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Eastern Poland Consumer Awareness of Innovative Active and Intelligent Packaging in the Food Industry: Exploratory Studies

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Abstract: For some time, traditional food packaging has not been able to meet the current market demand in some segments. This is mainly due to the advancing market globalization, increasing product complexity, the changing and increasingly high expectations and needs of customers, increasing requirements for monitoring packaging materials and, consequently, food safety, as well as the revival of national and international initiatives to support the circular economy and minimize the carbon footprint of manufactured products. Therefore, smart packaging with increased functionality has become indispensable. On the one hand, this solution allows for the offering or adaptation of products that meet the stricter national and international regulatory requirements (in particular for food safety) and allows a tracking from the cradle to the grave; on the other hand, it can serve as a way to expand markets in the context of globalization. Moreover attention should be paid to the development of knowledge on environmental protection and the increasing environmental awareness of consumers. In connection with the above, in recent years there has been an increase in interest in the design and production of new packaging for food products based on the latest technical and technological solutions. It is primarily intelligent and active packaging that should be mentioned here. Hence, the aim of the article, as well as that of our own conducted research, was to analyze consumer attitudes and behaviors in the field of modern food packaging, as well as to check the level of awareness of consumers from Eastern Poland in relation to innovative active and intelligent packaging in the food industry. In addition, the intermediate aim was also to identify other factors influencing the attractiveness of food packaging and, consequently, increasing the willingness to buy them. To achieve these aims, a literature study was carried out, as well as empirical research using the diagnostic survey method, conducted among the inhabitants of South-Eastern Poland. Based on our own research, it can be concluded that the level of knowledge of the essence of intelligent and active packaging in Eastern Poland is still at a low level. Among the other factors increasing the attractiveness of packaging for food products, contemporary consumers from the analyzed region of Poland indicated primarily their environmental friendliness, the possibility of recycling, as well as the readability and transparency of the information contained on the packaging.

Keywords: smart packaging; intelligent and active packaging; food industry; environmental awareness

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1. Introduction

Packaging, not only of food products, surrounds us practically everywhere. Often it is not even possible to market a product without packaging, e.g., in the case of liquid products such as milk, beverages, alcohol; it is then referred to as the so-called integrated product (product with packaging treated as a whole). However, the packaging is very diverse; it is characterized by a variety of shapes, forms, sizes, colors, graphics, materials and level of technological advancement.

The main purpose of the packaging is to protect the product against harmful effects caused by exposure and use in the external environment [1,2]. However, in the contemporary world, it also performs many other functions [3]: promotional (it serves as an effective

means of marketing communication with the consumer, which is particularly important in the case of self-service stores or online sales), informative (it provides important information about the packed product, e.g., in the case of food products, their nutritional value or method of preparation), distribution and logistics, ecological, economic and utility. In turn, Robertson [4] indicates four basic functions of packaging: protection, communication, convenience, and containment.

In the contemporary packaging market, there are several dominant trends and directions of development of food packaging. This is a consequence of general trends taking place in the modern market, including ecology, health and environmental protection (biodegradable, environmentally friendly packaging), health and wellness, ergonomics and comfort, aging society, consumer mobility, combining packaging with an important social or environmental theme, attachment to fully natural products (traditional and organic), minimalism and simplicity (graphics, colors, subtlety and a small amount of stimuli), economy and practicality, no use of artificial and synthetically produced food additives (flavors, dyes, sweeteners), increasing consumer individualization, the importance of the emotional sphere and the growing importance of modern technology [5–9].

Taking into account the functions of packaging, the currently dominant trends in their production and the premises and factors causing them, as well as the fact that packaging is an indispensable element of almost every product, it should be emphasized that designing and producing "appropriate" packaging is not easy. On the one hand, it must fulfill its basic function, i.e., a protective function (have an appropriate barrier), but on the other hand, it must be profitable for the producer; so, e.g., it should have a minimum weight in order to reduce the cost of production. On the one hand, it must be durable, resistant to various external factors (e.g., weather or shocks), ensuring quality, freshness, nutritional value and other values, and on the other hand, it must be comfortable, functional and, above all, ecological. Its shape, capacity and method of closing must be adapted on the one hand to the needs of logistics, and on the other hand, to the requirements of the recipient, including the individual customer. Moreover, it must be compatible with the current legislative solutions in this area (e.g., in the area of marking and labeling, but most of all, in the area of ensuring food safety) and keep up with new trends, production technologies, and design solutions of packaging machines, as it is currently one of the key instruments in the sale of products.

For some time, traditional food packaging has not been able to meet the current market demand in some segments. This is due to the progressive market globalization, increasing complexity of products, changing and increasingly high expectations and needs of customers, increasing requirements for monitoring packaging materials, strengthening the concept of food safety for consumers, emerging threats of food bioterrorism, as well as a recovery in the scope of national and international initiatives to support the circular economy and minimize the carbon footprint of manufactured products.= [10–14]. Smart packaging with increased functionality has become indispensable. They will make it possible to offer or customize products that meet stringent national and international regulatory requirements (especially food safety), to enable the tracking from cradle to grave and to also serve as a way to expand markets in the context of globalization [1,15].

Although the terms such as active packaging, intelligent packaging and smart packaging are often used interchangeably in the literature or in economic practice over the last two decades, they do not mean the same type of packaging. While they all relate to package systems used for food, beverages, pharmaceuticals, cosmetics and many other perishable goods, they differ in several important respects.

Otles and Yalcin [16] defined intelligent packaging as "a packaging system that is capable of carrying out intelligent functions (such as sensing, detecting, tracing, recording and communicating) to facilitate decision-making to extend shelf life, improve quality, enhance safety, provide information, and warn about potential problems". However, according to Kerry et al. [17], intelligent packaging is mainly used "to monitor the condition of packaged food, such as meat, to capture and provide information about the quality of packaged goods during transport and storage".

In contrast, packaging can be defined as active when it plays a different role than providing an inert barrier to the external environment [18]. They can be defined as a system in which the product, packaging and the environment interact in a positive way to extend the shelf life or achieve certain characteristics [19]. According to Kerry et al. [17], active packaging consists in incorporating certain additives or substances into packaging systems in order to maintain or extend the quality of the product and the shelf life; so unlike intelligent packaging, active packaging is not supposed to inform, but to actively influence the packed food.

However, smart packaging provides a comprehensive packaging solution, so it has the capabilities of both intelligent packaging (it monitors changes in the product or the environment) and active packaging (it works on these changes) [3,16]. The intelligent packaging system uses communication functions to facilitate decision-making to maintain food quality, extend shelf life and improve overall food safety [20].

The basic legal act regulating the use of active and intelligent materials is the Commission Regulation (EC) no. 450/2009 of May 29, 2009 on active and intelligent materials and articles intended to come into contact with food. According to it, only substances on the Commission's list of permitted substances may be included in an active or intelligent material or article. In article 3 of this regulation, the definition of active and intelligent packaging is also included: "(a) '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; (b) 'intelligent materials and articles' means materials and articles which monitor the condition of packaged food or the environment surrounding the food" [21].

It should be added that on the European market, especially in Poland, producers of active and intelligent packaging are obliged to comply with more restrictive legal regulations than in other regions of the world. The consequence of this is the extension of the period of placing food on the market in these packages [22].

The main idea of creating smart packaging was to guarantee food safety, the ability to monitor certain product parameters, extend the shelf life, maintain or even improve organoleptic properties (including improving the taste qualities and keeping the color of the product unchanged, while maintaining the best, i.e., original, nutritional quality and value), as well as provide information about the product. However, most of all, the key premise for their creation was the response to the requirements set by both producers and consumers. Because food, even largely processed, is still an active biological system, it oxidizes, changes its moisture content, color, emits gases, etc. All this consequently affects the assessment of the product by its final consumers, who pay attention to various qualities of food products, such as its appearance, taste, smell, freshness and broadly understood quality.

Taking the above into account, the aim of the work was to examine and define the knowledge, awareness and attitudes of consumers from Eastern Poland in relation to innovative active and intelligent packaging in the food industry. The starting point for the main goal was to set an intermediate goal, namely, to examine and analyze the phenomenon of the choice of food packaging by consumers and above all to identify the factors influencing this type of decision (according to respondents' declarations), as well as to identify factors increasing the attractiveness of food packaging in the opinion of consumers from the analyzed region of Poland.

Despite the regional scope of the sample and its exploratory nature, the results obtained from the conducted research seem important because, first of all, there is little research on this region of Europe relating to innovative packaging used in the food industry and its awareness and acceptance by consumers. In addition, the obtained research results may constitute an important starting point for further considerations, especially in the context of the possibility of increased use of this type of packaging by food industry companies.

2. Literature Review

Smart packaging (active and intelligent packaging) appeared for the first time in the mid-1970s on the Japanese market [23]. However, it was not until the 1990s that the European and American markets became interested in them. At that time, research on the design and possible applications of this type of packaging was developed. Initially, they concerned the pharmaceutical industry, and then also the food industry. In the late 1990s, this type of packaging appeared in use in the USA, Japan and Australia and contained mainly moisture and oxygen absorbers. So far, the passive protective function of packaging, understood as a passive barrier protecting food against harmful external factors, has been replaced by active protection.

2.1. Intelligent Packaging

Intelligent packaging has the ability to monitor the product and control its specific parameters (internal and/or external environment of the product) throughout the product life cycle, in order to inform the producer, seller or consumer about the condition of the product at any time [1,24]. Thus, they provide the user with information about the product, its quality and safety condition, and about detected changes or even irregularities in the product or its surroundings, during the storage and distribution of food, without the need to open the packaging itself. These can be information about the composition of the atmosphere, changes and fluctuations in temperature, oxygen or carbon dioxide content and the pH level [15].

Intelligent packaging uses chemical sensors or biosensors to monitor food quality and safety from producers to consumers [25] and can be used in food, pharmaceutical and many other types of products. Currently, the functions of intelligent packaging are mainly implemented and realized by three techniques [20]: 1. using indicators (e.g., time and temperature, freshness and/or maturation) [17,26], 2. sensors and biosensors (which detect, record and provide information related to potential biological processes and reactions taking place inside the package, e.g., changing levels of oxygen and freshness [15,20]) and 3. radio frequency identification systems (RFID) [27].

The most popular indicators include time, temperature, freshness, leakage, humidity and oxygen indicators [28]. However, due to the fact that temperature and gases are the most important factors influencing the speed of occurrence of unfavorable physical and chemical changes and changes caused by microorganisms in a food product, intelligent packaging most often contains time–temperature indicators (TTI), the so-called temperature history and operating time indicators [29–33] or gas indicators [20,34,35]. Freshness indicators, oxygen indicators, carbon dioxide indicators and microorganism growth indicators can also be used [25,27]. The operation of the indicators of freshness and the presence of gases is based on monitoring the conditions inside the package, while the TTI indicators are mounted outside of the package.

Biosensors are used to detect and transmit information about biological reactions taking place in a product. These are devices consisting of a bioreceptor, which monitors the microbiological state of food and enzyme activity, because it can recognize enzymes, antigens, microorganisms, hormones or nucleic acid, as well as a transducer (electrochemical, optical, acoustic type), which converts biological signals into electric ones. The biosensors are placed inside the package or integrally connected to the package itself. As an example of intelligent packaging with biosensors, it is possible to mention packaging signaling decay processes that begin in the packaging, or packaging of baby food containing sterility sensors [36–39].

Another solution in the case of food products are smart labels—RFID tags (radio-frequency identification). They allow the traceability, stock management and the promotion of quality and safety [40]. Their essence consists in tracking the product throughout the supply chain (from the producer to the consumer), saving the label's memory of essential information about the packed product, e.g., food, and delivering it to the consumer. Radio tags also allow the product to be secured against theft, e.g., in supermarkets, as well as to monitor the temperature, humidity, microbiological condition of food and the shelf life [41].

This is possible due to the use of a very thin chip integrated with the label, containing a memory transponder. The system can be placed on any carrier (e.g., foil, paper) and can be of any shape.

Smart RFID tags are a technological continuation of barcodes commonly used in logistics and retail. However, unlike standard codes, they are also used in places where barcode labels cannot be placed, e.g., due to unfavorable environmental conditions (high relative humidity, low temperature, dirt); then they can collect data in real time [27,42]. However, their disadvantage is that they are more expensive and require a more powerful electronic information network [29].

Due to various technological solutions, intelligent packaging can be used for many food products. As an example, we can give a quick-frozen food, where the color of the label placed on the product can be used to read whether it has been partially thawed and re-frozen in the distribution process. These packages can also be useful for determining the freshness of milk or other dairy products such as yoghurts, cheese and cream. In addition, intelligent packaging offers new business opportunities based on digitization and thus fits into the wider sphere of Industry 4.0 [1].

2.2. Active Packaging

As already mentioned, traditional packaging should be inert to the stored product, i.e., there must be no interaction between the packaging and the product. Therefore, in response to the constant changes in consumer requirements and market trends, as an alternative to traditional packaging methods, an innovative concept of active food packaging has been introduced, which, through special ingredients deliberately embedded in the packaging, can interact with the product and use them, releasing or absorbing substances from or into the packaged food or the surrounding environment [43,44]. As a result, they prevent or inhibit unfavorable changes in the quality of food during its distribution and storage (by, e.g., destroying or inhibiting the growth of microorganisms present in food), allow it to maintain its quality or even improve its quality and extend the shelf life and safe storage time of the product through active interaction with the product or the atmosphere inside the package [45,46]. It is obvious, however, that these impacts cannot be accidental; they must be carefully planned.

The advantages of using active packaging, especially with regard to perishable goods, are therefore the reduction of the localization activity and the migration of particles from the film to the food and the elimination of unnecessary industrial processes that can introduce bacteria into the product [47].

Active packaging is defined as systems that actively change the environmental conditions in packaged food and extend the shelf life, as well as guarantee or significantly improve the microbiological safety of products and the sensory properties of food. They can control the internal conditions, reacting to them appropriately, by emitting or absorbing substances that will have a negative effect on the product. Hence, the following can be distinguished among active packaging: absorbers and emitters. The first group is to absorb (and consequently eliminate) undesirable components from the environment inside the package, i.e., to protect against deterioration [48]. Depending on the packaged product, these are mainly moisture absorbers [14,49], ethylene absorbers [50,51], oxygen absorbers [52] or carbon dioxide absorbers [53,54] and unfavorable odors [55], wherein oxygen absorbers are currently the most commonly used technology for active food packaging. By contrast, the principle of operation of the emitters is to separate into the packaging the substances desired for the quality of the product, which have a positive effect on food. The emitters are fragrances, food ingredients, food additives, moisture and acidity regulators as well as active biological substances that counteract the growth of microorganisms. The most frequently used are carbon dioxide emitters [56,57], sulfur dioxide emitters [14] and alcohol.

Active packaging can therefore be divided into packages with antibacterial properties, oxygen-absorbing packages, CO_2-absorbing or emitting packages, ethylene-absorbing pack-

ages, ethanol-emitting packages, oxygen-absorbing packages, odor-absorbing/emitting packages and packaging protecting the color of the product [2].

Active substances used in active systems are most often placed inside the package, in the form of small sachets or inserts, or placed (soaked) on the entire internal surface of the package (which is a more advanced, but also more effective technology). It should be remembered that active materials and articles must not change the composition or organoleptic characteristics by concealing food spoilage, which could mislead the consumer as to the quality of the foodstuff.

The use of packaging with active systems in the food industry has been successful mainly in the United States, Japan and Australia. In Europe, it is not so popular, although producers are increasingly using this type of solution in food packaging. This mainly applies to fruit and vegetables (e.g., "smart" foils), cheese or bread.

Despite the many benefits generated by this type of packaging, it should be remembered that there are, however, several important issues related to newly emerging technologies, including costs, food safety and organoleptic quality, environmental safety issues, but above all consumer acceptance [14]. Hence, research was carried out to analyze consumer attitudes and behaviors in the field of modern food packaging, as well as to examine the level of consumer awareness in the area of innovative active and intelligent packaging applicable in the food industry. The research was conducted among consumers from a selected region, Eastern Poland.

3. Materials and Methods

3.1. Study Design: The Choice of the Research Method and Study Area

In order to achieve the set research goals, in 2021, research was carried out using the diagnostic survey method, in accordance with the assumed qualitative approach. Its aim was to illustrate the phenomenon of the choice of packaging for food products by individual consumers from Eastern Poland, and above all, investigate what influences them and what kinds of factors increase the attractiveness of such packaging. The main premise for choosing this form of research was that it allowed us to obtain information on both subjective and objective states of the respondents by collecting various information in the scope covered by the study, from many different perspectives and planes [58,59].

Taking into account the possibility of an appropriate processing of the collected data, a structured questionnaire was used as a research tool.

The area of Eastern Poland was selected for the study, with an emphasis on the Lubelskie Voivodeship, because this region is one of the 20 poorest regions of the EU [60]. The inhabitants of this region have a relatively lower income than the inhabitants of other regions of Poland, which may result in less interest in various kinds of novelties, including innovative packaging and, consequently, may be characterized by a lower level of awareness and acceptance in this area. On the other hand, due to the agricultural nature of the region, residents may be more aware of the ecological aspects, and may have a greater care for food (and, consequently, produce less food waste), which is the purpose of using this type of packaging.

3.2. Survey Questionnaire as a Research Tool

As already mentioned, the research tool was a structured proprietary questionnaire, distributed exclusively via the Internet. The survey was anonymous, and the respondents were informed about its assumptions and purpose and voluntarily decided to complete it.

The questionnaire used in the authors' own research consisted of two parts, metric and substantive. It also contained an introduction, which presented the essence and purpose of the study, as well as brief instructions on how to properly fill it in. The metric part of the survey made it possible to obtain basic information about the respondents in order to later develop their sociodemographic characteristics. The grouping variables were such descriptive features of the respondents as gender, age and place of residence. Hence, the second, substantive part of the questionnaire made it possible to provide information on the

research problems posed. It contained closed, single-choice or multiple-choice questions (in the case of multiple-choice questions, the possible number of maximum answers was indicated). In some questions, it was also possible to add one's own answer, if none of the proposed variants fully reflected the attitudes, behavior or feelings of the respondents. The respondents were asked mainly what kind of food packaging they preferred and what made them attractive to them. The remaining questions also focused on the level of knowledge of innovative solutions in this area, i.e., on intelligent and active packaging, as well as on whether respondents purchased products in this type of packaging.

3.3. Research Sample

The research sample was 488 respondents from Eastern Poland. One of the nonrandom methods of selecting the research sample was used, purposeful selection. The criterion of purposeful selection was the fulfillment by the participants of the study of the criteria defining the categories of grouping the variables included in the metric part of the questionnaire. The purpose of this method of selecting the research sample was to create a sample similar to the representative sample [61].

In the research sample, the distribution of respondents by gender was shaped in such a way that there were 312 women (63.9%) and 176 men (36.1%). In the case of the next grouping variable, i.e., the place of residence, in the structure of people participating in the study, the greatest number was those living in rural areas, with as many as half of the respondents or 244 respondents (50.0%). Inhabitants of small towns, up to 100,000 inhabitants, consisted of 96 people (19.7%), inhabitants of medium-sized cities (from 100,000 to 300,000 inhabitants) 78 people (16.0%), while the inhabitants of the largest cities, over 300,000 inhabitants, accounted for 14.3% of all respondents (70 people).

3.4. Data Analysis

Data analyses were carried out on the basis of statistical processing software Statistica 13.3 and Excel 2013. In order to present the obtained research results, a graphical method as well as a descriptive and tabular method were used.

Due to the assumed qualitative approach, it was necessary to choose such methods that would allow for a reliable and unambiguous interpretation of phenomena and give meaning to the responses of the research participants [62]. For this purpose, descriptive methods were used, as well as one of the methods of statistical data analysis, correspondence analysis, a data mining method. This analysis was used due to the nature of the studied variables, i.e., primary data from the questionnaire (qualitative variables, measured on a nominal and ordinal scale). It was carried out in order to distinguish groups of respondents who showed a similar behavior in relation to the preferred packaging.

Correspondence analysis is a specialized method of data mining and analysis of bivariate and multivariate tables, which includes certain measures that characterize the relationships between columns and rows. The results obtained allow the analysis of the structure of qualitative variables that make up a multidivisional table, the most common table of this type being a two-dimensional contingency table. In correspondence analysis, the frequencies in the contingency table are first standardized so that relative frequencies are calculated, and when all the fields (cells) of the table are summed, they yield 1.0. One way to represent the objectives of a typical analysis is to express the relative frequencies in terms of distances between rows or columns in a space with a small number of dimensions. In correspondence analysis, on the other hand, inertia is defined as the quotient of Pearson's chi-squared statistic calculated from a bivariate table by the total abundance (in the example presented, the total abundance is 488) [63,64].

The analysis of statistics and graphs resulting from the correspondence analysis method allows the intuitive inference of relationships between categories of variables. In addition, this method provides a graphical presentation of the results of the study, which facilitates their interpretation. In addition, thanks to this method, it is possible to accurately

identify the co-occurrence of categories of variables or objects, measured on nominal and ordinal scales [65,66].

Table 1 presents the basic information on the research, methods and tools as well as sample selection criteria, which were implemented for the purposes of this publication.

Table 1. Consumer awareness of product packaging in Eastern Poland: basic characteristics.

Description	Characteristic
Research objectives	- To collect research material that allows the segmentation of consumers with regard to the determinants that determine their product selection behavior due to its packaging, - To assess the knowledge and attitudes of consumers regarding intelligent and active packaging of food products
Research object	Individual food consumers
Type of research	Qualitative research
Research method and technique	Online survey
Research tools	Proprietary survey questionnaire posted on the Google platform
Selection of units for research	Nonrandom, targeted
Sample selection criteria	Individual food consumers, a group differentiated by gender, age, place of residence
Sample size	488 people
Spatial scope	Eastern Poland
Time range	May–September 2022

4. Results and Discussion

In the first question contained in the substantive part of the questionnaire used in our research, respondents were asked to declare their level of knowledge of intelligent and active packaging. Two grouping variables, namely gender and age, were used to analyze the results. According to the information obtained, the vast majority of the respondents (85% of men and 79% of women) had not heard of innovative solutions for food packaging before or had heard something but were not very knowledgeable about this subject. It should be added that in two extreme age groups, i.e., under 18 and over 60 (the youngest and oldest respondents), only these responses appeared. However, only women over 60 declared a poor knowledge of this subject. The rest of the people in these age groups had never heard of it before. Moreover, both women and men aged 18–25, also in the vast majority, either did not know the subject or were knowledgeable, but only to a negligible extent.

The structure of responses obtained may result from the fact that young people either still live with their parents and do not buy food products themselves, or, although they already live independently, they rather buy products from the economic shelf that meet only their basic needs, i.e., physiologically, and to a much lesser extent, the need for security or self-fulfillment (to which the use of intelligent and active packaging can be referred to). On the other hand, older people, over 60, may have little interest in new products appearing on the market. Sometimes they even use this type of packaging but are not fully aware of their properties and the benefits they generate.

Only 21% of women and 15% of men participating in the survey declared they knew the issues discussed at work to a large or very large extent. These were, in the case of women, mainly young people (26–40 years old) or middle-aged (41–60 years old), while in the case of men, mainly middle-aged people (41–60 years old).

It seems that the above structure correctly reflects, first of all, the aspect of using the "gender" grouping variable. The analyzed subject of innovative food packaging is mainly related to purchasing processes, especially food, which seems to be the domain

of women rather than men. It is also not surprising that the knowledge of this issue is declared mainly by middle-aged people; often these people already have an established professional position and a stable family situation, and thus also a stabilized financial situation. This allows them to purchase food products in packaging produced on the basis of modern technologies, which are often relatively more expensive than those in traditional packaging. The willingness to purchase safer, higher-quality products often causes an increase in interest in this subject.

Brennan and Crandison reached a similar conclusion [67], according to which active packaging materials were generally accepted in the USA, Australia and Japan, but much less in European countries. The authors further argued that the reasons for these different attitudes were not clear, but might be partly due to cultural differences and a lack of understanding of the features and benefits. This was also confirmed by the research carried out by Pennanen et al. [68], who concluded that European consumers were only to a certain extent interested and willing to adopt selected intelligent food packaging (especially those with embedded TTIs). Many other studies also showed that consumer attitudes ranged from indifference to cautious acceptance, e.g., [69].

The research carried out in Slovakia by Loucanov and his team [70] can also be mentioned as an example of low awareness of the concept and benefits of innovative forms of product packaging. According to their results, most respondents did not know what intelligent and active packaging was and had not come across such a term. Kocetkovs et al. also pointed out an insufficient knowledge and understanding of the essence of innovative packaging and a low awareness of new packaging technologies by Latvian consumers [71]. It is also worth mentioning the similar conclusions regarding the low familiarity with the concepts of intelligent and active packaging received by Dopico [72]. Moreover, Kocetkovs et al. [71] stated that consumers did not know and could not distinguish between intelligent packaging and active packaging.

In turn, in relation to Poland, but its other region (more industrialized and with higher incomes of its population), similar results were also recorded. The conducted analysis showed that although new solutions in the field of active and intelligent packaging appeared on the market, the state of knowledge about them among the inhabitants of the studied region (lubuskie voivodeship in Western Poland) was insufficient [73]. These authors also obtained a similar structure of respondents' answers with regard to the gender grouping variable, because the research showed that the term "intelligent packaging" was known to 17% of the respondents, 18% of the surveyed women and 10% of all surveyed men. This may prove that in various regions of Poland, both in the more industrialized and urbanized ones, as well as in the poorer ones, the level of awareness and knowledge of consumers in the area of modern solutions for packaging food products is, unfortunately, quite low.

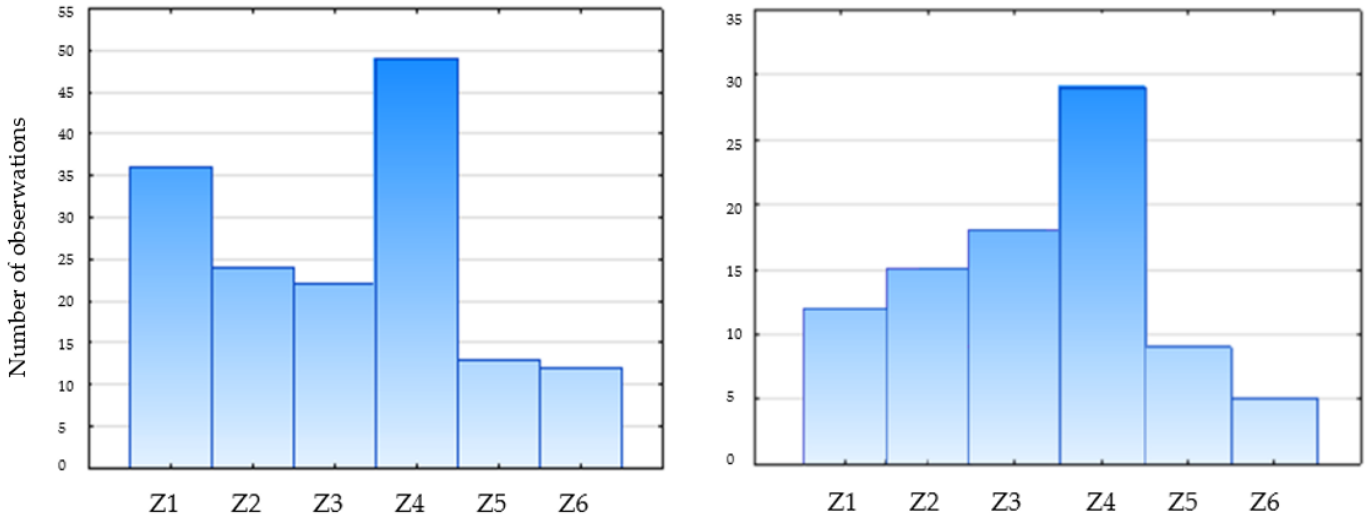
However, in relation to the grouping variable "age", the research conducted by Nosalova and her team can be mentioned [74]. They concluded that intelligent and active packaging was the most attractive for middle-aged respondents (25–45 years old), the so-called millennials (people born in 1980–2000). In addition, O'Callaghan and Kerry [75] found that older people were less positive and were more likely to see fewer benefits of smart packaging technologies.

In the further part of the questionnaire, all respondents, regardless of the answers given in the first question, were asked to continue filling in the questionnaire, due to the fact that the essence of active and intelligent packaging was briefly characterized and explained to them.

The next questions concerned checking the respondents' declarations regarding the most attractive food packaging for them, as well as their opinion on the possibility of increasing the attractiveness of this packaging. In each case, the option of active and intelligent packaging appeared as one of the possible variants of the answer.

In Figure 1, the histogram shows the respondents' opinions about the packaging that they thought was the most interesting. The main criterion here was the appearance of

the packaging, the function it performed or the material from which it was made. The responses of the respondents were separated by gender.



(**a**) Female (**b**) Male

Figure 1. Categorized data histogram showing respondents' opinions by gender regarding the most interesting food packaging. Z1—ecological; Z2—suitable for recycling; Z3—colorful (visually attractive); Z4—clear and legible; Z5—transparent; Z6—active and intelligent.

As can be deduced from the information obtained, women mainly chose transparent and legible packaging containing all the necessary information and ecological packaging. They also paid a lot of attention to those recyclable and visually attractive packaging, e.g., with interesting colors, graphics, or an attractive or unusual shape. In the case of men, transparent and legible, but also colorful and recyclable packaging was equally important.

Active and intelligent packaging turned out to be the least attractive in both groups of respondents, which correlated with the answers obtained in the first question, unfortunately showing a still not very high awareness of the benefits and functions generated by modern and innovative packaging used for food products.

The results of other studies carried out around the world confirm that for consumers, when it comes to packaging food products, issues related to ecology and sustainable development are important [76–78]. The transparency and readability of information on the packaging are equally important, e.g., information on the content, benefits, legal regulations, brand value or technical issues related to intelligent packaging [78–82]. The visual attractiveness of the packaging (design, shape, color, graphics) is also often indicated by consumers as one of the factors attracting attention, improving the image of the packaging and, consequently, often a factor that largely determines the choice of the product [83,84]. It should be added that, as confirmed by other studies [85], the vast majority of consumers would buy the product in more attractive packaging, taking into account the aforementioned factors.

In turn, when analyzing the differences between the sexes, it should be noted that women and men show different preferences and nutritional practices [86]. First, women are much more involved and aware of food and its packaging than men and pay more attention to information on food packaging than men [87]. Second, as confirmed by other studies, individual characteristics, such as the ability to understand and interpret visual cues or understand contextual constructs, can influence consumer responses to the external elements of a product and its packaging [88]. Moreover, the gender of the consumer may play an important role in perceiving the attractiveness of the packaging; women are more sensitive to color than men [89,90].

In order to deepen the analysis, another grouping variable was added. Hence, the next two Figures 2 and 3 present the most attractive packages of food products but taking into account both the gender and place of residence of the respondents.

In the case of women (Figure 2), respondents living in rural areas chose those products whose packaging was recyclable (Z2), clear and readable (Z4), but especially those that were colorful, i.e., visually attractive (Z3). On the other hand, women living in small towns (up to 100,000 inhabitants) chose ecological packaging (Z1), visually attractive (Z3), transparent and legible (Z4), but especially those suitable for recycling (Z2). Women who declared that they lived in medium-sized cities (100,000–300,000 inhabitants) stated that they chose both ecological (Z1), recyclable (Z2), visually attractive (Z3) but also transparent (Z5) packaging. However, those food products that are packed in transparent and legible packages (Z4) were the most interesting for them. In turn, residents of large cities (over 300,000 inhabitants) preferred ecological packaging (Z1), visually attractive (Z3), transparent and legible (Z4), but above all, those that could be recycled (Z2).

The situation was slightly different from the point of view of men (Figure 3), because men living in rural areas and small towns (up to 100,000 inhabitants) chose food products whose packaging could be recycled (Z2), but above all those that were visually attractive (Z3), clear and legible (Z4). Men who declared that they lived in medium-sized cities (100,000–300,000 inhabitants) stated that transparent and legible (Z4), transparent (Z5) packaging, but most of all, visually attractive (Z3) packaging, were attractive to them, and they chose them. Hence, residents of large cities (over 300,000 inhabitants) preferred visually attractive packaging (Z3), but mainly transparent and legible (Z4).

It should be added, however, that both groups, men and women, living in areas with varying degrees of urbanization, among the factors influencing the attractiveness of food packaging, paid the least attention to modern solutions in this area, manifested in the use of intelligent and active packaging.

This may result from a poor knowledge of the subject or a low level of awareness in the area of the possibility of increasing food safety due to the use of this type of modern solutions. One of the possible reasons for this may also be the concern of consumers that the use of active or intelligent packaging for a food product will significantly increase its price. This, especially in today's difficult economic times, may constitute a key premise for the existing structure of responses in the conducted research.

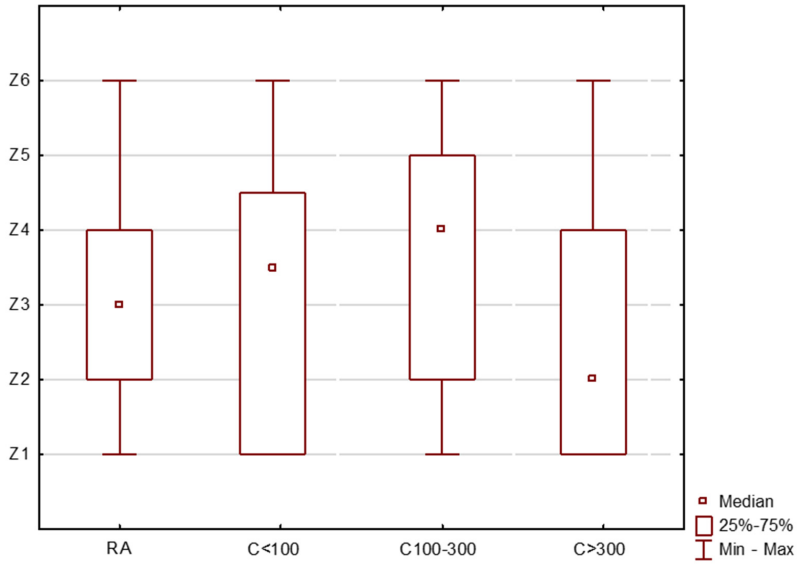


Figure 2. The most attractive food packaging in the opinion of women. Z1—ecological; Z2—suitable for recycling; Z3—colorful (visually attractive); Z4—clear and legible; Z5—transparent; Z6—active and intelligent.

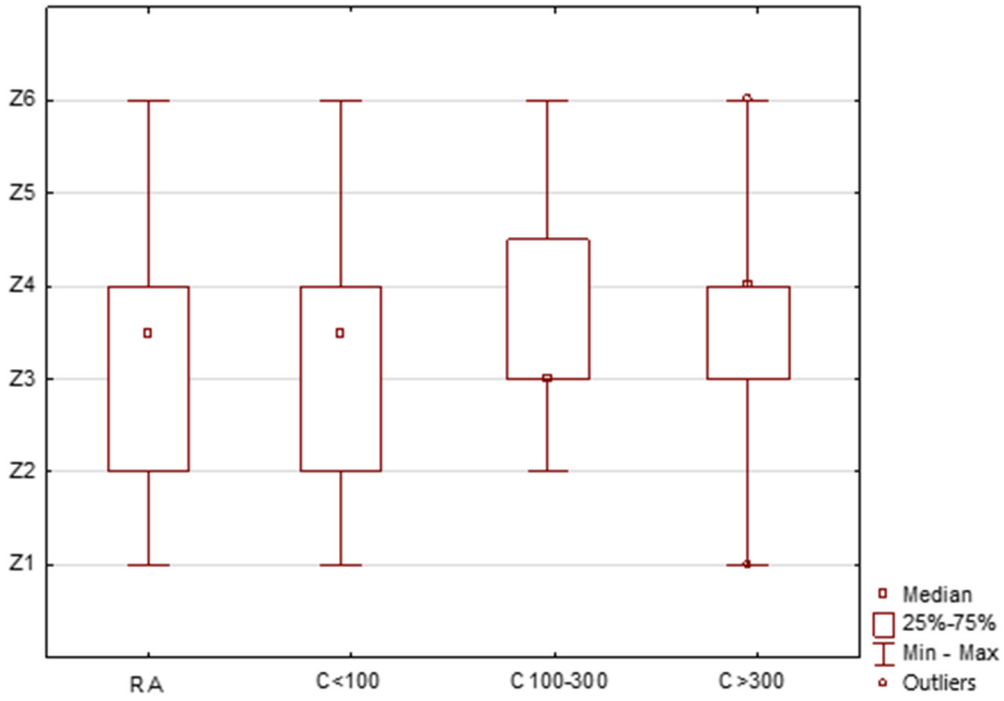


Figure 3. The most attractive food packaging in the opinion of men. Z1—ecological; Z2—suitable for recycling; Z3—colorful (visually attractive); Z4—clear and legible; Z5—transparent; Z6—active and intelligent.

The next stage of our research, in accordance with the adopted research procedure, was to check whether the selected grouping variables, gender and place of residence, affected the attitudes and declarations of respondents in the analyzed area. For this purpose, a correspondence analysis was carried out. This allowed for the identification of the structure of relations between the studied variables and the presentation of the original configurations of points representing the studied variables in a two-dimensional space.

Therefore, in the first step, the qualitative variables intended for the analysis were nominally rescaled. Table 2 presents basic information about the obtained eigenvalues and inertia.

Table 2. Correspondence analysis results: eigenvalues and inertia.

Number of Dimensions	Eigenvalues and Inertia, Total Inertia = 0.15987 χ^2 = 75.30 df = 56 p = 0.04384				
	Singular Value	Eigenvalues	Percentage of Inertia	Cumulative Percentage	χ^2
1	0.319847	0.102302	63.98960	63.9896	48.18442
2	0.183407	0.033638	21.04038	85.0300	15.84349
3	0.122652	0.015044	9.40967	94.4397	7.08551
4	0.081764	0.006685	4.18163	98.6213	3.14878
5	0.033719	0.001137	0.71119	99.3325	0.53553
6	0.029574	0.000875	0.54706	99.8795	0.41194
7	0.013878	0.000193	0.12047	100.0000	0.09071

According to the results summarized in Table 2, it can be concluded that the first dimension allowed the reconstruction of 63.99% of the total inertia, while two dimensions allowed us to explain as much as 85.03%, which meant that with two dimensions it was possible to recreate such an inertia value, i.e., 85.03% of the total value of the chi-squared statistics. It is known from the literature that if the total inertia exceeds 75%, we can consider the two-dimensional space as a good representation of the output data. It should be added that linking the inertia with the chi-squared test value showed that there was a good chance

of a significant relationship between the rows and columns of the multipart table. Thus, based on this criterion, it was advisable to position the profiles in a two-dimensional space.

Additionally, in order to confirm the obtained number of dimensions that the sought space should have, relevant for our further analysis, the scree criterion was used. Figure 4 shows a graph of the eigenvalues of the discussed relations between two dimensions and the seven characteristic groups distinguished in relation to them.

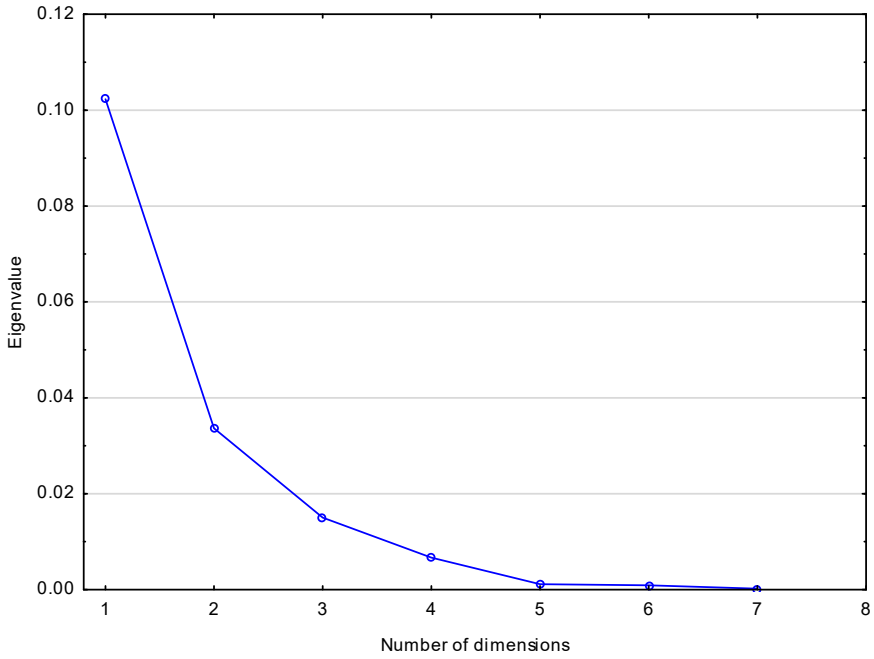


Figure 4. Scree plot of eigenvalues. Total Inertia = 0.15987; Chi2 = 75.30; df = 56; p = 0.4384.

On the basis of the results carried out, it can be seen that the successive dimensions (which are orthogonal to the others) explained smaller and smaller parts of the overall value of the chi-squared statistic (i.e., inertia). Figure 4 and Table 2 show seven eigenvalues, due to the seven dimensions distinguished in the statistical program, but for further, more in-depth analyses, only two were selected. The reason was that the first dimension could reproduce as much as 63.99% of the total inertia, and the second dimension included an increase in the percentage of explained inertia to 85.03% of the total inertia. Moreover, using the scree criterion (Figure 4), it was found that the scree started from the second dimension, therefore the graph of eigenvalues suggested adopting a two-dimensional space for the analysis. Therefore, based on this criterion, it was advisable to position the profiles in a two-dimensional space.

After determining the number of dimensions, in the next step, the coordinates of the column profiles were calculated in a new orthonormal coordinate system defined by singular vectors. In order to interpret the coordinates of the points representing the columns, the row–column standardization method was used, where the coordinates were calculated from the matrix of column profiles. This standardization made it possible to obtain coordinates of points representing the ratio of respondents with regard to the gender and place of residence of the respondents and their declarations on factors that may, in their opinion, increase the attractiveness of food packaging. Among these factors, various features of packaging were proposed, including—as separate features, two variants of the answer were inserted, namely—active packaging and intelligent packaging. The results obtained from the analysis are presented graphically in Figure 5. Each answer variant (packaging features) was assigned a designation explained below the figure.

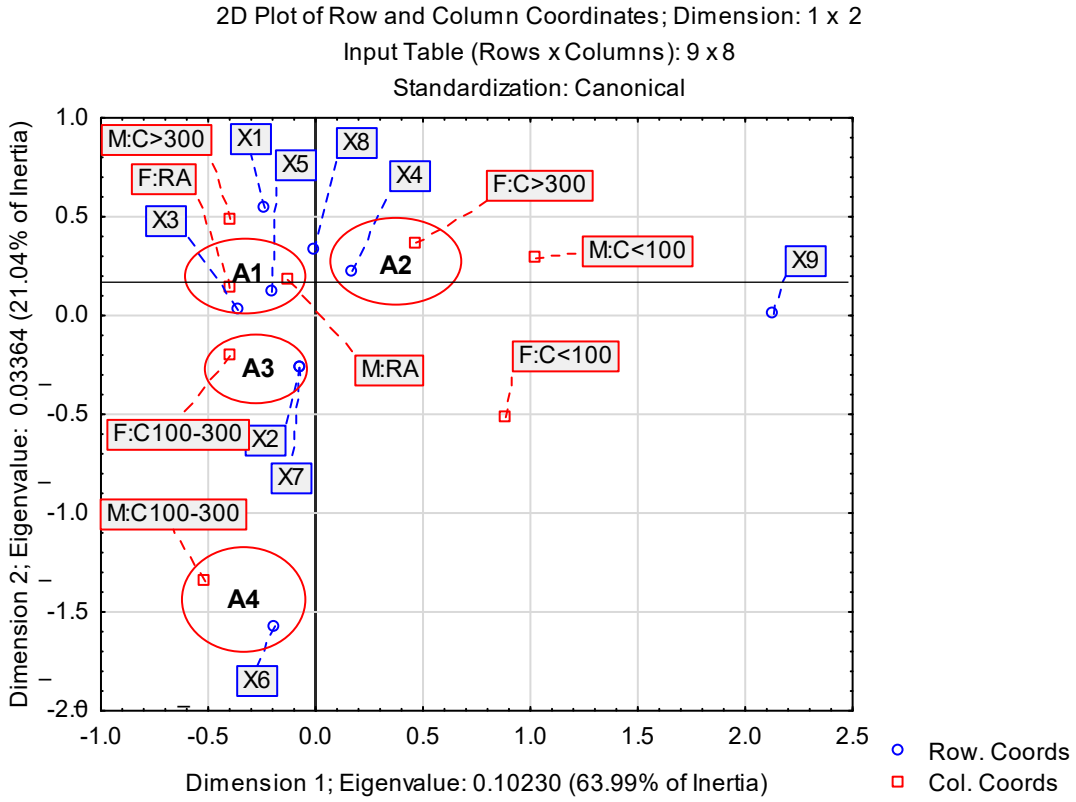


Figure 5. Correspondence analysis results between three groups of characteristics: gender, places of living and declarations of respondents regarding factors that could increase the attractiveness of food packaging. F—Female; M—Male; RA—rural area; C < 100—city of up to 100.000 residents; C100–300—100.000–300.000 residents; C > 300—city with more than 300.000 residents; X1—easy-to-open; X2—ecofriendly packaging; X3—resealable; X4—smart packaging; X5—clear information on packaging; X6—soft-color packaging; X7—recyclable packaging; X8—decorated packaging; X9—flashy packaging.

As can be seen in Figure 4, the horizontal axis had the greatest share in inertia (63.99%). It, therefore, belonged to the most important dimension explaining most of the variation between the columns.

We could distinguish four groups of respondents with a clear structure of indicators. The first group (A1) consisted of men and women living in rural areas. These two groups of respondents paid particular attention to packaging features such as resealability (X3) and the legibility of information on the packaging (X5).

The second group (A2) consisted of women living in large cities (over 300,000 inhabitants) who declared that it was important for them that the packaging should be intelligent (X4).

The third group (A3) was women living in medium-sized cities (100–300,000 inhabitants) who admitted that the packaging should be ecological (X2) and recyclable (X7). According to Popovic et al. [91], gender is an important factor in determining consumer choice of environmentally friendly food in packaging, as women who have higher emotions are more interested in the environment.

Finally, the fourth group (A4) was men living in medium-sized cities (100–300 thousand inhabitants) who paid attention to the packaging in delicate colors (X6).

Over the years, the attitude of consumers to the packaging of a product, especially a food product, has changed and evolved. According to previous studies, the packaging was an indispensable part of the product, mainly fulfilling protective functions. Currently, a change in these trends can be noticed; for several years, packaging has been perceived as part of the product, which may increase its attractiveness and, consequently, the competitiveness of a given brand [92]. However, even despite the positive first impression of the

packaging, it is important that it is user-friendly, functional and easy to use, and it should contain appropriate and legible information [93].

5. Conclusions

Nowadays, consumers are more and more aware of food and its impact on human health and well-being. Hence, they have much greater requirements regarding the quality and safety of the consumed products; they are more and more willing to choose natural, minimally processed food, without the addition of artificial colors or preservatives. At the same time, the convenience of use is important for them, as well as the extended shelf life. Consequently, it is a stimulus for food industry companies to introduce innovative solutions both in the area of food production and packaging production. Unfortunately, this is poorly correlated with the knowledge and awareness of Polish consumers in the field of intelligent and active packaging; they are still, as research has shown, poorly recognized by Polish consumers, especially from the region of Eastern Poland.

Therefore, in order to present the determinants of consumer awareness of food packaging chosen when shopping for food products, this research, analysis and consideration were carried out, which allowed the formulation of the following conclusions, referring primarily to the inhabitants of Eastern Poland:

1. The choice of packaging was a matter that varied among the respondents in terms of sex and age, but also the place of residence;
2. The respondents mainly chose clear and legible packaging;
3. Gender seemed to be the primary sociodemographic variable that potentially influenced the choice of food packaging; here both women and men declared that they chose clear and legible packaging;
4. Women living in rural areas chose colorful (visually attractive) packaging, women living in small cities (up to 100,000 inhabitants) chose colorful (visually attractive) and clear and legible packaging, those living in cities of 100,000–300,000 residents chose clear and legible packaging, while women living in large cities chose packaging suitable for recycling;
5. Men living in rural areas and small cities (up to 100,000 residents) chose colorful (visually attractive) and clear legible packaging, those living in medium-sized cities (100,000–300,000 residents) chose colorful (visually attractive) packaging, while those living in large cities (over 300,000 residents) chose clear and legible packaging;
6. The place of residence was another grouping variable that also seemed to be important; it could determine attitudes and thus influence various behaviors related to the choice of food packaging;
7. The correspondence analysis made it possible to distinguish four groups of respondents, with a clear structure of indicators: (A1)—men and women living in rural areas, who admit that they chose products in packages that were easy to open and close, and those whose description was clear; (A2)—women living in large cities, who declared that they chose smart packaging; (A3)—women living in large cities, who chose ecological and recyclable packaging; (A4)—men living in cities of 100,000–300,000 residents, who chose soft-colored packaging when buying food;
8. The obtained results indicated different attitudes regarding the choice of food packaging, but at the same time a relatively low level of knowledge and awareness of consumers from the Eastern Poland region in the field of knowledge about intelligent and active packaging.
9. Considering the factors that may increase the attractiveness of food products, active and intelligent packaging turned out to be the least attractive to the respondents. Only women living in large cities indicated such a feature of the packaging.

Therefore, due to the fact that the concept of innovative solutions in the field of packaging is, to some extent, attractive for customers, but their awareness in this area is still low, it seems necessary to conduct active activities aimed at promoting and popularizing solutions of this type and constantly raising consumer awareness of food products packed in active

and intelligent packaging. This is in line with the findings of other scientists [94,95], who stated that since the market success of food innovation depends on consumer perception of the technology, it is important to educate consumers to increase the overall acceptability of innovative packaging.

Further, in-depth research on consumer preferences in this area should also be carried out, as understanding them will allow, consequently, the development and implication of effective educational programs aimed at consumers, which then, as a consequence, will allow them to increase their awareness of the analyzed issues, while for food enterprises they may be a source of competitive advantage.

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