p-ISSN 0044-1600
e-ISSN 2392-3458

Problems of Agricultural Economics

www.zer.waw.pl

4(349) 2016, 138-159

Translation from Polish

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10.5604/00441600.1225668

CONSUMER PERCEPTION OF ACTIVE AND INTELLIGENT FOOD PACKAGING

Abstract

The paper discusses the essence and the use of active and intelligent packaging in the food industry. It presents the results of a survey whose aim was to determine the knowledge and attitudes of consumers towards this type of packaging.

The survey was conducted on a sample of 372 respondents – inhabitants of the Lubuskie Voivodeship. The use of active and intelligent packaging is related to the growing consumer interest in high quality food and new consumer preferences which influence the changes in the approach to food packaging. The analysis of the survey results showed that although there are new solutions for active and intelligent packaging appearing on the market, the state of knowledge on them among the inhabitants of the Lubuskie Region is insufficient.

Keywords: active packaging, intelligent packaging, consumer, food products, food industry, surveys.

Introduction

Packaging is a vital element in the modern commercial trade which determines maintenance of the food product quality and one of the more important means of advertising. It fulfils a major role by keeping the packaged product safe against the ambient conditions, influencing its quality and health safety, facilitating transport, storage and dosing. As Briston aptly phrased it: "packaging must protect what it sells and sell what it protects" (as in: Hales, 1999). A packaging used to package food products may be considered as a product placed on the market by itself or as a product inherently linked to the packaged food (Lisińska-Kuśnierz and Kawecka, 2012).

In Poland, 64.8% in the structure of packaging are food and beverage packaging. In 2014, average production in the packaging industry increased by ca. 6.5-6.8% and concerned nearly all industry segments, including wood packaging (ca. 5%). According to estimates in 2015, the market value amounted to EUR 8.62 billion (per capita it is ca. EUR 227), which meant a nearly 40% growth against 2009. Assuming that the economic growth rate in 2014-2020 is at 4-5%, the market value will come close to the level of the developed countries of Eastern Europe (ca. EUR 300 per capita). Presently, the packaging market in Poland amounts to ca. 1.4% of the global packaging market, which in 2013 was at EUR 535.7 billion (Wasiak, 2016).

A dynamic growth in the role of packaging fosters continuous improvement in production methods and manufacturing technologies. Food industry – given its expansiveness as regards the range of created products – has recently generated completely new needs in the field of packaging market. According to the forecasts, changes in the structure of the packaging market in the coming years will concern development of the segment of plastic packaging (especially flexible packaging), and wood and cardboard packaging. The sector of food and beverages packaging will continue to be the dominant sector, but it should be expected that there will be a dynamic development in the packaging provided with solutions supporting extension of the product use-by date and ensuring food security for the consumers. Development of new technologies linked to materials and goods intended to come in contact with food is dictated by the growing requirements both of packaging producers as well as new food products in line with the consumer needs.

Packaging is one of the more important product attributes which influences the shopping preferences of consumers. Awareness of consumer attitudes towards the new generation of packaging is a valuable source of information for producers when developing marketing strategies linked to designing and placement on the market of new goods. Zalega (2016) emphasises that "at the time of new technologies and possibilities which are created by the current economy it is exactly the innovative consumers that create the market for new brands and new products, initially by manifesting their use in front of imitators and next by popularising their attitudes".

Packaging is also one of the food product selection criteria linked to its functional properties (Barska, 2013). Due to growing interest of consumers in fresh products of extended shelf life and controlled quality, producers have to ensure modern and safe packaging. This is a challenge for the food packaging branch and it acts also as a driving force for development of new and improved technological concepts of packaging (Dainelli, Gontard, Spyropoulos, Zondervan-van den Beuken and Tobback, 2008). Packaging producers seek solutions which will enable to improve the properties of packaging materials such as: barrier to gasses, protection against UV radiation, extended storage period, transparency and environmental performance (Kubiak and Borowy, 2013).

Today, the market is dominated by traditional packaging but increasingly more often also new packaging materials, new packaging constructions and packaging technologies are used (Sykut, Kowalik and Droździel, 2013). Modern packaging extends the use-by date of food products while better storage techniques and cold chains allow for longer transport (Dybowski and Nosecka, 2015). Properties and attributes of new-generation packaging can emphasise the uniqueness and authenticity of a product and thus attest to its quality. There are different terms concerning new packaging technologies in literature: active, clever, interactive, smart and intelligent.

As a result of a project entitled "Actipak" definitions were organised and new packaging systems, along with relevant regulations, were introduced into the market (Ahvenainen, 2003; as in: Korzeniowski, Ankiel-Homa and Czaja-Jagielska, 2011). The terms of active packaging were divided into those that refer to quality protection of packaged products through relevant modern systems and intelligent packaging which in general supplements active packaging, and communicates with the buyer.

Farmer (2016) defines active packaging as "packaging which not only passively includes and protects food, but also performs other activities, while smart or intelligent packaging senses and reports." This is an extension of the traditional function of packaging, such as ensuring protection, convenience of use and longer use-by date and storage period. He also emphasises that "packaging of the future will not only be a barrier but it will also interact with the packed products" (Farmer, 2016).

Along with socio-economic development, consumption became an incredibly complex phenomenon taking on newer and newer forms which are accompanied by regular modifications of consumer behaviours in the field of consumer decision-making. The changes result in new consumer trends, which lead to the emergence of innovative properties of the current consumers, such as greater market awareness, need for creating social bonds, greater spatial and social mobility, and innovation in seeking information about goods and services and how to get them (Zalega, 2016). Innovation, as a personality trait has a different intensity which is reflected in different behaviours of a consumer towards new market phenomena (Bylok, 2016; Maciejewski, 2015; Matel, 2015; Zalega, 2015; Hall, 2014; Kucharska, 2014; Patrzałek, 2014; Sobczyk, 2014; Wasilik, 2014; Zalega, 2013a; Zalega, 2013b; Lisińska-Kuśnierz, 2011). Higher share of active and intelligent packaging in the shopping decisions of consumers results from the following trends:

- Deconsumption, i.e. informed and intentional reduction in the volume of consumed products and services to rational levels from the perspective of an individual. One of the aspects of anti-consumerism is reduction of the quantity of consumed goods to the advantage of their quality, which means resignation from purchase of larger quantities of cheap products in favour of

choosing the offer of higher quality and usability parameters.

- Changes in the lifestyle that affect, above all, a growth in the need for packaging that facilitates the use of a product. This indicates, e.g. growth in demand for convenient food products of desired sensory and nutritional characteristic, which are healthy and safe. In case of packaging – innovative solutions, which consumers pay attention to concern the manner of opening, closing and dosing as well as protection against unwanted opening.
- Improvement in the quality of life thanks to the value added offered by packed product – greater benefits can be achieved by extension of functions fulfilled by the packaging. Enterprises take up innovative activities concerning packaging to satisfy the continually changing market needs.
- Safety of packed products – it forces innovations as regards better protective function of packaging, especially as regards food products. Packaging has to efficiently protect a product against microbiological contamination, forging and unauthorised tampering with food.
- The need for environmental protection – influences development of packaging materials and contributes to manufacturing environment-friendly packaging. Growing environmental awareness makes consumers chose packaging which use less material, are easy to reuse, and are fit for recycling or incineration with energy recovery. Greening of consumption is a response to human and environmental threats caused by excessive and wasteful consumption. Changes in the area of consumption concern attitudes turned to sustainable consumption, preferring quality over quantity of consumed products and based on care for health.

Development of active and intelligent packaging has been visible for about thirty years. The use of active and intelligent packaging is linked first of all to consumer interest in high quality food and their new preferences, which influence changes in approach to food packaging. First of all, this type of solutions was introduced in Japan, next in the US and now in Europe. Probably their later dissemination on the European market resulted mainly from the binding legal regulations, which in Europe were much more restrictive (Cierpiszewski, 2015; Kozak and Biegańska, 2012).

According to forecasts by experts, the newly-created generations of active and intelligent packaging are the future of food packaging (Farmer, 2016; Cierpiszewski, 2016; Ghaani, Cozzolino, Castelli and Farris, 2016; Aday and Yener, 2015; Realini and Marcos, 2014; Vanderroost, Ragaert, Devlieghere and De Meulenaer, 2014; Pereira de Abreu, Cruz and Losada, 2012; Brody, Bugusu, Han, Sand and Mchugh, 2008).

Table 1

Overview of selected international research projects concerning active and intelligent packaging

Project name	Financing source	Coordinator	Year	Project description
Chack Pack	Belgium-IWT	Ghent University – Belgium	2013	Development of chemical sensors based on silicon photonics to detect food spoilage and check integrity of packaging with modified atmosphere
SusFoFlex	EU-FP7	Oulu University – Finland	2012	Intelligent food packaging solutions to extend the use-by date of food products and protection against microorganisms
IsaPack	EU-FP7	United Kingdom Materials Technology Research Institute	2012	Flexible and sustainable active and intelligent technological platform to pack fresh products aiming to extend the shelf life and quality, increase safety and reduce food and packaging waste
Flexibility	EU-FP7	Technische Universitaet Dresden – Germany	2011	Development of spectroscopic chips identifying harmful substances (mycotoxins, allergens and pesticides) in fresh products at the place of demand
IQ-Fresh-label	EU-FP7	Technologie--Transfer--Zentrum Bremerhaven	2010	Promotion of implementation of new intelligent labels through research of expectations of consumers, retailers and the industry. Development of a new intelligent label to monitor over-temperature for frozen food and development of new intelligent label to monitor oxygen content in the modified atmosphere of packed products

Source: Vanderroost, Ragaert, Devlieghere and De Meulenaer, 2014, pp. 50-51.

Greater interest in active and intelligent packaging in Europe is also reflected in the growing number of research projects linked to their development (Table 1) (Vanderroost, Ragaert, Devlieghere and De Meulenaer, 2014).

This paper presents the idea behind active and intelligent packaging in the food industry and their use. It also demonstrates research results which aimed to find out what the consumers know about such packaging and how they feel about them? Specificity of behaviour of the contemporary consumers, their determinants, directions of changes and trends, should be the subject of regular research enabling entrepreneurs to generate forecasts, design efficient development strategies, gain advantage on competitive market (Hall, 2014; Lisińska--Kuśnierz, 2011; Szymańska, 2013; Szymańska, 2007).

Research methodology

At the beginning, the research reviewed literature dealing with the issues of active and intelligent packaging. This enabled to explain the essence of these solutions and indicate their practical uses in the food industry. One of the aims of empirical research was identification of the consumer's knowledge on active and intelligent packaging of food products, and identification of respondent's approach to such packaging. Field studies were held as a survey, with the use of an original questionnaire. Research of consumer behaviours towards active and intelligent packaging referred to research at the declaratory stage and at the stage of actual consumer behaviours. The research was non-exhaustive, which means that they were implemented on a general population (Popławski and Skawińska, 2012). Respondents covered adult residents of Lubuskie Voivodeship, doing food shopping alone or with family and/or friends. Sample selection criteria considered representativeness of the population by voivodeship. Selection was based on quotas, considering sex and place of residence of respondents. The choice of the Lubuski region was determined by selection of the specialisation in the region "Health and quality of life", which covers e.g. "Healthy and safe food". Properly designed and manufactured packaging is a guarantee for all links in the trade chain that the product will not spoil during transport and storage. Packaging meets the need for safety by:

- keeping the highest product quality, which can be obtained with the use of new-generation packaging – active and intelligent;
- ensuring product authenticity;
- delivering reliable and legible information, and also using environment-friendly technological solutions.

The research was held in October and November 2015. Development of standardised measurement tool in the form of the survey questionnaire required preliminary research, which used the focus method enabling to construct a full range of multiple-choice answers. The survey questionnaire included 19 closed alternative and multiple-alternative questions. They concerned: identification of circumstances and criteria of food product shopping, assessment of knowledge on innovative solutions as regards packaging of food products (active and intelligent packaging), markings of significance of information values of a packaging and characteristic of respondents. Reliability of the scale was checked by the Cronbach's alpha test. Among 383 gathered questionnaires – 372 were classified as complete and suitable for further analysis. Field studies were preceded by pilot research, which enabled verification of the measurement tool. These were held in retail outlets. In the researched group women constituted 52% and rural residents 36%. Collected data, analysed and interpreted, have significant cognitive and application values, thus can be useful for food producers in the process of establishing their marketing strategies. This paper uses only selected research results, other were used in further publications (Barska et al., 2015).

Active packaging

The current consumer is not satisfied with a "passive" protective function of traditional packaging and provision of information on the product and how it is stored. Hence, in 1980s research on new active packaging started which influenced the quality and safety of a product (Martyn and Targoński, 2010). In active packaging, also known as interactive packaging, the packaging, the product and the environment interact with each other. The used active materials, contrary to the traditional packaging materials, in the course of interaction between the internal atmosphere and the product cause extension of its use-by date and, simultaneously, keep its higher quality (Borowy and Kubiak, 2008; Dobrucka, 2014).

Apart from product protection, active packaging fulfils additional functions of protection against the impact of external factors. Their main mechanism of action is cooperation with the packed product. The interaction between the product and its packaging is very important and extends the storage period or improves sensory properties of the product. This type of packaging introduces active factors in two ways: active factors are put is small bags in the packaging or they are introduced directly to the packaging material (Drzewińska, 2010).

Activeness of packaging (Korzeniowski and Czaja, 2003; as in: Baran and Bińkowski, 2014) consists in:

- inclusion to packaging or packaging material of chemical or enzymatic substances which are to absorb and/or remove oxygen from the atmosphere inside the packaging;
- use of substances generating or absorbing carbon dioxide in the packaging;
- control of the ethylene content in the packaging by the use of absorption on oxidising agent or on organometallic compound;
- introduction of an object expressing ethanol in volatile form to the inside of the packaging as a factor stopping the development of microflora;
- use of preservatives, bactericides or antioxidants emitted by the packaging material;
- use of humidity regulators;
- use of a technology enabling smell and taste control;
- introduction of light absorbers into the packaging;
- use of foil emitting a mineral substance protecting the product colour;
- refining packaging film surface to change its permeability ("smart films" and "forgiving films").

Food industry uses the following systems of active packaging:

- oxygen and carbon dioxide scavengers, and ethanol absorbers,
- carbon dioxide emitters,
- emitters and absorbers of smells,
- relative humidity regulators (water content in the packaging atmosphere),
- antibacterial substances,
- antioxidants.

Table 2 presents selected contemporary solutions for active packaging considering their potential functions in retail food trade.

Table 2

Selected uses of active packaging in the food industry

Type	Form	Function	Use
oxygen scavengers	sachets, labels, bottle tops, films	inhibiting lipid oxidation and mould growth, preventing change of colour	oils, fats, bakery products, roast coffee, dried beef, dried fruit
carbon dioxide scavengers and emitters	sachets, films	inhibiting microbiological growth, preventing packaging swelling	roast coffee, cheese
ethylene absorbers	sachets, films	regulating ripening of fruit and vegetables	natural and processed fruit
smell emitters and absorbers	films	smell stabilisation	absorption of odours, emission of smells
relative humidity regulators	sachets, films	humidity regulation	meats, vegetables, dried products
antibacterial agents	sachets, films	inhibiting microorganism growth	cheese, meat, bakery products
antioxidants	films	inhibiting oxidisation processes	cereal products

Source: Pereira de Abreu, Cruz and Paseiro Losada, 2012; as in: Popowicz and Lesiów, 2014, p. 85.

Oxygen scavengers are the best known group of active packaging. This group covers packaging including both compounds binding oxygen by physical means (absorbers) and compounds blocking oxygen access (interceptors) (Korzeniowski, Ankiel-Homa and Czaja-Jagielska, 2011). Scavengers remove oxygen from the atmosphere in which the product is and/or absorb oxygen diffusing through the packaging material during storage. Readily oxidizable compounds (iron powder, ascorbic acid, unsaturated fatty acids, unsaturated hydrocarbons), enzymes (glucose oxidase, alcohol oxidase) or a photosensitive colorants are used as oxygen scavengers (Lesiów and Kosiorowska, 2006).

Market applications of oxygen scavengers can be divided into (Popowicz and Lesiów, 2014a):

- Independent systems, e.g. bags, strips or labels, which are attached to the inside of the packaging and are its integral part, being at the same time a separate element; examples of independent air scavengers are: Ageless®, ATCO®, FreshPax®, Fresh-Max®, FreshCard®, Freshilizer®, O-BUSTER.
- Systems integrated with the packaging, visually indiscernible as a separate element – iron, ascorbic acid and elements of low molecular mass are incorporated into the packaging and/or covered with polymers. Such inte-

gration minimises the risk of rejection by the customer of the packaging equipped with oxygen absorption system, and the risk of accidental rapture of the sachet and consumption of its contents. Examples of oxygen scavengers integrated with the packaging include: SHELFPLUS® O2, OxyguardTM, OxbarTM, CryovacOS, valOR Activ100, valOR ActivBloc100, Amosorb series, ZERO2, Bioka Oxygen Scavenging Film Laminate, ActiTUF®.

Removal of all oxygen is impossible, but scavengers available on the market allow for reduction of oxygen concentration to even 0.01%. Their application is especially useful for products maladjusted to vacuum packs or packed in modified atmosphere (Korzeniowski, Ankiel-Homa and Czaja-Jagielska, 2011).

The effect of the most popular oxygen scavengers is based on oxidation of iron compounds. First scavengers of the type were produced already in the 1970s Ageless® scavengers of a Japanese company Mitsubishi Gas Chemical Company, presently manufactured under other names, e.g. FreshPax™ of the company Multisorb Technologies Inc. (Yoshiaki, Komatu and Yuyama, 1979; Cullen and Vaylen, 1991; Senoo and Tezuka, 2000; Kashiba, 1998; as in: Kozak and Cierpiszewski, 2010). In these scavengers iron oxides with the addition of sodium chloride are applied on zeolites, which under the influence of oxide and humidity of the packed products, oxidise to iron oxides. Newer, more effective iron absorbers are based on metallic iron obtained as a result of electrolytic reduction (Mc Ked, 2001; as in: Kozak and Cierpiszewski, 2010).

The second group of active packaging are emitters (Nowacka and Niemczuk, 2012). This type of packaging includes and produces compounds that can penetrate into the packaging and inhibit unfavourable processes. Their task is to guarantee stabilised state during storage and they should ensure extension of the use-by period. Emitters can help to control the moisture content in the packaging (vegetable packaging), inhibit growth of unfavourable microorganisms (CO_2, SO_2 emitters, ethanol emitters) and prevent bacterial spoilage (antibacterial agents).

Especially interesting in the group of emitters are systems emitting carbon dioxide because of their beneficial antibacterial effect. This gas penetrates much quicker through most packaging materials and it needs to be regularly supplemented inside the packaging, to ensure its relevant level (minimum 20%).

The largest group of emitters are agents to fight microorganisms inside packaging. These agents can be added to packaging in different formats (Korzeniowski, Ankiel-Homa and Czaja-Jagielska, 2011), such as:

- sachets or pads with volatile antimicrobial compounds,
- active substances incorporated in the polymer structure,
- active substances applied to the polymer surface,
- active substances fixed on polymer via ionic and covalent bonds,
- packaging films which have antibacterial effect (e.g. films based on chitosan),
- edible food coatings.

Taste and smell emitters are another interesting solution. Losses concerning smell and appearance following from storage of goods are the effect of interaction between the product, packaging and environment. Smell emitters give off odorants concealing the smell emitted in the packaging. Moreover, the produced smells can reinforce the natural aromas of the packaged product (e.g. fruit) and thus encourage the consumer to purchase the product. Smell emitters are most often substances which can be used as additives to plastics, e.g. polyethylene, polypropylene, polyamide, polyester, polyvinyl chloride. These substances are characterised by significant thermal resistance (Janicki, 2013).

A major problem in preserving durability of many food products is water surplus in the packaging. Too much water in the packed product influences higher microbiological contamination and, at the same time, reduces product durability, which may mean that customer will resign from buying the product. The main task of moisture control is reduction of biological activity of water and stopping growth of bacteria, mould and yeasts for meat, fish, bread or sliced vegetables. Goods which are sensitive to humid air should be packed in films made of materials showing high barrier to water vapour. The so-called drying films and sachets, which control humidity, are also used as well as special pads absorbing too high drip, e.g. in case of meat portions packed on trays. Drying agents are usually placed between polyolefin layers or a plastic coat of high water vapour permeability. More technically advanced are wraps of a Japanese company Chefkin, which control relative humidity in packaging. They are made of two layers. The external layer is impermeable to water vapour, and the internal one lets through water vapour, but not water. The space between the layers is filled with glucose solution. When relative humidity inside the packaging is high, water contained in the food product permeates through the internal layer of the wrap into the glucose solution. The Japanese company Showa Denko Company presented similar solution, in a form of a "sandwich" wrapping made of polyvinyl alcohol layers and propylene glycol in between them (Janicki, 2013).

In the field of active packaging antimicrobial packaging is also used. They are tasked with protection of the packed food against different microorganisms with the use of chemical and physical factors. They are added to the packaging as packages or are directly imbedded in the packaging material. Their effect is twofold, because some of them migrate to the surface of the product and create a protective barrier on it, while others have antibacterial effect without the need to migrate into the product. It is a competitive packaging solution compared to those used to date and based mainly on the effect of increased temperature. The disadvantage of thermal methods is primarily the loss of valuable nutritional elements, which are not resistant to high temperature, e.g. vitamins, during the process of preservation. Organic acids and their salts as well as sulphides, sulphates, alcohols, vegetable extracts and silver compounds are usually used

in antimicrobial packaging. The type of factor used depends mainly on the type of the food product, because each good is different from other in terms of microflora. An important aspect is also the manner of goods storage, the required temperature, humidity and access to light, because these factors have a direct impact on the growth rate of microorganisms (Kozak and Cierpiszewski, 2010a).

Oxidisation of fats is commonly considered as the most important mechanism leading to spoilage of food containing triglycerides. Lipid oxidisation leads to shorter period of food durability because of highly undesired and unfavourable changes in taste and/or smell and deterioration of texture and nutritional quality. The oxidisation processes are prevented and/or slowed down with the use of oxygen scavengers and antioxidants put in the packaging. Free radicals are the major triggers of lipid oxidisation. Preventing oxidisation, primarily of triglycerides, consists in elimination of free radicals when and if they appear. There are many natural compounds, which efficiently react with free radicals and eliminate them. Therefore, high barrier and/or vacuum packaging materials are not required to prevent unwanted oxidisation reactions, what is needed are only absorbers of free radicals (Popowicz and Lesiów, 2014a).

Intelligent packaging

Intelligent packaging, also known as smart packaging, is the newest generation of packaging. The packaging is to monitor or provide information on the product, its quality, safety or location during transport, storage, retail sales or during use (Kozak and Cierpiszewski, 2010b). It has an internal or external indicator providing information on the history of the packaging (Drzewińska, 2010).

There are many types of intelligent packaging on the market (Fig. 1). They operate on the basis of interactive indicators. Most often these are colour indicators enabling to evaluate the packed product. A change in colour happens continuously in case of a change in the amount of heat that the product gets during transport and storage, whereas in case of detection of raptures in the packaging the colour changes abruptly. Indicators are a simple tool, which allows to reduce the risk of losses and limit costs arising from the losses linked to replacement or repair of damaged products or their disposal. The use of a relevant indicator is linked to the specificity of a given product and a factor, which is to be controlled, therefore, the following indicators were recognised: storage time and temperature indicators, freshness, humidity, shock or electronic labels and bar codes (Dobrucka, 2014).

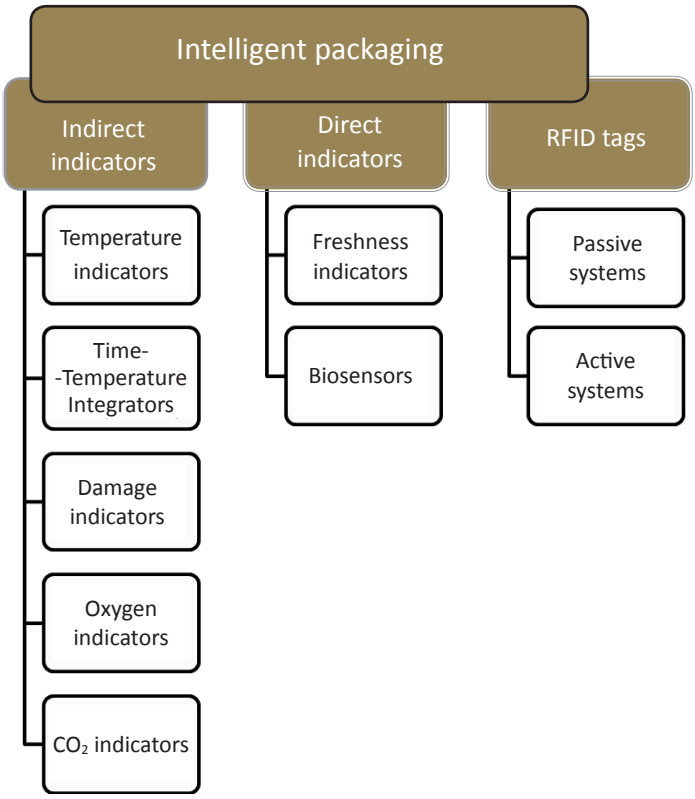

Fig. 1. Types of intelligent packaging.
Source: Nowacka and Fijałkowska, 2014, p. 4.

Packaging equipped in temperature sensors are to easily detect a change in quality of the packed product, which results from its improper storage conditions. The rule of their operation consists in irreversible visual change in the indicator under the influence of temperature. These changes can be registered mechanically (deformation of the indicator) or as a result of chemical, electrochemical, enzymatic and microbiological reactions (change or switch of the colour).

Depending on the fulfilled function, the indicators can be divided into three categories:

– critical temperature indicators (CTI) – inform on the effect of higher or lower temperature than the one indicated on a specific product,
– critical time-temperature indicators (CTTI) – reflect the total time of exposure to temperature above or below the so-called critical temperature,
– time-temperature indicators (TTI) – demonstrate the entire temperature--related history of product storage (Korzeniowski, Ankiel-Homa and Czaja-_Jagielska, 2011).

From the perspective of the distributor these are used to monitor and optimise distribution and storage or stock management (Simpson et al., 2012).

Another group of intelligent packaging covers freshness indicators. Their effect is based on detecting the presence of metabolites, produced by microorganisms, i.e. carbon dioxide and sulphate, ammonia, hydrogen sulphide, amines, ethanol, organic acids, enzymes and toxins (Nowacka and Fijałkowska, 2011). This method uses mostly electronic and optical detectors as well as colourful compounds generated in reaction with a substance absorbed from the inside of the packaging (Kubiak and Borowy, 2013).

Most of the concepts of the freshness indicators rely on colour-based identification of microbial metabolites. These can be divided into:

- indicators using pH changes,
- indicators using volatile nitrogen compounds,
- indicators using the presence of hydrogen sulphide,
- indicators basing on colour changes of chromogenic enzyme substrates produced by microbial contaminants (Korzeniowski, Ankiel-Homa and Czaja-Jagielska, 2011).

Another group of intelligent packaging is leakage indicator (indicator of being open). In an untight packaging the protective impact of the modified atmosphere on the product is reduced and risk of microbiological contamination grows because of increased susceptibility of the product to microorganisms hazardous to human health. The indicators of oxygen and carbon dioxide measurement in the packaging (Ageless Eye and Tell-Tab Oxygen Indicator as leakage indicators) can be used to monitor the quality of, for instance, food products. The mechanism of action of this type of indicators is based on a change in their colour as a result of chemical or enzymatic reaction. The most commonly used redox colour in leakage indicators as regards oxygen is methylene blue (Kubiak and Borowy, 2013).

An interesting solution is the RFID (Radio Frequency Identification) technology, which is not included among the quality indicators, but it constitutes an integral part of intelligent packaging, transferring electronic information about the product. It is a modern production identification system, often known as "radio barcode" (Cichoń and Lesiów, 2013).

In the RFID technology not only the use of radio waves is important but also the data record in the memory, the so-called microchip. The system is built from a reader, a recording unit and a tag (type of a label). The reader is a transceiver that has a possibility to send or receive decoded beams of electromagnetic radiation. Two types of readers are used: stationary (intended for installation, e.g. production lines, entry gates to the storage house) and portal (integrated with a portable terminal). The RFID tag is actually a receiver-transmitter (transponder) which consists of a chip with embedded processor, an antenna and data carrier integrated with the above elements.

Products equipped with RFID chips have a uniform, unique ID number. Apart from the number producers provide it with one more important combination of numbers – Electronic Product Code (EPC). A difference between them consists in identification of the entire pallet or batch of a product in case of the ID number, while the EPC indicates a specific unit in a given batch.

Presently, the so-called intelligent labels are very popular, their main element are the RFID tags. The basic part of such a label is ultra-thin integrated circuit combined with a label of any shape or size. The circuit of any shape placed on any carrier (e.g. film, paper) has a transponder with memory enabling to record product information. These types of labels do not use batteries, because communication between the transponder and the reader consists in inductive coupling (Borzyszkowski, 2013).

Consumer attitudes towards active and intelligent packaging

Active and intelligent packaging is one of the innovative solutions in the field of food packaging, but their origin is largely determined by the consumer awareness of values of such solutions. Without the feedback information flow manufacturers of goods and packaging cannot develop efficient innovative solutions as regards the offered packed products as well as the effective marketing strategy and participate in the market game (Ucherek 2010). Packaging including, e.g., colour indicators informing the potential purchaser about the current level and quality of the packed food product can be appreciated only by a consumer having a relevant knowledge about the use of such solutions. Thus, what is very important is research aiming at determination of the consumer knowledge about this type of packaging and their perception. The conducted research shows that the term "intelligent packaging" is known to 17% of respondents. In this group women constituted 18% of surveyed women, and men 10% of all surveyed men. The most numerous were respondents from cities of more than 50 thousand residents (24% of the total for the group), 17% were representatives living in rural areas and the smallest percentage belonged to the group of residents living in cities up to 50 thousand residents (13%). The term "active packaging" was known by only 4% of respondents, in the group the share of female and male representatives was similar – respectively 4% and 3%. The group does not identify residents of rural areas, while residents of cities of more than 50 thousand residents were most numerously represented (9% of the entire group), the groups of residents of cities below 50 thousand residents were much less numerous (5% of the entire group). In everyday life the respondents came across this type of solutions, but they were not aware that these were practical examples of intelligent or active packaging. The highest percentage of respondents came across packaging containing interactive indicators – 53% of respondents (Table 3) (Barska et al., 2015). These monitor the conditions inside the packaging and most often are in the form of a colourant which changes its colour. Interac-

tive indicators of packaging include: the freshness indicator, leakage indicator and time-temperature integrator (important for, e.g., frozen strawberries, where temporary temperature raise caused by partial thawing results in decolouration of labels).

Unquestionable advantages of such solutions are:
- no effect between the product and packaging,
- current information on the product quality,
- much extended use-by period of a product without chemicals additions.

In case of products packed in active packaging, where the product, the environment and the packaging interact on each other, the quality of the product grows, and its use-by and durability period extends.

Examples of active packaging cover:
- perforated films releasing aromas relevant for a given product,
- packaging emitting substances protecting the product against spoilage (mainly carbon dioxide, sulphur dioxide and alcohol),
- packaging absorbing unwanted gasses, e.g. ethylene.

Packaging containing scavengers were known to 42% of respondents.

Table 3

Knowledge of practical solutions in the field of intelligent and active packaging (% indications, N = 372)

Types of packaging of food products	Declarations of respondents on knowing these solutions		
	yes	no	I do not know
Containing scavengers (e.g. oxygen, carbon dioxide, water, ethylene or aromas), which are to remove harmful gasses from the packaging and extend product durability	42	30	28
Containing emitters, which enable release of defined substances to the inside of the packaging, e.g. restricting development of unwanted microorganisms, including pathogens	16	42	42
Use of interactive indicators, e.g. temperature sensors – overtemperature is signalled with a change in the indicator colour (e.g. on beer bottles) which enables to control whether the product temperature is as recommended for consumption	53	30	17
Using indicators of atmosphere composition – these indicators are to signal changes in the atmosphere composition inside the packaging and changes taking place on the surface of the product. This allows to check whether the product is stored in the right environment	5	56	39

Source: own study on the basis of surveys.

The most often used types of food packaging include oxygen scavengers because of the following advantages:

- they prevent oxidisation, i.e. the so-called rancidity of fats and oils, which in consequence leads to release of odour and unpleasant taste, and can also result in the loss or change in colour characteristic for the food and a significant reduction in the oxygen-sensitive nutrients (e.g. vitamins A, C, E, etc.),
- they prevent propagation of aerobic microorganisms,
- they make it possible to limit the use of preservatives and antioxidants,
- they are an efficient and economical alternative to packaging in modified atmosphere and/or vacuum packaging,
- they slowdown unfavourable and unwanted metabolic food processes.

Whereas control of the level of phytohormone, known as ethylene, during food storage plays a key part in extending food freshness. The presence of the phytohormone in the packaging deteriorates visual and organoleptic quality of fresh or minimally processed fruit and vegetables. Placing ethylene absorbents in the packaging protects fruit and vegetable sensitive to the effect of the phytohormone, e.g. apples, kiwis, mango, tomatoes and other (Popowicz and Lesiów 2014a). Research shows that a major part of respondents upon familiarising with the essence and advantages of active and intelligent packaging declared a willingness to purchase food thus packaged, despite its higher prices (Table 4). Similar conclusions were formulated by a team of researchers Popowicz and Lesiów (2014b). It needs to be emphasised, though, that the actual behaviour of consumers on the food market is decided by the level of income – the key factor determining demand and consumption (Cyran, 2014). A factor limiting the dynamic development of intelligent and active packaging in the area of the Lubuskie Voivodeship probably is worse income situation of residents, because the average gross remuneration in 2015 was 89.6% of the national average, and the share of expenditure on food in the total structure of expenditure in the researched area was 26.3%.

Table 4

The willingness of respondents to purchase food in active and intelligent packaging (% of indications, N = 372)

Type of packaging	Yes	No
In intelligent packaging which enables monitoring of the status of quality and safety of products packed in it and transfers the information to the consumer, e.g. it is equipped with a special label changing colour depending on the suitability of the product for consumption	67	33
In the active packaging, which is individually adjusted to the properties of the packed food products related to the type of changes taking place in food, i.e. physiological (breathing of fresh fruit and vegetables), chemical (oxidisation of fats, degradation of vitamins) or microbiological; these type of packaging is based on scavengers and emitters	68	32

Source: own study on the basis of surveys.

The dominant view among the respondents, who showed their interest in solutions in the field of intelligent and active packaging, was that in order for the solutions to be successful on the market it will be important to show how they actually improve food quality (98% of indications). It is very important to raise the awareness of the society by providing full information on how they work (69% of indications) and to conduct a more intensive media promotion (29% of indications). A major part can be also played by new consumption trends and higher mobility of the society. According to the respondents a major part in the development of active and intelligent packaging can be played by the growing food awareness of the consumers (66% of indications) and also decrease in food losses and food and packaging waste (63% of indications). This group of respondents indicated also the factors, which can discourage the consumers from choosing intelligent and active packaging:

- higher price of food products packed in intelligent and active packaging (65% of indications),
- scepticism of consumers towards such solutions (65% of indications),
- lack of knowledge of the consumers as regards such solutions (56% of indications),
- habit of buying products in traditional packaging (40% of indications),
- lack of demand for such solutions, for some consumers the product expiry date on the label may be just enough (27% of indications),
- concerns about changes in the products, e.g. in contact with the indicator and their possible impact on food quality (21% of indications).

Research carried out by Popowicz and Lesiów (2014b) shows that active packaging would be most useful to ensure storage safety of meat and cold cuts, especially packaging absorbing oxygen. This category was indicated by 84% of respondents. Another very highly assessed packaging was active packaging preventing the development of microorganisms and packaging regulating the water content in products from the group of meat and fish products.

Conclusion

The economic development of Poland had a positive impact on the consumption structure and quality of human nutrition. This is manifested not by better quality of nutrition measured by the nutritional value of consumed food, which in developed countries is rather stable, but by improvement of provision with food as a result of change in consumption structure and greater provision of food products with varied types of services, facilitating access to food and convenience in its use (including changes in the related packaging) (Kowalski, Figiel and Halamska, 2011). The growing demands of consumers regarding safe, minimally processed food and extended time of its storage mobilise the food industry to introduce, e.g., active and intelligent packaging (Martyn and Targoński, 2010). Numerous research works conducted on the active and intelligent pack-

aging are an evidence of a major significance of this type of packaging, especially for food products. Already today there are many new solutions on the market in the field, which are, however, poorly recognised by the consumers. Analysis of survey research results showed that the level of knowledge on active and intelligent packaging among the residents of the Lubuskie Voivodeship is insufficient. The most recognisable are packaging using interactive indicators, but also in this case the knowledge about them was not universal, only 53% of declarations of respondents. Thus it is necessary to conduct measures aiming at popularisation of the solutions and research on the consumer preferences in the field. Research results clearly show that a definite majority of consumers declares a willingness to purchase food in active and intelligent packaging, at the same time, accepting the need to pay for it a higher price which is a positive premise for popularisation of such packaging. In the society it is clearly needed to popularise food packed in active and intelligent packaging, but the success of implementation of such solutions requires active measures to promote them. It needs to be noted, though, that migration of substances used in active packaging cannot pose a threat for security of food and the environment, therefore, their use is minutely regulated by the European Union (Restuccia et al., 2010).

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KONSUMENT WOBEC OPAKOWAŃ AKTYWNYCH I INTELIGENTNYCH NA RYNKU PRODUKTÓW SPOŻYWCZYCH

Abstrakt

W artykule zaprezentowano wyniki badań, których celem było określenie wiedzy i stosunku konsumentów do aktywnych oraz inteligentnych opakowań w branży spożywczej. Stosowanie tego rodzaju opakowań związane jest ze wzrostem zainteresowania wśród konsumentów wysokiej jakości żywnością oraz ich nowymi preferencjami, które wpływają na zmiany w podejściu do pakowania żywności.

Badaniami ankietowymi objęto 372 dorosłych mieszkańców województwa lubuskiego, dokonujących zakupów produktów żywnościowych. Analiza wyników badań ankietowych wykazały, że stan wiedzy na temat opakowań aktywnych i inteligentnych wśród Lubuszan jest niewystarczający. Decydujący dla rozwoju opakowań aktywnych i inteligentnych jest pozytywny stosunek respondentów do dalszego rozwoju tych rozwiązań.

Słowa kluczowe: opakowania aktywne, opakowania inteligentne, konsument, produkt żywnościowy, przemysł spożywczy, badania ankietowe.

Accepted for print: 14.12.2016.