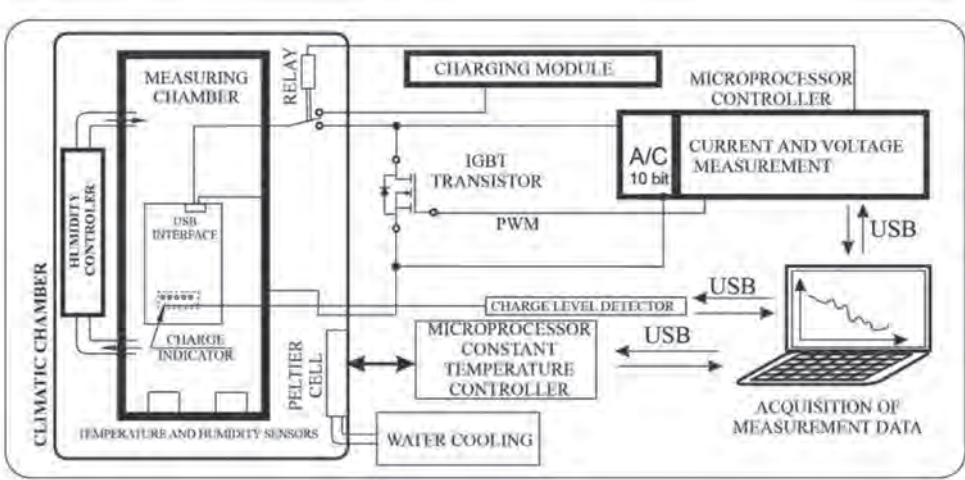


Figure 1. Schematic of the measuring apparatus

Source: own study.

The loading protocol was completed in two scenario. In the first the charging process was considered finished when the current parameters were set at a constant level invariable in time or, for the second scenario, immediately after the LED indicator was lit. After the charging process was completed, each of the tested

devices was discharged using the aforementioned recorder. The discharge device was based on an IGBT transistor controlled through a PWM signal supervised by a single chip microcomputer. This design allowed the discharge parameters of the tested power banks to remain constant. All tested power banks were discharged with a constant current of 1A. This ensured comparable parameters for all tested power banks.

Results

The column chart (Figure 2) presents the results of the survey. The chart indicates that the capacity of the power bank is the most important feature to which consumers pay attention to when buying this type of device. It is also worth emphasizing that the power bank charging indicator is equally important. This proves that the charge indicator is referred to while charging the device. The analysis of the survey also proves that consumers are willing to pay a higher price for products with a higher capacity and the mentioned charging indicator. Strength, weight or even design of the device are of secondary importance.

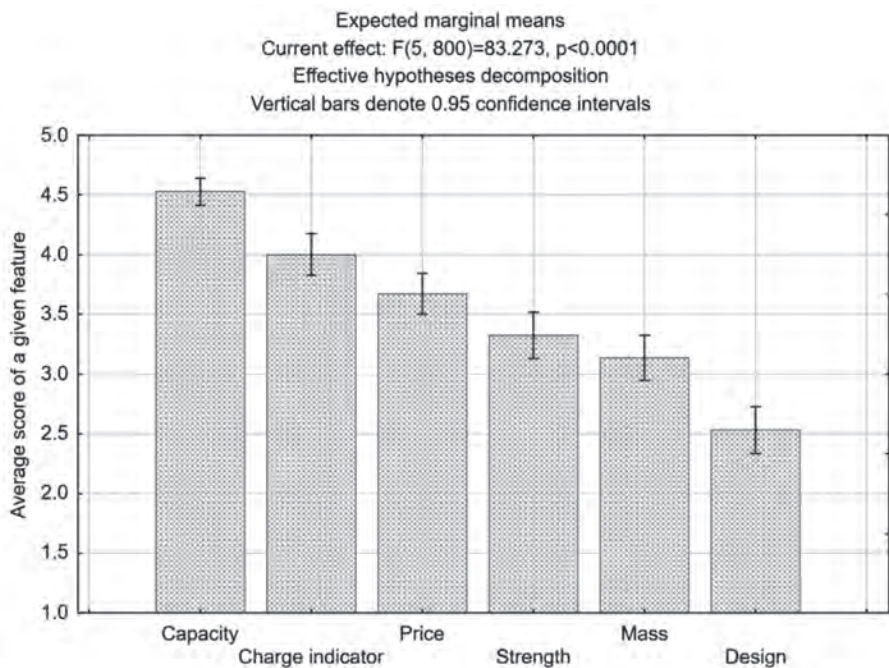


Figure 2. The most important features of a good power bank as indicated by respondents

Source: own study.

Since the capacity of a power bank correlates positively with its price, it is worth trying to improve this parameter by proper use. Therefore, an attempt was made to optimize the use of the power bank, in order to make the maximum use of its capacity by using it in a thoughtful way.

The main effects of the analysis of variance presented in the column chart (Figure 2) are statistically significant with $F(5, 800) = 83.273, p < 0.0001$. A statistically significant difference was demonstrated by a few criteria. The following were undifferentiated in relation to each other: strength and mass of the power bank (Table 1).

As shown by the results of this part of the survey, according to the respondents, the most important feature determining the quality of a power bank is its capacity. As the second determinant of quality, the respondents indicated that the power bank should be equipped with charging indicators, while the price of the product was the third criterion. The respondents placed in fourth place such features as strength, and mass of the power bank. The design of the device turned out to be the least important quality criterion.

Table 1. LSD-Fischer test showing statistical differentiation for analysis concerning important features of a power bank

No.	LSD-Fischer test; variable: average score. Probabilities for post hoc tests. Error: between MS = 0.93804, df = 800.0						
	R1	{1} 4.5280	{2} 4.0000	{3} 3.6708	{4} 3.3230	{5} 3.1366	{6} 2.5342
1	Capacity		0.000001	0.000000	0.000000	0.000000	0.000000
2	Charge indicator	0.000001		0.002367	0.000000	0.000000	0.000000
3	Price	0.000000	0.002367		0.001324	0.000001	0.000000
4	Strength	0.000000	0.000000	0.001324		0.084704	0.000000
5	Mass	0.000000	0.000000	0.000001	0.084704		0.000000
6	Design	0.000000	0.000000	0.000000	0.000000	0.000000	

Source: own study.

In the column chart (Figure 3) we can follow the capacity measurement results related to the capacity declared by the manufacturer and included in the power banks specification. In this diagram the power banks were divided into two groups depending on the chemical system used in power cells. The capacity of each power bank tested was measured at maximum charge. In this case, a scenario involving the measurement of the current supplied to the power bank during charging was

used because preliminary studies have shown that such charging allows better results.

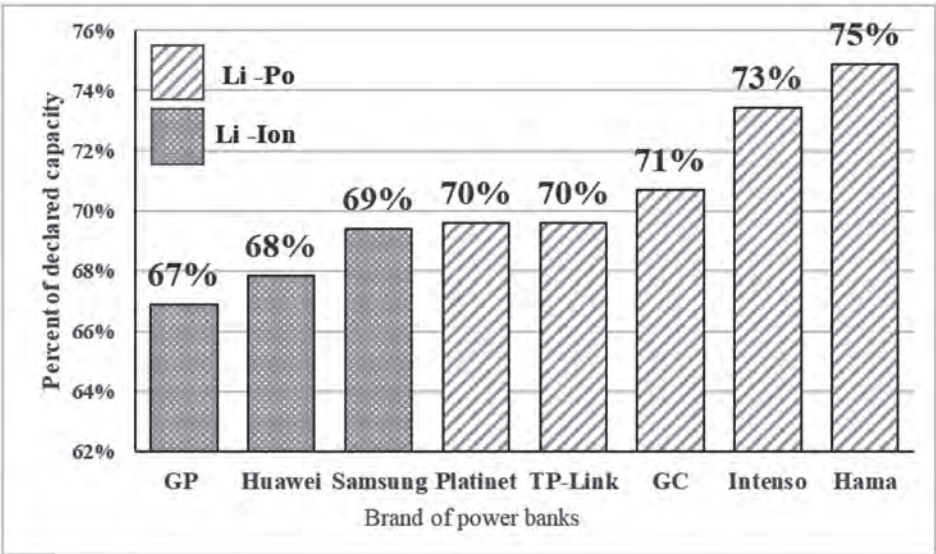


Figure 3. Percentage of the declared capacity of the power bank being charged until the current stabilizes at a minimum level

Source: own study.

After analysing the graph (Figure 3) it can be concluded that the Hama power bank has the best performance. The ratio of its actual capacity to the declared capacity is 75%, which means that both the batteries and the voltage conversion devices installed in the power bank have the highest efficiency. Similar conclusions can be drawn by observing the test results for all the power banks equipped with lithium-polymer cells, which show an advantage over power banks equipped with lithium-ion cells.

Charging was stopped when the current was established at a constant level, for each power bank usually 25 minutes after the LEDs on the power bank turned on. After analysing the graph (Figure 3) it can be concluded that the Hama power bank has the best performance. The ratio of its actual capacity to the declared capacity is 75%, which means that both the batteries and the voltage conversion devices installed in the power bank have the highest efficiency. Similar conclusions can be drawn by observing the test results for all the power banks equipped with lithium-polymer cells, which show an advantage over power banks equipped with lithium-ion cells.

In the second phase of the research, tests were conducted for the second charging scenario and then the results were compared and presented in the form of a column graph (Figure 4).

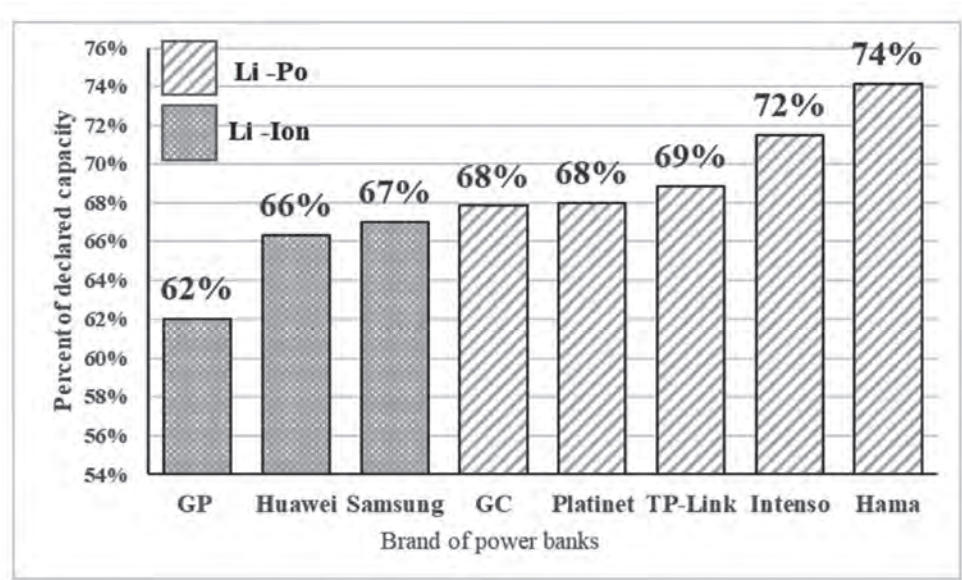


Figure 4. Percentage of the declared capacity of the power bank being charged until its electronic system indicates full charge

Source: own study.

The graph (Figure 4) shows the results of measurements of the capacity of power banks that were charged until their electronic system indicated full charge. The charging process took place automatically and the charging was interrupted immediately after the charging message occurred. It is worth noticing, that in this case the capacity does not depend on the chemical system of the power bank as the capacity differences, regardless of the chemical system, oscillate between 1 and 7 percentage points. Differences in working time in both charging scenarios of the power bank amounted to up to 30 minutes of work when discharged with a current of 1A. Undoubtedly, a bigger difference will show the lower quality of the tested device. Both in first and second phase the same device emerges as the leader. Its tested capacity had the smallest difference between the capacity declared by the manufacturer and the capacity obtained during the tests. This device also shows the smallest differences between the charging methods used. Similarly the device with the worst performance has the biggest difference between the measured capacity and the capacity declared by the manufacturer,

and shows the biggest differences with both charging scenarios. As the results of the questionnaire showed the most important feature for the customer is the capacity of the power bank. Hence in case of the devices especially those with worse parameters to extend charging time is recommended. This method provide to better results can be obtained.

Conclusions

After conducting a literature study, it is easy to see that the most important safety factor for both lithium-ion and lithium-polymer cells is to protect them from the from charging current of too high amperage. It is also important to monitor the voltage, the levels of which, in some cases, adversely affects the electrochemical processes occurring in the cells. In case of power banks, responsibility for safety falls on the manufacturer, who has to build appropriate electronic charging systems into their structure. The empirical part presents the influence of the charging process on the fluctuations of the working capacity of the power bank in a given work cycle. Power banks charged in the second scenario, i.e. with indicator monitoring, showed a lower working capacity. Devices which showed insignificant differences between declared and measured capacities also did not show large discrepancies in both charging scenarios. In summary, the electronic devices built into the structure of the power bank prevent the dangerous effects of overcharging. Choosing a power bank characterised with similar capacity results during tests to the one declared by the manufacturer also guarantees that it will prove high efficiency regardless of the charging mode. This is due to the use of high quality electronics, which allow for better protection of the cells built into the structure of the power bank. Power banks equipped with lithium-polymer cells give better results. This may be due to the stricter electronic requirements (control of overcharging, undercharging, etc.). In the case of power banks characterised by a larger discrepancy between the declared capacity and the capacity resulting from tests, it seems beneficial to extend the charging time. In this way, up to 5% more energy can be obtained in comparison with charging terminated when the led indicator is lit.

References

Berrueta, A., San Martín, I., Sanchis, P., Ursúa, A. (2019). Chapter 6 – Lithium-ion batteries as distributed energy storage systems for microgrids. In: R.K., Chauhan, K., Chauhan (Eds.), *Distributed Energy Resources in Microgrids Integration. Challenges and Optimization*, 143–178, Academic Press.

Czerniak, J., Gacek, A., Szopa, P. (2021). Analysis of Power Bank Quality Criteria That Are Important from the Consumer's Point of View. *Energies*, 14(18):5747, doi: 10.3390/en14185747

Finegan, D.P., Quinn, A., Wragg, D.S., Colclasure, A.M., Lu, X., Tan, C., Heenan, T.M., Jervis, R., Brett, D.J., Das, S., Gao, T., Cogswell, D.A., Bazant, M.Z., Di Michiel, M., Checchia, S., Shearing, P.R., & Smith, K.A. (2020). Spatial dynamics of lithiation and lithium plating during high-rate operation of graphite electrodes. *Energy & Environmental Science*, 13(8) DOI: 10.1039/D0EE01191F

Gao, N., Kim, S., Chinnam, P., Dufek, E.J., Colclasure, A.M., Jansen, A., Son, S.-B., Bloom, I., Dunlop, A., Trask, S., Gering, K.L. (2022). Methodologies for Design, Characterization and Testing of Electrolytes that Enable Extreme Fast Charging of Lithium-ion Cells. *Energy Storage Materials*, 44, 296–312, doi: 10.1016/j.ensm.2021.10.011

Guo, Z., Liaw, B.Y., Qiu, X., Gao, L., Zhang, C. (2015). Optimal charging method for lithium ion batteries using a universal voltage protocol accommodating aging. *Journal of Power Sources*, 274, 957–964, doi: 10.1016/j.jpowsour.2014.10.185

Indra, W.D., Majid, I.A., Sya'bani, F., Rahman, R.F., Cahyadi, A.I. (2013). Battery modeling for lithium polymer battery management system. In Joint International Conference on Rural Information & Communication Technology and Electric-Vehicle Technology (rICT & ICeV-T), 1–4. IEEE, doi: 10.1109/rICT-ICeVT.2013.6741501

Jing, L., Glazier, S. L., Nelson, K., Ma, X., Harlow, J., Paulsen, J., Dahn, J. R. (2018). Effect of Choices of Positive Electrode Material, Electrolyte, Upper Cut-Off Voltage and Testing Temperature on the Life Time of Lithium-Ion Cells. *Journal of The Electrochemical Society*, 165(13), A3195-A3204. DOI:10.1149/2.0931813jes

Kang J.-M., Seo S.-S., Won-Ki Hong J. (2011). Personalized battery lifetime prediction for mobile devices based on usage patterns. *Journal of Computing Science and Engineering*, 5(4), 338–345, doi: 10.5626/JCSE.2011.5.4.338

Keil, P., Jossen, A. (2016). Charging protocols for lithium-ion batteries and their impact on cycle life – An experimental study with different 18650 high-power cells. *The Journal of Energy Storage*, 6, 125–141. DOI:10.1016/j.est.2016.02.005

Krintz, Ch., Wen, Y., Wolski, R. (2004). Application-level prediction of battery dissipation. Proceedings of the International Symposium on Lower Power Electronics and Design, Newport Beach, CA, 224–229.

Min, H., Sun, W., Li, X., Guo, D., Yu, Y., Zhu, T., Zhao, Z. (2017). Research on the optimal charging strategy for Li-ion batteries based on multi-objective optimization. *Energies*, 10, 709, doi: 10.3390/en10050709

Pandey, N., Verma, O.P., Kumar, A. (2019). Nature Inspired Power Optimization in smartphones. *Swarm and Evolutionary Computation*, 44, 470–479, doi: 10.1016/j.swevo.2018.06.006

Paul, P., Thampy, V., Cao, C., Steinruck, H., Tanvir, T., Dunlop, A., Dufek, E., Trask, S., Jansen, A., Toney, M., Weker, J.N. (2020). Quantification of heterogeneous, irreversible lithium

plating in extreme fast charging of Li-ion batteries. *Energy & Environmental Science*, 9(14), 4979–4988, doi: 10.1039/D1EE01216A

Rahmati, A., Qian, A., Zhong, L. (2007). Understanding human-battery interaction on mobile phones. In Proceedings of the 9th international conference on Human computer interaction with mobile devices and services (MobileHCI ,07). Association for Computing Machinery, New York, NY, USA, 265–272, doi: 10.1145/1377999.1378017

Rodrigues, M.T.F., Son, S.-B., Colclasure, A.M., Shkrob, I.A., Trask, S.E., Bloom, I.D., Abraham, D.P. (2021). How Fast Can a Li-Ion Battery Be Charged? Determination of Limiting Fast Charging Conditions. *ACS Applied Energy Materials* 4(2), 1063–1068, doi: 10.1021/acsaem.0c03114

Tanboonjit, B., Fuengwarodsakul, N.H. (2014). Implementation of charger and battery management system for fast charging technique of Li-FePO₄ battery in electric bicycles. In Ninth International Conference on Ecological Vehicles and Renewable Energies (EVER), (pp. 1-5). IEEE, doi: 10.1109/EVER.2014.6844103

Yao, K., Okasinski, J., Kalaga, K., Shkrob, I., Abraham, D.P. (2019). Quantifying lithium concentration gradients in the graphite electrode of Li-ion cells using operando energy dispersive X-ray diffraction. *Energy & Environmental Science*, 2(12), 656–665, doi: 10.1039/c8ee02373e

Zheng, J., Engelhard, M.H., Mei, D., Jiao, S., Polzin, B.J., Zhang, J.G., Xu, W. (2017). Electrolyte additive enabled fast charging and stable cycling lithium metal batteries. *Nature Energy*, 2, 17012, doi: 10.1038/nenergy.2017.12

Ericsson Mobility Report, November 2021, <https://www.ericsson.com/4ad7e9/assets/local/reports-papers/mobility-report/documents/2021/ericsson-mobility-report-november-2021.pdf> [12/11/2021]

The basics of the six staple lithium chemistries. (2018). *Energy Storage Journal*, Michael Halls (eds.) HHA Limited, London, 20, 57–61. <https://issuu.com/energystoragejourna>

DIRECTIONS OF USING THE KANO MODEL TO IMPROVE THE QUALITY OF PRODUCTS AND SERVICES

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Abstract

The Kano method is one of the quality management methods used to improve the quality of products and services. Using the assumptions of this method it is possible to answer the question: How does the fulfillment/non-fulfillment of a given requirement (attribute) of a product or service influence the satisfaction/dissatisfaction of a consumer/customer. Moreover, using the Kano method enables assigning attributes of a product/service to 6 categories, proposed by the inventor of the method (Noriaki Kano), such as Must-be, One-dimensional, Attractive, Indifferent, Questionable and Reverse. The purpose of this paper is to present the applicability of the Kano method in improving services, industrial products, and food products.

As a result of literature analysis, it has been found that the Kano method has been applied mainly in improving the quality of the quality of catering, hospital, educational, aviation, cosmetic and delivery services. The Kano model has also been adopted in the improvement of industrial products such as cell phones, baby carriages and automobiles. In contrast, limited application of the Kano model has been observed in food product quality improvement. Findings included food packaging, use of food additives, and the improvement of food products in general.

Keywords: Kano model, quality, product, service, improvement

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Introduction

Quality improvement is a natural part of management. It is related to widely understood variability, the factors and conditions of which are located both inside and outside the organization (Szczepańska, 2011).

There are many methods of quality improvement, used in a very wide range. These methods are used both in improving the quality of processes, services, industrial and food products. They are also used to measure and analyze service quality and customer satisfaction with the product/service. There are also many quality methods that can be used to identify expectations and to classify customer requirements in relation to products, services or in defining relations between requirements and product features.

The aim of the article is to present the possibilities of applying the Kano method in the improvement of services, industrial – and food products.

To achieve the objective, desk research was used, i.e. the analysis of available literature data and other thematic sources. Desk research consists of compiling, analyzing and processing data from existing sources. The next stage is to formulate conclusions on the basis of the data concerning the research problem. Existing data analysis, or secondary research, uses primary research as a source (Bednarowska, 2015). Due to the fact that the contribution to the development of science is continuous and dynamic, the number of literature sources is constantly increasing, and it is constantly necessary to follow the latest research in the analyzed topic. The secondary analysis method also has weaknesses, as often the found data does not fully correspond to the specific topic being searched for. It is sometimes more difficult to use existing data if it is collected for a different research purpose than the one formulated in the paper. The problem of desk research can also be insufficient information on how primary data were obtained (Nachmias, 2001). According to Perri 6, & Bellamy (2012) there are five classes of research methods: generating, collecting, coding, organizing and analyzing information. Desk research belongs to the second class – information gathering methods. While the next stage of the thesis, i.e. classification of the found articles by type of application (services, industrial products and food products) belongs to class four, i.e. methods of ordering information. The article is the result of the analysis of the obtained information, which belongs to the fifth class of research methods (Perri 6 & Bellamy, 2012; Lisiński & Szarucki, 2020).

As part of the preparation of the article, a review and analysis of found data in internet scientific databases concerning application of the Kano method for improving the quality of food products in particular. Such search engines as Scopus, ELSEVIER, EBESCO, IEEE Xplore, Google Scholar, and the multi-search

engine of the Gdynia Maritime University Library were used. The article presents the identified areas where the Kano method has been applied so far.

Kano quality improvement method

The Kano quality improvement method (Kano model) was developed in 1979 by Tokyo University professor, Japanese quality expert Noriaki Kano. The principles of this model are based on the assumption that not all product attributes (quality attributes) satisfy customers to the same extent. In addition, there are product/service attributes that the customer considers essential and those that he/she does not expect because he/she considers them useless. The Kano model proves very useful in better understanding the customer's perception of product/service quality. The method is helpful in determining the relationship between product/service attributes and customer satisfaction. The purpose of using the Kano method is to determine what influence the fulfilling or not fulfilling a requirement for a given product or service attribute has on customer satisfaction or dissatisfaction. By using the Kano model, it is possible to find an answer to the question of how big impact the changes to a product/service will have on customer satisfaction. With the help of the Kano method, it is also possible to assess how customers evaluate a product or service and to identify the most important features that should be improved in terms of quality. For this reason, the model has found very wide application in the process of improving products and services (Rashid, *et al.* 2011; Szkiel, 2016; Ulewicz, 2016).

The Kano method consists of 6 stages. The first stage consists of identifying the attributes (requirements) that define a product or service. Product attributes can be identified from three sources. The literature is the first source of information used to identify attributes. The next source is the previous experience and own research of those who apply the method. The last source of identifying requirements for the analyzed product/service is the collection of information from a group of customers. This can be done, for example, based on the principles of brainstorming or by means of a survey. The second stage is the preparation of a survey questionnaire in accordance with the principles of the Kano method and its validation, conducted in order to check whether the questions contained in the questionnaire were formulated in a manner understandable for respondents. The Kano questionnaire contains two types of questions for each of the identified product/service characteristics. The first question aims to assess how the customer feels, the second (opposite) question aims to assess how the customer feels if the requirements are not fulfilled. The next step is to conduct a survey. After collecting responses from respondents, an individual and collective categorization of the characteristics is made.

Noriaki Kano has divided product attributes into six categories:

1. M – Must-be (Mandatory),
2. O – One-dimensional,
3. A – Attractive,
4. I – Indifferent,
5. Q – Questionable,
6. R – Reverse.

The individual groups of product characteristics are presented in the Table 1.

Table 1. Product feature categories according to the Kano model

Type of feature	Charakteristic	Recommendations for the company
M – Must-be (Mandatory)	The presence of this characteristic is required by the consumer. The presence of the attribute does not make the customer happy, but its absence causes a significant increase in customer dissatisfaction.	These features must necessarily be included in the product.
O – One-dimensional	The presence of this feature is expected by the customer. The greater the realisation of this feature, the greater the customer satisfaction and vice versa.	These features should be developed in the product/service and their level should not be lower than in competing products.
A – Attractive	This is a feature that the customer does not expect, but it turns out to be useful to them. The presence of this feature will increase customer satisfaction, but its absence will not cause dissatisfaction.	All these features should not be included in the product/service at the same time. It should be ensured that a few selected features are realised at the maximum level.
I – Indifferent	It is a feature that, whether present or absent, will not result in customer satisfaction or dissatisfaction.	These should be avoided in the product/service.
Q – Questionable	There is a contradiction – customers want the feature to be present as well as not to be present.	No recommendations.
R – Reverse	It is a characteristic whose absence causes customer satisfaction, while its presence causes customer dissatisfaction.	They should not be included in the product.

Source: own elaboration based on: (Rashid, Tamaki, Ullah, & Kubo, 2011; Szkiel, 2016).

After performing an aggregate categorization of product/service features, the impact of fulfilling a requirement on the customer satisfaction size and the impact of not fulfilling a requirement on the customer dissatisfaction size are calculated. The calculation of satisfaction and dissatisfaction is shown in Figure 1.

$$\text{Size of satisfaction} = \frac{A+O}{A+O+M+I} \quad \text{Size of dissatisfaction} = \frac{O+M}{(A+O+M+I) \times (-1)}$$

Figure 1. The method of counting the magnitude of satisfaction and dissatisfaction is presented

Source: own elaboration based on: Wiśniewska, 2009.

The final stage of the Kano model is to identify directions for improving product/service quality. When applying the Kano improvement model, it should be remembered that it is dynamic in nature. A specific feature is not adopted permanently. Over time, customer needs change and become more sophisticated. As a result, the affiliation of a given customer attribute to a specific model group changes. Attributes that are attractive become more and more accepted by competitors over time and become one-dimensional attributes. As the market develops and innovations emerge, the importance of competition for one-dimensional attributes diminishes and they become mandatory because their existence in the product/service becomes obvious. Robertshaw (1995) suggested that it should be priority to meet the requirements for mandatory attributes, the next stage is to meet the requirements relating to one-dimensional attributes and then attractive attributes. Furthermore, using the Kano model, it is possible to identify which product/service attributes influence or do not influence the fulfilment or non-fulfilment of requirements. However, it is not possible to determine the reasons for these relationships (Gajewska, 2012; Szkiel, 2016).

Using the Kano method to improve service quality

Literature research revealed that the Kano method has been applied to improve many types of services. Research using the method has been conducted, among others in relation to customers' perceptions of the attributes of catering, educational, hospital, delivery, airline, mobile applications and services offered by certification societies. The aim of most of the studies conducted was to assess the attributes of these services and the impact of their fulfilment or non-fulfilment on customer satisfaction or dissatisfaction of customers, as well as overall service quality. The paper describes some selected examples of the application of the Kano method to improve service quality.

The first focus was on the application of the Kano model to foodservice. In her study, Gajewska (2012) applied the Kano method to explore the impact of food service attributes on the quality perceived by customers. Respondents taking part in the study rated their satisfaction with the fulfilment and non-fulfilment of such attributes of a catering service as location, opening hours, interior design, atmosphere of the place, professionalism of service, adaptation of the premises for guests with children, adaptation of the menu for guests with children, quality of food and drinks, price, discounts and individual approach to guests. The research made it possible to identify price and food and beverage quality as the main factors influencing the choice of a catering establishment. At the same time, the decoration and atmosphere, the level and standards of service and the location of the restaurant should also be areas of interest for their owners. The author used the results of the survey to identify potential directions for the development of the catering industry, confronting needs and opportunities for improvement with customer expectations.

Improving the quality of food service using the Kano method was also the subject of research by Tutko & Pokrzywa (2019). The research did not involve the application of all the steps of the Kano method, but only the preparation of a questionnaire to measure the quality of the catering service provided by people with disabilities, which can be a tool to know the impact of the attributes of the catering service provided by people with disabilities on the satisfaction of the customers of these services. The authors focused on three research objectives, such as: identifying methods used to measure and evaluate the quality of services provided by people with disabilities, developing an evaluation template to measure the quality of catering services, and designing a Kano questionnaire to measure the quality of catering services. The result of their research was the presentation of proposals for the modification and integration of methods used to assess the quality of catering services, including in particular the Kano method.

In turn, Malinowska, Wiśniewska & Grudowski (2014) used the Kano method to isolate and prioritize the features of an educational service, taking into account their importance from the point of view of a student (customer of an educational service). As a result of the analysis, the authors identified features that are worth improving (such as the theoretical foundation of the classes, availability of the lecturer and infrastructure conditions) and those that are of lesser importance for students (such as the availability of infrastructure for disabled people). Distinguishing features of the quality of educational service were also identified, which may be decisive for the competitiveness of the university and the highest satisfaction of customers (students), and thus reveal into a good image of the university.

Research on the quality of educational services was also conducted by Szeliga-Duchnowska & Szewczyk (2018). The aim of the study was to present the

usefulness of the Kano questionnaire in the context of developing appropriate (from the student's point of view) characteristics of an educational service. The authors identified the characteristics of the educational service from the student's point of view and prioritized them, which made it possible to determine the level of quality and student satisfaction with the educational service offered and to identify those characteristics that require development. The research shows that both tangible and intangible features of the educational service are equally important for students.

The article *Using the Kano model to classify the requirements placed by students on the educational service* also describes the application of the Kano model in the process of improving the quality of educational services. The aim of the study was to identify and classify the requirements placed by students on the education service and to establish priorities for the improvement of individual services provided by universities. The first stage was for students to identify 25 features that should characterize the services provided by a higher education institution. The analysis of the survey results showed that the must have features include: developed infrastructure adopted to the needs of the disabled and mothers with children as well as high level of teaching and availability of lecturers. The greatest number of one-dimensional features were identified, which included features such as low fees, convenient access to the university and modern laboratory equipment. Attractive features included, for example: providing students with internships and placements and a virtual dean's office. Students did not indicate any questionable or reverse features. The results of the survey made it possible to identify priorities for the HEIs in terms of improving their offer to students and ensuring a high level of teaching. The survey allowed for the identification of the features of the service, which have the greatest impact on student satisfaction and therefore are worth improving (Szkiel & Gut, 2014).

Priyono and Yulita (2017) applied the Kano model to investigate the quality of hospital services in terms of reception activities, particularly in the context of identifying strategies to improve the features of the service. The starting point for the study was the SERVQUAL model, which was developed using a comprehensive set of techniques including literature review, interviews and focus group discussions. The analysis used of information collected from customers of an international hospital located in Yogyakarta, Indonesia enabled the identification of 14 attributes of the hospital reception service that were required by customers. The study identified 5 attributes belonging to the attractive category (e.g. personal attention given by front office staff), 4 one-dimensional attributes (e.g. responds to any request from customers) and 5 must-be attributes (e.g. provide services as promised). The results of the survey made it possible to indicate the features that are worth improving as a priority, as they have the greatest impact on customer satisfaction.

Also studying the quality of hospital services, Howsawi *et al.* (2020), in their article *Application of the Kano model to determine quality attributes of patient's care at the primary healthcare centers of the Ministry of Health in Saudi Arabia*, described the application of the Kano model to determine quality attributes of patient's care at the Primary Health Care (PHC) clinics of the Ministry of Health of Saudi Arabia. The study was conducted in primary health care (PHC) centres within the MOH (Ministry of Health) in Saudi Arabia between October 2018 and February 2019. Of the 18 attributes that were identified, 14 were unidimensional, three were attractive and one was indifferent. The top three one-dimensional attributes were: kindness and respect from the hospital receptionist, kindness and respect from the nurses and laboratory staff, and care and attention from the doctor. Unified electronic medical records, the showing of educational videos in the waiting room, and advanced radiology services such as MRI were considered attractive attributes. An indifferent attribute for the respondents was a small operating room. The results of the survey allowed the organization to orient its activities towards improving those features that are most important to the customer.

The Kano method has also proved to be helpful in evaluating delivery services. Singgih, *et al.* (2018) applied Kano to evaluate supplier performance. The aim of the study was to develop a multi-criteria measure for evaluating the performance of maintenance outsourcing service providers. The study classified the criteria based on Kano principles. In order to better understand the criteria in the context of the needs of an actual hospital maintenance department, a managed case study analysis was conducted in five private Class B hospitals in East Java. The result of this study was the development of a simple tool that can be used to evaluate the performance of maintenance outsourcing service providers.

Airport services were another type of service to which the Kano method was applied for improvement. It was important for the authors to identify the attributes of these services that have a negative and positive impact on passenger satisfaction. The Kano method was used to classify and diagnose the attributes of airport services and to identify opportunities for their improvement. The model was validated using a case study of Taoyuan International Airport (TPE) in Taiwan. It combined the quality categories of the Kano model with the importance and performance of each attribute and was developed to classify and diagnose service attributes at TPE airport. The study showed that the proposed approach could help managers identify a correct and effective service improvement strategy for their airport. Another feature of the approach was its simplicity associated with no advanced statistical knowledge required. The study used the Skytrax scale, which uses a ranking system to survey passenger satisfaction according to 39 airport service attributes. Analysis of the survey results showed that over 40% of the attributes belonged to the "must be" group, almost 30% were "one

dimensional” attributes, nearly 19% of the attributes belonged to “attractive” and only 1% were indifferent attributes. Based on the assignment of service attributes to each criterion, it was indicated which attributes needed to be improved as they most influence customer satisfaction (Tseng, 2020).

Yao, Chuang & Hsu (2018) found an application to Kano’s method for mobile app services. The authors identified over 200 mobile security applications (MSAs) with rich functionality in the Google Play app shop. The study consolidated and extracted 12 main attributes – mobile security and antivirus features from the top 25 MSA providers. The aim of their study was to find out how users evaluate and rank the quality attributes of MSA features using a two-dimensional Kano Model questionnaire. The analysis showed that all features could be classified as one-dimensional or of indifferent quality. Four features with the highest impact on satisfaction were identified, i.e., malware prevention, safe browsing, parental control, and privacy protection. The authors indicated that MSA vendors should place emphasis on these four features. They also identified features that have a greater impact on increasing customer satisfaction than on reducing dissatisfaction. The authors suggested that MSA vendors need to put more effort into designing these features to achieve higher customer satisfaction.

The identification of opportunities for improving mobile apps was also addressed by Zhang (2018). The subject of the study was mobile reading apps. According to the author, satisfying readers’ needs and improving reading outcomes could contribute to the survival of the apps in the market. Based on his analysis, he identified three areas (basic, individual and social reading functions), covering 24 specific functions. Through data analysis, two functions that are attractive to the Chinese university students surveyed were identified, which include cumulative reading time and gift books. In addition, some features, for example, catalogue navigation, eye protection mode, copy, search functions, classification and collection, were one-dimensional features that readers expected. The analysis also showed that message notifications had a negative impact on readers using the app. Readers also indicated problems with sending messages from the app. The findings suggest that not every app reading feature can satisfy users. The findings of the study also provide guidance for the design of reading apps.

Szkiel (2011), in turn, used the Kano model to classify the requirements for certification services. The presented research results concerned the requirements formulated by organizations with an implemented and certified management system by accredited certification societies. The research covered 72 manufacturing and service organizations in various industries which had a certified management system: quality, food safety or environmental. The aim of the research was to identify and classify the requirements set by organizations holding a certified standardized management system to accredited certification societies for management systems. The first stage of the research was to

conduct an interview with representatives of the management of the quality management system in five organizations having implemented and certified quality management system according to PN-EN ISO 9001:2009. The aim of the interview was to identify the requirements for the certification service. As a result, 16 requirements were identified. The results of the research made it possible to divide the identified attributes into criteria in accordance with the principles of the Kano model. The analysis of the research results has shown the attributes which have the highest impact on the satisfaction of the customers of certification services, such as competent and polite administrative staff, recognition of the body, and those which have the highest impact on customer dissatisfaction, such as transparent procedures for working with the body or individual approach to the audited system. The requirement that has no effect on customer satisfaction or dissatisfaction was also indicated. The analysis of the results could provide a basis for planning the direction of development of the certification bodies' activities.

Application of the Kano method to improve the quality of industrial products

The Kano model has also been used to improve industrial products such as vehicles (cars, electric scooters), prams, tableware, footwear, and mobile phones.

Agassi, Ushada & Suyantohaadi (2020) analyzed user needs towards industrial design. The first research objective was to identify the attributes of user needs towards KESAN industrial design. The second objective involved analyzing user needs using the Kano method. 13 user needs were identified and selected. Based on the research results, 7 attributes were identified for the one-dimensional category, 4 attributes for the must be and 2 attributes for the attractive category. The results of the research indicated that the most important attribute is the desktop application as a complement to KESAN in displaying information and documentation.

The Kano model was found to be a useful tool by Yadav, *et al.* (2013) to determine the impact of satisfying the requirements for the aesthetic attributes of the car profile on customer satisfaction. Attributes were identified based on data collected from customers through a survey questionnaire, identifying 12 requirements. Four of the 12 aesthetic attributes (i.e. elegant, family, modern and youthful) were found to be attractive (more significant). The authors presented an integrated approach that transforms customer emotions into useful design data. This enabled industrial consultants, professional product designers and researchers to categorise user requirements, which can then be incorporated into the final product design.

Four years later, the same authors again addressed the subject of the application of the Kano model in the improvement of car quality. They described the application of the Kano method to achieve an optimal combination of shape parameters and aesthetic aspects of a car. They recognized that the visual shape parameters and aesthetic aspects of a product are one of the key factors determining the success of a product in the market. The type and value of shape parameters plays an important role in the visual appearance of a product, and designers tend to be critical when deciding on these parameters. The Kano model has proven to be a useful tool for establishing the relationship between performance criteria and customer satisfaction (Yadav, Jet *al.* 2017).

Another industrial product that was studied in terms of its potential for improvement using the Kano model was tableware. The Kano model was used to identify and study user emotions and user involvement in tableware design. Attributes were studied using two types of questionnaires. The first questionnaire included functional and dysfunctional questions of the Kano model. The second questionnaire asked respondents to rank these attributes, according to their personal opinion, within the Kano categorization. Based on all the findings and results, the product attributes were categorized based on user requirements, and the degree of user involvement in the design was determined (Mamaghani & Izadoanah, 2011).

Application of the Kano method for quality improvement of food products

Limited application of the Kano model was observed in food product quality improvement. The findings focused on food product packaging.

Williams, Wikstrom & Lofgren (2008) used the Kano method to explore how to increase customer satisfaction and reduce the environmental impact of food packaging systems in a life cycle perspective. Investigating customer requirements at an early stage of product and packaging development was considered to help build competitive advantage. This was related to the fact that the basic functions of packaging, i.e. protection of contents and ease of storage and transport, are no longer sufficient according to the customer. This observation confirms that the attribution of product features to one of the criteria and customers' attitudes to these features evolve over time. In the study, performed by the Authors, the Kano method was used to analyze how consumers perceive the functions and quality of packaging of everyday products. For this purpose, data were collected on Swedish customers' experiences with packaging of everyday goods. For the preparation of the survey, 24 attributes were identified and categorized when analyzing the results. Most of the quality attributes were classified as one-dimensional. The

results proved that packaging is characterized by quality attributes that customers perceive as essential. Quality attributes classified as attractive were also identified. Only one attribute was considered an indifferent quality attribute. None of the packaging attributes studied were considered to be an inverse quality attribute. The authors noted that there are opportunities to increase customer satisfaction while reducing the environmental impact of the food packaging system, even more so when the packaging design helps to reduce food waste.

The literature review identified only one article on food product improvement in the context of the Kano method. Szkiel (2016) presented the results of a study on the identification and classification of consumer requirements for food products. In the first step, the requirements for food products were identified using an interview method among a group of consumers. Twenty-five attributes/requirements for food products were identified. The attributes belonging to the “must be” category included: lack of danger of the product for consumer’s health, sensory values of the product, legible label. Failure to meet these requirements may result in abandonment of the purchase of the product. There were also identified features whose fulfilment directly affects consumer satisfaction, such as: low price, easy availability, easy preparation. The greatest number of features belonging to the attractive category were identified: lack of preservatives, artificial coloring and flavorings, low level of processing, content of only natural ingredients. Meeting these requirements to the greatest extent affected consumer satisfaction, while their absence was not noticeable to consumers. On the basis of the obtained results, the influence of fulfilling and not fulfilling of individual requirements on consumer satisfaction was assessed, and also priorities in the area of development of individual food product features in order to adjust them to consumer needs and expectations were indicated.

Conclusions

As a result of the literature analysis, it was found that the Kano method was primarily applied to service quality improvement. More than 70% of the publications identified so far were related to services, more than 20% to industrial products, and only about 5% to food products. The analysed literature was published by both Polish and foreign (80%) authors.

Among the services where opportunities for improvement were identified using the Kano model were food services, hospitality, education, airline services, delivery services and mobile applications. Kano was used to assess the attributes of these services and the impact of their fulfilment / non-fulfilment on customer satisfaction / dissatisfaction and overall service quality. The application of the Kano model enables a better understanding of how customers evaluate a service and

also points businesses towards targeting the development of the requirements that are most important from the customers' point of view. Companies have the opportunity to develop those attributes that most influence customer satisfaction.

A smaller but still significant application, the Kano model has also found its way into the improvement of industrial products such as mobile phones, tableware, prams and vehicles such as cars and electric scooters. Using the principles of the Kano model in product development, the guideline is to meet all essential attributes, compete with market leaders on one-dimensional attributes and add attributes deemed attractive. This combination can result in the complete fulfilment of customer requirements.

Limited application of the Kano model was observed in food product quality improvement. The results of the study were mainly related to food product packaging. Also, only one article on a food product improvement study was identified. The literature search did not find articles on the application of the Kano model to the selected food product. Based on the analysis, an empirical gap was identified regarding the application of the Kano method to food product improvement, which provides a basis for further research into the use of the Kano method for this purpose.

References

- Agassi, T.N., Ushada, M., Suyantohadi, A. (2020). Industrial Design of Kansei Engineering-based Sensor for Agroindustry (KESAN). *Management and Production Engineering Review*, 11(1), 13–22.
- Bednarowska, Z. (2015). Desk research – exploiting the potential of secondary data in market and social research. *Marketing i rynek*, 7, 18–26.
- Gajewska, P. (2012). Metoda Kano w ocenie jakości usług gastronomicznych. *Turystyka i rekreacja, Zeszyty Naukowe Wyższej Szkoły Turystyki i Języków Obcych w Warszawie*, 9(1), 113–128.
- Howsawi, A.A., Althageel, M.F., Mohaideen, N.K., Khan M.S., Alzahrani, A.S., Alkhadir, M.A., Alageel, S.M., Alkathiri, M.A., Hawsawi, R.A. (2019). Application of the Kano model to determine quality attributes of patient's care at the primary healthcare centers of the Ministry of health in Saudi Arabia. *Journal of Family and Community Medicine*, 27(3), 178–185.
- Lisiński, M., Szarucki, M. (2020). *Metody badawcze w naukach o zarządzaniu i jakości*. Warszawa: Polskie Wydawnictwo Naukowe.
- Malinowska, E., Wiśniewska, M., Grudowski, P. (red.) (2014). *Pomiar jakości usług edukacyjnych z wykorzystaniem metody Kano*. Usługi 2014, Wybrane uwarunkowania rozwoju usług, Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu nr 354, Wrocław: Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu, 235–247.

Mamaghani, N.K., Izadpanah, P. (2011). Applying the Kano model into designing dinnerware for Iranian user with the approach of emotional design. *Ergonomics for All: Celebrating PPCOE's 20 Years of Excellence – Selected Papers of the Pan-Pacific Conference on Ergonomics*, Wydawnictwo CRC Press, 449–454.

Nachmias, D. (2001). *Metody badawcze w naukach społecznych*. Poznań: Wydawnictwo Zysk i S-ka.

Perri 6, Bellamy, Ch. (2012). *Principles of Methodology: Research Design in Social Science*, Sage Publications Ltd.

Priyono, A., Yulita, A. (2017). Integrating Kano Model and Quality Function Deployment for designing service in hospital front office. *Intangible Capital (IC)*, 13(5), 924–947.

Rashid, M.M., Tamaki, J., Ullah, A.M.M.S., Kubo, A. (2011). A Kano Model Based Linguistic Application for Customer Needs Analysis. *International Journal of Engineering Business Management*, 3(2), 29–36.

Singgih, M.L., Dalulia, P., Suef, M., Karningsih, P.D. (2018). Performance modelling for maintenance outsourcing providers based on the Kano model. *International Journal of Technology*, 9(4), 797–808.

Szczepańska, K. (2011). *Zarządzanie jakością, W dążeniu do doskonałości*. Warszawa: Wydawnictwo C.H. Beck.

Szeliga-Duchnowska, A., Szewczyk, M. (2018). Rozwój właściwych cech usługi edukacyjnej przy zastosowaniu kwestionariusza Kano. *Problemy Jakości*, 50(1), 31–36.

Szkiel, A. (2016). Klasyfikacja wymagań stawianych produktom spożywczym z wykorzystaniem modelu Kano. *Bromatologia i Chemia Toksykologiczna*, 49(3), 641–647.

Szkiel, A. (2011). Wykorzystanie modelu Kano do klasyfikacji wymagań stawianych usługom certyfikacyjnym. *Problemy Zarządzania, Finansów i Marketingu, Zeszyty Naukowe Uniwersytetu Szczecińskiego*, 22, 197–205.

Szkiel, A., Gut, M. (2014). *Wykorzystanie modelu Kano do klasyfikacji wymagań stawianych przez studentów usłudze kształcenia*. Zarządzanie przedsiębiorstwem – teoria i praktyka, Kraków: Wydawnictwo AGH, 565–578.

Tseng, Ch. (2020). An IPA-Kano model for classifying and diagnosing airport service attributes. *Research Transportation Business and Management*, 37, 100499.

Tutko, M., Pokrzywa, M. (2019). Pomiar jakości usług gastronomicznych świadczonych przez osoby z niepełnosprawnościami – prezentacja kwestionariusza Kano. *Problemy Jakości*, 51(5), 7–13.

Ulewicz, R. (2016). The use of Kano model for the classification of the elements of product quality. *Systemy Wspomagania w Inżynierii Produkcji*, 3(15), 117–126.

Williams, H., Wikstrom, F., Lofgren, M. (2008). A life cycle perspective on environmental effects of customer focused packaging development. *Journal of Cleaner Production*, 16(7), 853–859.

Wiśniewska, M. (2009). Rozpoznanie i zaspokojenie wymagań klienta z wykorzystaniem modelu Kano. *Problemy Jakości*, 41(4), 6–10.

Yadav, H.C., Jain, R., Shukla, S., Avikal, S., Mishra, P.K. (2013). Prioritization of aesthetic attributes of car profile. *International Journal of Industrial Ergonomics*, 43(4), 296–303.

Yadav, H.C., Jain, R., Singh, A.R., Mishra, P.K. (2017). Kano integrated robust design approach for aesthetical product design: a case study of a car profile. *Journal of Intelligent Manufacturing*, 28(7), 1709–1727.

Yao, M.L., Chuang, M.C., Hsu, C.C. (2018). The Kano Model Analysis of Features for Mobile Security Applications. *Computers & Security*, 78(11), 336–346.

Zhang, Y. (2018). Research on the functional requirements of reading apps based on kano model: A case study in China. Proceedings – 2018, 7th International Conference of Educational Innovation through Technology, Auchland, New Zeland.



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