

Intelligent Packaging

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Abstract

The paper discusses the benefits associated with the use of intelligent (smart) packaging, which are gaining popularity and recognition as a technological innovation that brings benefits to all participants in the economic process. Theoretical summary is given about the nature of smart packaging and the advantages of their application for the retail trade and the consumers. Moments related to the regulatory requirements for their use are given. Data on the global market for smart packaging and for the production of packaged goods and packaging in Bulgaria in general are presented.

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Introduction

In the digital age of human existence, everyday life is filled with new products or the existing ones improve their characteristics, where their product and market positioning is increasingly associated with the wide possibilities of information and communication technologies. One of the directions of these innovations is the emergence of goods packaged in innovative solutions, which increase the overall consumer utility. Moreover, they allow part of the satisfaction of a product to be obtained even before the moment of its use.

These packaging innovations are defined as intelligent or smart packaging. Smart packaging has received a specific European definition in Regulation (EC) № 450/2009 of the European Commission (Commission of the European Communities 2009), where in Article 3 (b) defines "intelligent materials and articles" as materials and articles that monitor the condition of packaged foods or the environment that surrounds them.

They can be used alone or in combination with "active materials and components" that perform tasks related to the safe handling of the shelf life of food products, the preservation of their consumer properties or even their improvement. This is achieved through the use of components that affect the packaged food or form a suitable environment to improve, optimize or maintain its condition. In addition, smart packaging provides, through the technology of their production and operation, important consumer information that can be obtained at the point of sale or at the point of consumption.

The main aim of this paper is to summarize some of the benefits associated with the application of intelligent (smart) packaging for business, in particular retail trade and final consumers.

The article implements the methods of the review of the applicable regulations related to intelligent (smart) packaging and identification of the best practices of their use in real business. The second part analyzes statistical and secondary data, which present quantitative assessments of the state and future development of the global market for smart packaging and the national market for packaged goods and packaging. The work presents the content, characteristics and advantages of intelligent packaging for all participants in the product supply chain and the information security function that smart packaging provides for all economic agents. The present study adopts the broadest and most common understanding of the concept of smart packaging as a technological

solution, through which certain desired effects are achieved with regard to the packaged product and the information provision of stakeholders who have contact with it.

1. Review of the nature and features of intelligent (smart) packaging

An important point in the use of intelligent packaging is that they can be used in relation to the individual product unit, but can also be used more generally in relation to larger transport packages. However, in both (product smart packaging) and in the other case (transport smart packaging) we have the generation of specific and timely information utility for participants in the economic process.

The use of smart packaging with built-in electronic components only in the intermediate phases of product distribution can be attributed to the concept of Industrial Internet of Things (IIOT), as they can be a source of data to be used for an in-depth analysis and serve for certain adaptive changes in the volume and characteristics of the business activity. For example, a more accurate response to modify commercially manufactured articles in relation to the turnover rate of certain product units or the need to change commodity characteristics to ensure longer shelf life or other qualities and properties.

The intensity of competition between traditional business models and those positioned in the digital world of the information society requires all participants to seek modern product solutions, including at the packaging level. Smart packaging gives an advantage to the arsenal of tools and strategies in the competition for the consumer resource of traditional traders with e-traders. They turn the physical store, where the products are available and can be acquired immediately, into a place provided with huge information resources (product data and events that brought the product to the specific point of contact with it, information about exchange conditions, user reviews and opinions and anything that can be accessed online through the global or local Internet network) or transfer and successfully apply some of the benefits of electronic exchange in the physical environment of a traditional store. Through them, conventional stores acquire particular of the features and innovative digital advantages of e-commerce, which means that traditional trade intermediaries integrate through digitalization competitive advantages that are typical of e-commerce.

The main function for which smart packaging is used is to provide an opportunity for each intermediate or retail trader and end-consumer to be more fully and thoroughly informed about the characteristics of the product, its quality status, the way of its production and the events that led to its display for sale at the commercial site. According to its technological implementation, this can be ensured by sensors and / or indicators (active and passive RFID, NFC, Bluetooth, etc.), and / or design solutions (barcode, QR code, etc.) or other solutions of intelligent packaging systems. Their task is to provide information at the point of sale and / or at the point of consumption and to provide relevant knowledge as a result of interactive synergy with the packaging.

A distinctive feature of smart packaging is that they can accumulate certain data about their condition, storage regime and previous handling of the product, which are extremely important for certain goods (e.g. medicines or perishable food products with short shelf life and / or specific storage conditions). These components can be passive parts of the product and they are not used to influence the main product, but only provide technology to expand the information security and connectivity of the product with modern information and communication technologies.

At present, smart packaging is widely used to preserve the consumer properties of food and beverages. Initially, they were widely used in the distribution of larger bulk or transport packages, where they serve to monitor and track the conditions and circumstances of transportation and handling of individual batches (lots) and larger volumes of cargo, but gradually with a decrease in their cost contribution to the price of the packaging, they become widely used to monitor the

condition of each individual product unit. This means that intelligent packaging technology is applicable to both bulk or groupage loads and individual product unit. They allow adequate monitoring of the movement of the entire batch and reporting the conditions of its transportation and handling throughout the supply and storage chain, but can also be able to optimal tracking control of individual units.

The latter is related to the assumption that, if all other terms and conditions being equal, in one consignment it is always possible to deviate from the general conditions of transport for individual products, the latter is not critical in respect of the other elements of the consignment being transported. In practice, this means that control authorities and sales staff, and even the consumer, are given a real opportunity to track and monitor possible expected or undesirable dynamics in the quality characteristics of each product unit, without having to destroy, test or repackage it. This is because the packaging itself will inform, through appropriate information exchange carried out through the built-in sensors or active elements, about its movement from the place of production to the trade premises or at the point of consumption and about the changes in its initial features. It can accumulate information about various characteristics and parameters of the environment for a certain period of time, but it can also directly provide the user with information about its current qualitative and quantitative state.

One of the main tasks that is most often set when using smart packaging is an adaptive change in the durability of the product. It can be both in the direction of increasing or reducing the term of its safe use. It is determined according to the relevant key consumer characteristics of a product and its safety. This objective may be achieved by means of those permitted and allowable for the simultaneous or independent use of active materials and articles in packaged foods or the environment surrounding them or absorbing substances thereof, as defined in Regulation (EC) № 450/2009; components of individual substances or a combination of individual substances or through the functional barrier that surrounds the product and isolates it from the environment in which it is located (Commission of the European Communities 2009). This allows, depending on the applied technological solution, to create modern “intelligent packaging systems that provide information about the state of food” (Dobрева 2009). By default, which is also regulated by Article 9 (2) of the Consumer Protection Act, the product label must provide information on the shelf life and storage conditions (Zakon za zashtita na potrebitelite 2020). Therefore, the packaging, which most often bears this information, must be provided with the appropriate label at the time of manufacture of the product. Often this decision is set in advance as best before or expiration date, which, however, does not take into account the real and objective state of the product. For example, it may have been subjected to different types of forces during storage or transport, leading to various changes in composition and quality. Thus, the term determined for whole batches or commodity varieties indicates the condition of the product in an organizational, technological and/or normative way, without taking into account the objective situation, but with one accepted as optimal under equal other conditions or under precisely defined conditions and specified requirements. Usually, in order to protect the manufacturer from commercial or consumer claims against him, this period is in accordance with the conditional lower limit for storage, which is not economically reasonable.

In such a situation there is a hypothesis described in the norm of Article 20 (2) of the Food Act, which stipulates that when “a food that is not safe for consumers is part of a batch or supply of food of the same type with the same characteristics, it is considered that the whole batch or supply does not meet safety requirements, unless after inspection and / or laboratory tests and / or verification, it is established that the rest of the batch or delivery is safe” (Zakon za hranite 2020). Smart packaging allows, without this additional cost of testing and time to perform it, to inspect and sort each product unit and, if readings are found for deviations given through the packaging, to

remove it. Thus, only those items that are outside their safe and normal condition are removed from the entire batch and the others that give an indication of the absence of significant changes can be offered for sale. Of course, the control process can be performed either by the trader or by the consumer through the information on the packaging and its correct reading and application.

Additionally, smart packaging allows this moment to be managed in real time. This means that if, at the end of its shelf life, a product has not lost its consumer properties, the packaging can provide the correct information to the trader and the consumer and thus limit losses and unpleasant consumer experiences. This is because if a product is outside the specified time limit set for its storage, it must be suspended from sale, withdrawn from the commercial network and it can be processed either in the direction of destruction or transfer for subsequent disposal outside the consumer market. An important point here is the text of Article 43 of the Law for management of the agro-food chain, which “prohibits the return of food from wholesale and retail outlets to production outlets, except in the cases under Article 19 of Regulation (EC) № 178/2002” (Zakon za upravlenie na agrohanitelnata veriga 2020). This means that in case of difficult realization for a number of reasons, product surpluses can be reached and their unsuccessful commercial sale during the shelf life will lead to losses for their owner.

Another aspect is related to the consumer point of view, in which the product, as a result of many forces and reasons, may have lost its quality properties, initial volume or quantity and thus not be safe to use, although it is within its shelf life. Thus, the consumer has been misled by what is permanently written on the package and has acquired a product which appears to be in an inappropriate condition, even though it is within the standard expiration date (based on regulations or previous testing). Of course, the mechanisms of consumer protection allow this moment to be resolved in favor of the client, but this involves additional costs of time and resources and mainly a large amount of negative emotions and unsatisfactory user experience. The described situations allow, through the application of smart packaging, to be resolved for the benefit of all participants and thus the overall satisfaction increases. Therefore, the use of smart packaging has advantages that can be valid simultaneously or individually for the manufacturer, intermediate actors in the supply chain, final traders and consumers.

In a similar direction are the designations for “best before”, which is a predefined approach to determine the period in which the product is best, but after which it has not necessarily lost its suitability and safety under certain conditions. The “best before” label serves to inform that the packaged product may be safe for consumption and has retained its expected quality after the date indicated in the label, but this should occur before the critical date defined as “use by / expiry date” (European Commission 2020).

Smart packaging is also associated with the reduction of unpleasant consumer experiences, mainly related to the acquisition of products that visually and according to information on the label are with the qualities announced by the manufacturer, but subsequently when consumed it is found that they do not meet and clearly suffered compromising. The latter may have occurred in the phase of storage and handling of the finished product at the manufacturer, but mainly occurs during storage and transportation in the intermediate units of the supply channels, which has led to a deterioration of the manufacturer's standards. In this situation, the smart packaging can indicate the current quality of the product and properly visualize this information for the particular user. This means that intelligent packaging helps to improve the safety of the product, thus protecting consumer interest to the greatest extent.

Also, the smart packaging can perform supplementary informational functions in addition to those announced through the product label. Adding a barcode, QR code to the package (one-way machine-readable information forms) or the use of electronic components (e.g. RFID, NFC,

Bluetooth) allows anyone who has access to the package to do their scanning using modern information and communication smart technologies and receive extended feedback that cannot be part of the product label. The latter is related to its volume and accumulation during the movement of the product in the distribution channels. Thus, the consumer could be informed in more detail about the composition of the product, its manufacturer, the technology for its creation, its stay in different stages of the distribution process and the manipulations it has undergone, changes in certain characteristics of its storage environment, receive instructions and recommendations on the use of the product, to find user opinions, reviews, etc. It should be noted that the operations initiating the exchange of information (scanning) and its processing (reading, sharing, etc.) should be highly standardized and relatively easy to mass use.

The application and enforcement of smart packaging is mainly initiated by manufacturers who are looking for ways to increase overall product utility. That is why they package the finished products in this innovative way. The main motive for their behavior can also be related to the search for solutions to minimize product losses, the fight against fraud, the accumulation of information about the life of the product after production, etc. However, the use of smart packaging can also be done at a later stage when the goods are repackaged in the distribution channels. This may partly undermine the overall process of monitoring product life. With regard to intellectual property fraud, smart packaging can be applied to ensure the originality and origin of each product. They allow consumers to make multiple checks to verify the novelty, source and authenticity of the product. Smart packaging can be tested for origin before, during and after the acquisition of the product and thus provide the customer not only with passive protection, but this can be extended through the application of active anti-counterfeiting systems. At present, this makes them applicable and economically viable for more expensive and luxurious branded products, where protection against imitations is equally important for both the manufacturer and the loyal customer who prefers the respective brand.

Intelligent packaging can improve the state of information symmetry between the participants in the product exchange. This circumstance is related to the nature of smart packaging to accumulate information related to product life from the place of production to the place of consumption. In this way, each of the participants has the opportunity to review the accumulated information content in the product distribution channels at a given time and that can influence the decisions for resource allocation.

2. The global packaging market and production of packaged goods and packaging in Bulgaria

In 2018, the smart packaging market is estimated at 6,87 billion USD and in the forecast of the market analysis company Research and Markets is expected in the period 2019-2027 to grow by an average annual rate of 8,3%, mainly driven by the growing demand for environmentally friendly sustainable products from various industries (Research and Markets, 2020), which is close to the slightly lower estimate for the average annual growth rate of 7,8% for the forecast period from 2020 to 2027, conducted in the market research carried out by the company Data Bridge (DataBridge, 2020).

The annual survey conducted by the National Statistical Institute on the main producers of packaging and packaged goods provides information on the production volumes and the related generation of packaging waste and packaged goods in Bulgaria. The amount of newly formed packaging waste in the country reached an annual volume of 497 493 tons at the end of 2018, which is 31,38% more than the reported volume of 378 668 tons in 2014 (see Figure 1).

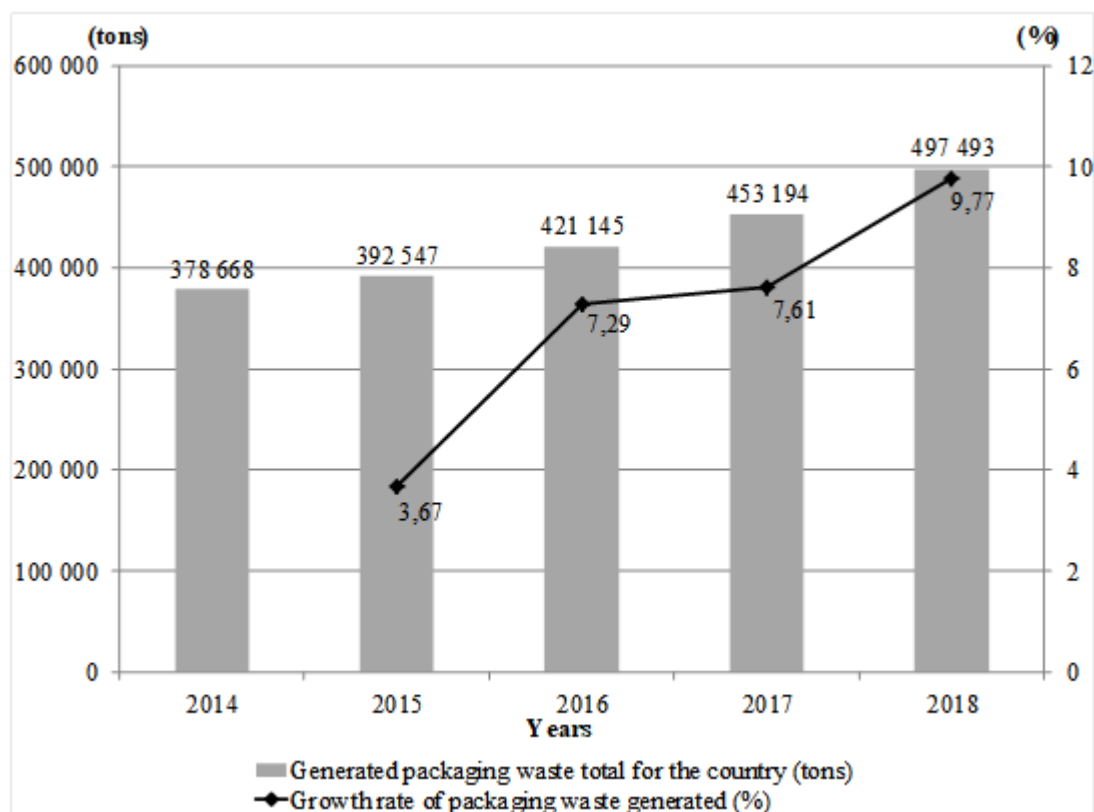


Figure 1. Production of packaged goods and packaging in total in Bulgaria by years for the period 2014-2018

Source: (Natsionalen statisticheski institut 2020)

During the study period 2014-2018, a compound annual growth rate of 7,06% was registered, which clearly indicates a significant increase in the volumes of used packaging, which are used to “put in them, store, carry, deliver and present goods - from raw materials to processed goods - from producer to user or consumer” (Natsionalen statisticheski institut 2019). Moreover, an acceleration of this process is registered, as for the last reporting period a relative change of 9,77% was reached, which is the most significant annual increase for the studied period 2014-2018. The increase in the volume of packaging and packed goods on the market, which ensures the distinctiveness of the products and ensures the preservation of their consumer value in a commercial environment, is accompanied by the growing problems of their subsequent disposal. The concept of smart packaging is also developing in the dimensions of environmental protection, which is mainly achieved through the creation of packaging with a specific useful life, after which they undergo full biodegradation or they can be processed by effective recycling technologies. The latter is an alternative to the effective inclusion of packaging in the circular economy model and the utilization, recovery or reuse of the resources invested in them.

Conclusion

Their widespread use of smart packaging in everyday life and for most goods will be reached at the moment when the use of these passive or active electronic components (RFID, NFC, etc.) reaches a relatively insignificant value to the total price of the product. Currently, this is a business strategy for innovative companies and those that adapt and impose cutting-edge information and communication technologies. The widespread incorporation of these electronic components in mass-produced products will occur at the moment when the price of these digital elements reaches the value of the “elusive target of 0,01 USD per tag” (Ewers 2018). In this situation, the main obstacle to “the search for new packaging solutions and their implementation in

industry... is related to the necessary funds and resources, which significantly complicates the path from the laboratory to mass production” (ProPack Magazine 2011).

Smart packaging is an expression of the advent and active penetration of Industry 4.0 in the business, where through digital innovations will reach their wider application in the economy, to create a continuous and comprehensive connection between the real and digital world. Their application in the near and distant future will grow, driven by the massification of the products of the digital economy and the search for solutions to provide information to all participants in the commercial cycle.

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