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Original research paper

THE POTENTIAL OF INTELLIGENT FOOD PACKAGING APPLICATION IN THE MARKET OF AP VOJVODINA

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ABSTRACT: The aim of the paper was to analyze the potential of using intelligent food packaging in the market of AP Vojvodina. In the theoretical part of the paper, the basic properties of intelligent packaging and its importance in the process of packaging food products are presented. Particularly, the communication of intelligent packaging and packaged product with final consumers through the use of various sensors, data carrier devices and indicators is emphasized. On the basis of theoretical analysis, external limitations and advantages of using intelligent food packaging for final consumers and participants of the food supply chain are defined. In the empirical part of the paper, research was conducted on two stratified samples. The first stratum included 117 final consumers who were questioned about the importance of intelligent packaging for their habits, decisions and expectations in the food purchasing process. In the second stratum, consisting of participants in the food supply chain, on a sample of 51 companies, the external factors of limitation and expected benefits from the application of intelligent food packaging in the AP Vojvodina market were analyzed. The results of the study showed that the habits and expectations of final consumers are statistically significant in relation to the use of intelligent packaging in the food purchasing process. On the other hand, external limitations and expected advantages for food supply chain participants have a significant impact on the implementation of intelligent technology in food packaging. Based on the results obtained, a set of measures and incentives have been defined which the competent institutions and supply chain management have to take in order to benefit from the potential of intelligent food packaging. Suggestions for future research are outlined in the paper.

Keywords: *intelligent food packaging, food products, supply chain, consumers, shopping habits, Province of Vojvodina.*

INTRODUCTION

Intelligent packaging is increasingly used in logistics (Maksimović et al., 2015), physical distribution and transportation (Bledsoe, Rasco, 2018), pharmaceutical industry (Dobrucka, 2014) and, above all, food production and market placement of food products (Asri et al. 2019). Studies show that intelligent packaging systems are increasingly being used in easily perishable food products such as meat and meat products, fish and fish products, milk and milk products, fruits and vegetables, so as to facilitate their use, preserve quality and provide additional information on their current status (Chowdhury and Morey, 2019; Purbey et al., 2019). Equipped with sensors (biosensors and gas sensors), data carriers (barcodes and Radio-frequency identification systems - RFID) and indicators (time-temperature indicators - TTIs, freshness indicators and gas indicators) intelligent packaging ena-

bles more efficient exchange of data and information throughout food supply chain with the aim of optimizing logistics efficiency (Wang et al., 2019; Ghaani et al., 2016). At the same time, it provides more efficient communication of the packaged product with the final consumer (Fathahillah et al., 2020; Yam and Lee, 2012).

Since the primary objective of the food supply chain is the safe delivery and preservation of the quality of packaged food (Lee et al., 2015), manufacturers, farmers, trading companies and final consumers are increasingly demanding the introducetion of intelligent and innovative technologies in packaging systems to guarantee food safety, quality, and traceability (Vanderroost et al., 2014). Food quality control based on intelligent technology directly maximizes the efficiency of the food industry and ensures more effective consumer protection. As an integral part of intelligent packaging, active packaging is based on the incorporation of active agents into/onto packaging material with the aim of maintaining the quality for a longer time and extending the shelf life of food products (Xing et al., 2010, Vilela et al. (2018).

Despite these advantages, intelligent food packaging has not found widespread use in the domestic market. The most common reasons are the commercial unsustainability of these systems due to the high initial costs of their implementation, strict food safety and hygiene regulations, and limited acceptance by final consumers (Đurđević et al., 2016; Radusin et al., 2016; Vanderroost et al., 2014). In this regard, the main purpose of this paper is to present the results of ongoing academic and scientific studies, new technological developments and new technologies in order to gain a better insight into the perspective and potential of the application of intelligent packaging in food production and marketing. The aim of this paper is to analyze the possibility of using intelligent food packaging in the market of AP Vojvodina. In this context, the habits, decisions and expectations of final consumers in the food purchasing process were examined and the external limitations and expected benefits of introducing intelligent packaging by food supply chain participants were identified. *The practical importance of the work* is reflected in the fact that on the basis of the collected and systematized data, an insight for the competent institutions and supply chain management is provided on what measures should be taken to encourage the implementation of intelligent technologies in food packaging.

The paper consists of five parts. After the introductory consideration, the Literature Review provides an overview of the most important theoretical points about the importance of intelligent food packaging, the benefits of implementing new technological advances in food packaging, and the basic components of final packaging that detect, record and transmit product information throughout the supply chain. The research objective, research hypotheses, method, sample structure, measurement variables, and research procedure are presented in the *Materials and Methods* chapter. *Research Results* summarizes the most important data and test results of the hypotheses. In the *Discussion* chapter, a comparison was made with the results of related studies and a set of measures, procedures and activities were defined to encourage the development of intelligent food packaging in the market of AP Vojvodina. The *Conclusion* summarizes the most important research findings, points out the identified shortcomings and provides suggestions for future research.

Literature review

Although conventional forms of packaging and packaging materials today meet the highest number of requirements, both from manufacturers of final products, logistics, distribution and retail systems, and consumers themselves, in the period since 2000 with the increasing development of information technology, a number of research in the global market is dedicated to the development of a new type of packaging, known as intelligent packaging. The authors agree that the implementation of intelligent technologies in packaging systems upgrades and enhances the basic functions of traditional packaging such as protection (Adeyeye, 2019; Restuccia et al., 2010), communication (Fuertes et al.,

2016), convenience (Ghaani et al., 2016) and containment (Vanderroost et al., 2014). Using a variety of technologies that are built into the final packaging, intelligent packaging enables the timely exchange of information and the monitoring of the packaged product within the supply chain, as well as the exchange of information between the packaging itself and the final consumer. This is achieved through three components: I) sensors - they detect any changes in the physical (biosensors) or chemical (gas sensors) properties of the packed product (Yousefi et al., 2019); II) data carrier devices or RFID tags and barcodes - they provide more efficient flow of information between chain members about product location, production method, storage and distribution conditions, inventory status, physical damage, etc. (Liao et al., 2019) and III) indicators - through visual changes on the packaging itself indicators transmit information to consumers about harmful changes in temperature of packaged contents (time-temperature indicators - TTIs), the impact of microbes and the occurrence of chemical changes on the product (freshness indicators), and changes in the internal atmosphere of the packaging (gas indicators) (Ghaani et al., 2016).

Market indicators are in favour of the increasing practical use of intelligent packaging. The packaging industry is currently one of the fastest-growing industrial sectors, especially in the area of food production and marketing, which in Europe is named the largest manufacturing sector worth over the US $ 1.100 billion. Total market share for intelligent and active packaging is estimated at approximately US $ 5.68 billion in 2018, with an expected average annual growth rate of 5.9% in the global market, reaching a total value of US $ 7.56 billion by 2023 (Marie Mohan, 2018). The number of mobile applications available is also increasing significantly, enabling consumers to directly connect with the packaged product and keep track of any changes, thus creating a new market of over 2.5 billion potential customers.

Requirements to preserve the product's value in use, its safety and quality, as well as its longer shelf life, have led to the widespread use of intelligent packaging primarily in the food industry. With its properties, intelligent packaging can monitor food and instantly transmit information about certain parameters of its quality during transport, storage and sale (Grubor, Djokic, 2015). Studies (Končar et al., 2018; Lee et al., 2015; Danielli et al., 2008) show that detecting and recording external and internal changes to packaged content, with timely exchange of information along the entire supply chain, is particularly important with easily perishable food products, such as meat and meat products, fruits, vegetables, fish, etc., where organoleptic properties and visual identity are critical to the purchasing decision. In addition, studies show that over 40% of food in the US market, with a total value of approximately US $ 165 billion, is lost, that is, not consumed in the intended use period and ends up in landfills (Gunders, 2012). The main challenge for intelligent food packaging is the development and implementation of packaging systems that continually monitor and increase the shelf life of foods and are easily degradable or recyclable, thus reducing the adverse impact on the environment. To this also contributes the EU Directive (EU) 2018/851 on the obligation to reduce food waste from 1.3 billion tonnes in 2017 to 0.6 billion tonnes or by 50% by 2030.

In addition to some of the benefits of intelligent food packaging, both for supply chain participants and for final consumers, its application is still not fully exploited, especially in transition countries. The most common reasons for limited application are the high costs of intelligent technology implementation into existing business systems, the high retail price of packaging and the product itself, limited readiness to be accepted by final consumers and supply chain participants, and complicated legislative and safety regulations, especially in the area of hygiene and contact of intelligent components with food (Dainelli et al., 2008). In the market of the Republic of Serbia and AP Vojvodina, few manufacturers, distributors and retailers have integrated intelligent components into their packaging systems. The exception is some

logistic companies that have embraced the trend of tagging shipments with RFID tags, as well as foreign retail chains, which, through the use of intelligent packaging, reduce inventory costs, enhance the logistics concept of *Quick Response* (QR) and communicate more effectively with final customers. For domestic Small and Medium Sized Enterprises (SMEs) in the production and marketing of food, the biggest problem with the commercial sustainability of intelligent food packaging is the high cost and insufficient purchasing power of consumers. Other than that, some studies state that there is still no satisfactory level of readiness and habit in the domestic market for consumers to replace conventional packaging with intelligent packaging (Đurđević et al., 2016).

Considering the stated aspects, it is necessary to determine whether and in what way intelligent packaging is related to the habits, decisions and expectations of consumers in the process of purchasing food on the market of AP Vojvodina. This would define the economic justification for introducing intelligent food packaging into the supply chain, viewed from the perspective of the final consumer, because if the market does not recognize the need for intelligent packaging, then it is necessary to first take measures to popularize it in the final consumption segment, and only after this start with its practical application. At the same time, in accordance with the set area of research, it is necessary to accurately identify all external factors that act as constraints for the implementation of intelligent components in the food supply chain participants' packaging systems and clearly define and present the concrete advantages that this type of business brings to all economic entities in the production.

MATERIALS AND METHODS

Aim and Hypotheses

The aim of the research is to analyze the potential of using intelligent food packaging in the market of AP Vojvodina. The set research goal was operationalized through two research tasks: 1) to define the degree of correlation between intelligent packaging and habits, decisions and expectations of final consumers in the food purchasing process, and 2) to determine the dependence between the introduction of intelligent packaging in the food supply chain and external constraints, that is, specific benefits for supply chain participants. On the basis of the set goal and research goals the following research hypotheses have been defined:

H_1: Consumers' shopping habits and food choices statistically significantly predict the use of intelligent packaging?

H_2: Consumers' decision to buy food statistically significantly predicts the use of intelligent packaging?

H_3: Consumers' expectations of food quality statistically significantly predict the use of intelligent packaging?

H_4: External constraints statistically signifycantly predict the use of intelligent packaging in the business processes of food supply chain participants?

H_5: Expected benefits of food supply chain participants predict statistically significant use of intelligent packaging?

Variables and measurement instruments

In order to confirm or reject the hypotheses as accurately as possible, the study included several predictors and criterion variables. In order to test the first three research hypotheses, the predictor set consisted of variables describing the habits, decisions, and expectations of final consumers when purchasing food products, and was operationalized through seven indicators for habits, five indicators for decisions, and three indicators for expectations. Respondents evaluated the contributions of individual indicators on the basis of a standard Likert-type scale (grades 1 - 5). The criterion variable consisted of an assessment of consumer familiarity with the basic properties of intelligent packaging. In testing the remaining two hypotheses, a set of predictor variables consisted of indicators indicating different types of external constraints and the expected benefits of introducing intelligent food packaging with supply chain participants. There were eleven indicators for external constraints and four indicators indicating benefits.

Table 1.
Structure of research sample of final consumers

Gender	**No.**	**%**
Male	65	55.6
Female	52	44.4
Total	117	100.0
Education level	**No.**	**%**
Primary	17	14.5
Secondary	27	23.1
College degree	40	34.2
University degree	33	28.2
Total	117	100.0
Age	**No.**	**%**
Under 30	13	11,1
30 to 50	43	36,8
50 to 65	40	34,2
Over 65	21	17,9
Total	117	100.0
Household income	**No.**	**%**
Under 50,000 RSD per month	25	21.4
50,000 to 100,000 RSD per month	30	25.6
100,000 to 150,000 RSD per month	40	34.2
Over 150,000 RSD per month	22	18.8
Total	**117**	**100.0**

A standard Likert scale was also used to evaluate individual indicators.

The criterion variable was the application of intelligent packaging itself in the business processes of the food supply chain participants.

Research sample characteristics

The research was conducted on two separate stratified samples of final consumers and participants of the food supply chain. The final stratified consumer sample comprised of 117 responders on AP Vojvodina market. Detailed structure of the first research sample is presented in Table 1.

The second stratified sample included respondents from 51 different companies as participants in the food supply chain. By looking at the distribution, it can be seen that there were 11.8% of micro-enterprises, 29.4% of enterprises were classified as small, 35.3% were medium-sized and 23.5% were large. Most companies, almost three quarters (74.5%), have the HACCP standard, while the rest is outside the defined standard. The survey included enterprises engaged in food production (n = 9; 17.6%), agriculture (n = 14; 27.5%), physical distribution (n = 15; 29.4%), and retail (n = 13; 25.5%).

Procedure and statistical data processing

In both strata, the testing was carried out in the period from August to November 2019 in the territory of AP of Vojvodina, as part of the project "Possibilities of using intelligent packaging as a segment of green marketing logistics in the function of sustainable development in the market of AP Vojvodina". Survey of the respondents was done electronically on the basis of e-questionnaires, as well as field questioning of managers in business entities related to the food supply chain. The obtained data were systematized and processed on the basis of the statistical software SPSS20. The set research hypotheses were tested on the basis of multiple regression analysis, while the correlation was tested on the basis of Pearson's correlation coefficient.

RESULTS

The first three hypotheses seek to determine the correlation of consumers' habits, decisions and expectations with the basic properties of intelligent food packaging, that is, with the function, usability and con-

fidence they have in intelligent packaging. In this context, based on hypothesis **H_1**, we are trying to determine whether it is possible to predict based on consumers' purchasing habits and choice of food, their familiarity with the properties of intelligent food packaging. Multiple regression analysis was applied in order to test the first hypothesis. The predictor set consisted of variables describing consumer purchasing habits and operationalized through seven indicators; the criterion variable consisted of assessing consumer familiarity with the properties of intelligent packaging. The regression analysis performed was statistically significant ($F(7,109) = 24.48$, $p<0.001$). The set of predictive variables describes 61.1% of the variance of familiarity with the properties of intelligent packaging. In addition to the significance, individual predictor contributions to the criterion variable were tested (Table 2). Based on the information given in the table above, it can be seen that paying attention to freshness, organoleptic properties (appearance, colour and odor), the packaging itself, as well as a real insight into the quality and content of food when shopping predict a criterion variable in a positive direction. A significant correlation is also present in the preservation of the quality of

Table 2.
Individual predictor contributions to explaining criterium variance

Indicators	Stan. coefficient (Beta)	t	Sig.
I pay attention to the freshness of food products	0.442	5.165	0.000**
I pay attention to organoleptic properties of food products	0.333	4.483	0.000**
I pay attention to the packaging of food products	0.446	5.249	0.000**
Food packaging should enable a real insight into the quality and content of the food	-0.079	1.246	0.005**
Packaging should ensure the preservation of value in use and quality of food in a longer period	-0.352	4.764	0.011*
I buy food products with more modern and attractive packaging	-0.479	-7.518	0.000**
It is important that packaging is simple and practical to re-use	-0.202	2.369	0.020*

*** Significant at the level 1%; * significant at the level 5%;*
Beta: relative importance of each independent variable in predicting the dependent variable;
t: regression parameters (individually) other than 0;
Sig.: individual predictor contributions to the dependent variable

Table 3.
The correlation between consumers' buying decisions and the impact of the intelligent packaging on buying decisions

	An increasing number of food products has intelligent packaging	Intelligent packaging has a positive impact on loyalty	Accepting a higher price for intelligent food packaging	Participating in intelligent packaging return	The advantage of foreign producers is related to intelligent packaging
An increasing number of food products has intelligent packaging	0.245	-0.320*	-0.094	-0.079	-0.031
Intelligent packaging has a positive impact on loyalty	1	-0.002	0.086	0.044	0.072
Accepting a higher price for intelligent food packaging		1	0.309**	0.304*	-0.066
Participating in intelligent packaging return			1	0.440	-0.051
The advantage of foreign producers is related to intelligent packaging				1	-0.029**

*** Significant at the level 1%; * significant at the level 5%*

Table 4.
Individual predictor contributions to explaining criterion variance

Indicators	Stan. Coefficient (Beta)	t	Sig.
The use of Intelligent packaging is justified in protecting the environment and human health	0.408	5.072	0.000**
The use of intelligent packaging reduces the level of deterioration of food products	0.071	0.882	0.008**
Intelligent packaging shortens the food supply chain	0.330	4.106	0.000**

*** Significant at the level 1%; * significant at the level 5%;*
Beta: relative importance of each independent variable in predicting the dependent variable;
t: regression parameters (individually) other than 0;
Sig.: individual predictor contributions to the dependent variable

Table 5.
Individual predictor contributions to explaining criterion variance

Indicators	Stan. coefficient (Beta)	t	Sig.
Lack of financial assets	0.029	0.171	0.000**
Low skilled and untrained labour	.160	0.955	0.006**
Outdated technology and equipment	- 0.256	1.782	0.022*
High cost	0.034	0.223	0.005**
Suppliers unwillingness to innovate packaging	-0.493	3.260	0.002**
Inadequate quality of logistics services in physical-manipulation activities	-0.322	-1.679	0.101
Retailers' pressure to limit the price of the final product	-0.117	0.700	0.058
The lack of awareness of the intelligent packaging concept by final consumers	0.002	0.014	0.989
Cost reduction effects are not adequate in relation to investments	0.270	1.679	0.001**
Inadequate level of quality of intelligent packaging in the domestic market	-0.036	-0.227	0.822
Low level of interest in the application of the concept of returnable packaging	0.029	0.171	0.865

*** Significant at the level 1%; * significant at the level 5%;*
Beta: relative importance of each independent variable in predicting the dependent variable;
t: regression parameters (individually) other than 0;
Sig.: individual predictor contributions to the dependent variable

Table 6.
Individual predictor contributions to explaining the criterion variance

Indicators	Stan. coefficient (Beta)	t	Sig.
Increasing the efficiency of inventory turnover ratios	0.392	2.861	0.006**
Reducing the return on perishable and expired products	0.214	1.613	0.004**
Reducing the share of total logistics costs	-0.136	-0.987	0.029**
Gathering information on the habits and expectations of final consumers	-0.187	-1.435	0.057

*** Significant at the level 1%; * significant at the level 5%;*
Beta: relative importance of each independent variable in predicting the dependent variable;
t: regression parameters (individually) other than 0;
Sig.: individual predictor contributions to the dependent variable

the food. for a longer period and the possibility of practical reuse of the packaging.

On the other hand, the focus on more modern and attractive packaging in the negative direction predicts familiarity with the properties of intelligent packaging. Based on the obtained results, it can be said that the first hypothesis $\mathbf{H_1}$ is confirmed and that there is a statistically significant correlation between consumers' shopping and food choices and the basic properties of intelligent packaging. The conclusion is that based on the defined habits of consumers when buying and choosing food products, it is possible to predict their familiarity with the properties and functions of intelligent packaging.

The second research hypothesis $\mathbf{H_2}$ related to the correlation of consumers' decisions when buying food and the basic properties of intelligent packaging was tested by Multiple regression analysis. The predictor set was made of indicators which describe consumers' purchasing decisions. Criterion, that is, the dependent variable is the impact of intelligent packaging

itself on the purchasing decision. After the application of regression analysis, the obtained results indicate that the predictor set describes only 1.7% of criterion variable, hence the regression equation is not statistically significant. Based on the obtained results, the second research hypothesis $\mathbf{H_2}$ is rejected and it can be concluded that consumers' decisions on buying food products are not related to the properties of intelligent packaging. Besides regression analysis itself, the correlation of consumers' buying decisions was also tested by using Pearson's correlation. The correlation matrix results are given in Table 3.

Table 3 shows that most correlations between the indicators related to the decision on buying food are low and statistically insignificant. There are only a few correlations that are statistically significant, mostly mean values. The highest correlation was observed between the indicator of higher price acceptance for intelligent food packaging and the perceived advantage of foreign participants in the supply chain in the greater use of intelligent packaging. The results obtained confirm the previous conclusion about the rejection of the second research hypothesis $\mathbf{H_2}$.

Multiple regression analysis was also applied in testing the third hypothesis $\mathbf{H_3}$ regarding consumer expectations of using intelligent food packaging. A set of predictor variables consists of consumer expectations operationalized through three indicators. The dependent or criterion variable was defined as the respondent's response to the item that the use of intelligent packaging instils confidence in the quality of food products. The regression equation was statistically significant ($F = 14{,}657$, $p < 0.001$). The predictor set describes 28% of the criterion variable. The predictor contributions are given in Table 4.

Predictor contributions indicate that all three indicators make a statistically significant contribution to explaining the criterion variable. The beta coefficients of all indicators are positive and relate to the significant properties of intelligent packaging in protecting the environment, reducing food deterioration and shortening the supply chain. Respondents who score high on these variables will see intelligent packaging as a basis of confidence for the quality of food products to a greater extent. Based on the results obtained, the third hypothesis $\mathbf{H_3}$ is accepted and the conclusion is that consumer expectations of food quality statistically significantly predict the use of intelligent packaging, that is, the confidence that intelligent packaging gives to food products.

Hypotheses $\mathbf{H_4}$ and $\mathbf{H_5}$ seek to describe the nature of the connection between perceived external constraints and expectations of intelligent packaging on the one hand, and its implementation in the food supply chain, on the other. The entities in this analysis are enterprises engaged in production, agricultural, physical distribution and retail, trade, transport, production and farms. In order to test the research hypothesis $\mathbf{H_4}$, the predictor set of regression analysis included 11 indicators indicating different types of external constraints. The criterion variable was the very use of intelligent packaging in the business activities of the company. The results of the regression analysis show that the set of predictor variables statistically significantly predicts the use of intelligent packaging in business processes ($F (11, 39) = 2.221$, $p < 0.05$). External constraints predict 38.5% of the variance in the use of intelligent packaging. Table 5 provides individual contributions to the explanation of the criterion variable.

The table above shows that the use of intelligent packaging in the food supply chain is statistically significantly influenced by indicators of constraint such as lack of financial assets, untrained labour, outdated technology and equipment, high cost, negative cost /investment ratio and supplier unwillingness to innovate packa-ging. A high contribution, although not statistically significant, is also an item that speaks to retailers' pressure to limit the price of the final product. Based on the results of the Multiple Regression Analysis, it is concluded that the $\mathbf{H_4}$ hypothesis is accepted and that the observed external constraints can statistically significantly predict the use of intelligent packaging in the business processes of food supply chain participants.

In examining the fifth research hypothesis $\mathbf{H_5}$ the predictor set consisted of four indicators indicating the expected benefits that food supply chain participants would derive from the use of intelligent packaging. The criterion variable represents the increase in the use of intelligent packaging. The percentage of this variance is 25.7%. The regression equation was statistically significant ($F(4,46) = 3,973$, $p < 0.01$). Table 6 lists individual predictor contributions to explaining the criterion variance.

Based on the presented data, it can be concluded that significant predictor contributions are realized by indicators of increasing the efficiency of the inventory turnover ratio, reducing the level of return of perishable products and reducing the share of total logistics costs. They predict the criterion variable in a positive direction. The remaining indicator regarding the ability to gather information about consumer needs, habits and expectations are on the verge of statistical significance and negative direction, primarily as a result of responses from physical distribution companies that do not show a high level of interest in the behaviour and habits of final consumers. The conclusion is that the research hypothesis $\mathbf{H_5}$ is accepted and that the expected benefits of food supply chain participants statistically significantly predict the use of intelligent packaging. In other words, higher scores on these indicators significantly predict the increase in the use of intelligent food packaging.

DISCUSSION

The obtained data, performed analyses and performed testing of the hypotheses lead to the conclusion that based on the habits and expectations of final consumers from the market of AP Vojvodina, it is possible to predict the level of application of intelligent food packaging. At the same time, there is no correlation between the decision to buy food and intelligent packaging, that is, intelligent packaging does not affect the purchase of food products in the AP Vojvodina market. Intelligent packaging responds to the habits and expectations which consumers have in the food purchasing process, but it is not a decisive factor that influences their decision on product selection and purchase. Such results are confirmation of some previous studies which as the main motives for purchasing state price, consumer purchasing power, the convenience of purchase, consumer needs, etc. (Končar et al., 2019; Liang, 2012).

Summarized results of the analysis of the first stratified sample in the market of AP Vojvodina show that consumers pay the most attention to freshness, organoleptic properties and method of packaging of food products. They prefer realistic insight into the quality and content of food, as well as the possibility of multiple functional uses of packaging. Final consumers are aware that the use of intelligent food packaging boosts logistics, contributes to environmental protection, human health and safety, reduces food spoilage and deterioration, and shortens the food supply chain. In this way, the results of previous research have been confirmed (Đurđević et al., 2016; Lee et al., 2015; Dainelli et al., 2008), which marks these advantages of intelligent packaging as the primary factor that will lead to the complete replacement of conventional packaging forms by intelligent systems packaging.

External factors which act as constraints on the full exploitation of intelligent packaging in the food supply chain have been identified within the second stratified sample. Testing showed a statistically significant correlation between limitations and the use of intelligent packaging. Similar to the results of the study by Dainelli et al. (2008) the growing importance of indicators such as lack of financial resources, untrained workers, outdated technology and equipment, high price and high implementation costs, reduces the potential for the use of intelligent food packaging. With regards to this, the competent institutions and food supply chain managers have to take a whole set of complex measures and policies to minimize the impact of external constraints. In this context, it is imperative that the competent ministries and secretariats: I) adopt a comprehensive incentive program in the form of tax credits, favourable credit lines and financial subsidies for all food supply chain participants opting for the use of intelligent packaging,

II) organize workshops and seminars in which they will make clear to all businesses in the manufacturing, agriculture, physical distribution and retail sectors the benefits of applying intelligent technologies; III) cofinance the introduction of smart technologies and digitalization processes such as Internet of Things, RFID, etc. In addition, it is essential that the competent ministries fully harmonize existing legislative solutions and legal acts with EU direc-tives and regulations such as CT 98-4170 (FAIR-project Actipak), EC Directive 450/2009; EU Framework Directive Directive 89/109 / EEC, Directive 94/62 / EC on Packaging and Packaging Waste, etc. In addition, the management of the food supply chain should take a set of measures that will reduce the negative impact on the implementation of intelligent packaging, by devoting training and prequalification of employees, modernization of production and physical-manipulation processes, standardization of business processes and activities, etc.

Contemporary needs, habits and expectations of consumers, place the task of paying special attention to improving the methods of production and marketing of food that maintain value in use and extend the shelf life of the product, in front of all the participants of the food supply chain.

One way to accomplish this complex task is to fully implement intelligent packaging systems. When it comes to the benefits of intelligent packaging for the food supply chain itself, such as increasing the efficiency of inventory ratios, reducing the return on perishable products, reducing logistics costs and more effectively communicating the needs and habits of final customers, it becomes clear that investing in the application of intelligent packaging and its implementation are a reality, and only those businesses that apply intelligent technology in a timely manner will be able to count on survival in the global market.

CONCLUSIONS

The need to explore the potential of intelligent food packaging in the market of AP Vojvodina stems from the fact that it is a segment of business that is increasingly applied in the sector of production, processing, physical distribution and retailing of food. Since the domestic market is still not open enough to embrace new technologies, the purpose of this paper was to point out the real benefits that intelligent packaging provides, both to final consumers and to all participants in the food supply chain. The results showed a strong correlation between intelligent packaging and the habits and expectations of final consumers in the food purchase process, but not with their purchasing decision. Also, the most common external factors that appear as limitations for the application of intelligent technology in the market of the Republic of Serbia and AP Vojvodina are pointed out. Based on the results obtained, a set of measures to be taken by the competent institutions, ministries and secretariats, as well as the food supply chain management, was proposed, with the obligation of complete harmonization of national provisions, rules and regulations governing packaging and packaging waste, with international law and legislation, and above all EU directives.

Limitations of the study are reflected in the research being limited to the area of AP Vojvodina. An objective reason for choosing this given market lies in the orientation of the basic research project towards the analysis of the functioning of the market of AP Vojvodina, owing to which the research in question was realized. In addition, the reasons for choosing this sample are in the author's familiarity and knowledge of the functioning of production, physical distribution, retail, habits and behaviour of domestic consumers in the regional market, but also in the fact that the market of AP Vojvodina is suitable for research due to the developed production, distribution and retail network.

Suggestions for future research should be directed towards the selection of a larger research sample that would include all countries of the Western Balkans region, with particular emphasis on the comparative exploration of the potential of using intelligent food packaging between EU and non-EU countries. In addition, the testing itself should include an analysis of the economic viability of intelligent technolo-

gies, in the form of the impact of intelligent packaging on business performance, that is, the productivity and profitability of participants in the food supply chain.

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REFERENCES

1. Adeyeye, S.A.O. (2019). Food packaging and nanotechnology: safeguarding consumer health and safety. *Nutrition and Food Science, 49* (6), 1164-1179.
2. Asri, N.A.S.M., Maqsood-ul-Haque, S.N.S., Ibrahim, U.K., Tan, H.L. (2019). A review of biodegradable films from industrial by-products for food packaging. *International Journal of Environmental Engineering, 10* (2), 157-173.
3. Bledsoe, G., Rasco, B. (2018). Recent advances on intelligent and active packaging in food and beverage technology. *Food Health and Technology Innovations, 1* (2), 72-74.
4. Chowdhury, E.U., Morey, A. (2019). Intelligent packaging for poultry industry. *The Journal of Applied Poultry Research, 28* (4), 791-800.
5. Dainelli, D., Gontard, N., Spyropoulos, D., Zondervan-van den Beuken, E., Tobback, P. (2008). Active and intelligent food packaging: legal aspects and safety concerns. *Trends in Food Science and Technology*, *19*, 103-112.
6. Directive (EU) No. 851 (2018). *Official Journal of the European Union, L150/109.*
7. Dobrucka, R. (2014). Recent trends in packaging systems for pharmaceutical products. *LogForum, 10 (*4), 393-398.
8. Fathahillah, F., Siswanto, M., Fauziyah, M., Parlindungan, R., Putri, R.I., Roh, Y.G. (2020). Implementation of Programmable Logic Controller in multi machine operations with product sorting and packaging based on colour detection. IOP Conference Series: Materials Science and Engineering, IOP Publishing, Bristol, United Kingdom, *Proceedings,* 732 (1), pp. 12-69.
9. Fuertes, G., Soto, I., Carrasco, R., Vargas, M., Sabattin, J., Lagos, C. (2016). Intelligent packaging systems: sensors and nanosensors to monitor food quality and safety. *Journal of Sensors, 2016,* 1-8.
10. Gunders, D. (2012). Wasted: How America is losing up to 40 percent of its food from farm to fork to landfill, Natural Resources Defense Council, New York, USA (Retrieved November 03, 2019 from *https://www.nrdc.org/sites/default/files/wasted-food-IP.pdf*).
11. Ghaani, M., Cozzolino, C.A., Castelli, G., Farris, S. (2016). An overview of the intelligent packaging technologies in the food sector. *Trends in Food Science and Technology, 51*, 1-11
12. Grubor, A., Đokić, N. (2015). Determinants of choice of global and national food products' brands. *Strategic Management, 20*, 58-67.
13. Đurđević, S., Novaković, D., Zeljković, Ž., Avramović, D. (2016). Using augmented reality technology for controlling state of smart packaging products, *Preliminary report,* University of Novi Sad, Faculty of Technical Sciences, pp. 427-437.
14. Končar, J., Marić, R., Vukmirović, G. (2018). Izazovi vertikalne integracije učesnika lanaca snabdevanja prehrambenih i organskih proizvoda nacionalnog porekla. *Anali Ekonomskog fakulteta u Subotici*, *54*, 149-169.
15. Končar, J., Marić, R., Vukmirović, G. (2019). Analysis of key indicators that affect the expected benefit of customers when using loyalty cards. *Journal of Business Economics and Management, 20* (5), 821-840.
16. Lee, S.Y., Lee, S.J., Choi, D.S., Hur, S.J. (2015). Current topics in active and intelligent food packaging for the preservation of fresh foods. *Journal of the Science of Food and Agriculture, 95* (14), 2799-2810.
17. Liang, Y.P. (2012). The relationship between consumer product involvement, product knowledge and impulsive buying behaviour. *Procedia-Social and Behavioral Sciences, 57*, 325-330.
18. Liao, Y., Zhang, R., Qian, J. (2019). Printed electronics based on inorganic conductive nanomaterials and their applications in intelligent food packaging. *RSC Advances, 9* (50), 29154-29172.
19. Marie Mohan, A. (2018). Five trends boosting intelligent packaging adoption (Retrieved November 01, 2019, from *https://www.packworld.com/home/article/13375091/five-trends-boosting-intelligent-packaging-adoption*).
20. Maksimović, M., Vujović, V., Omanović-Mikličanin, E. (2015). Application of internet of things in food packaging and transportation. *International Journal of Sustainable Agricultural Management and Informatics, 1* (4), 333-350.
21. Purbey, S.K., Pongener, A., Marboh, E.S., Lal, N. (2019). Advances in packaging of litchi fruit to maintain the quality. *Current Journal of Applied Science and Technology, 38* (1),1-11.
22. Radusin, T.I., Ristić, I.S., Pilić, B.M., Novaković, A.R. (2016). Antimicrobial nanomaterials for food packaging applications. *Food and Feed Research*, *43* (2), 119-126.
23. Restuccia, D., Spizzirri, U.G., Parisi, O.I., Cirillo, G., Curcio, M., Iemma, F., Picci, N. (2010). New EU regulation aspects and global market of active and intelligent packaging for food industry applications. *Food Control, 21* (11), 1425-1435.

24. Vanderroost, M., Ragaert, P., Devlieghere, F., De Meulenaer, B. (2014). Intelligent food packaging: The next generation. *Trends in Food Science and Technology, 39* (1), 47-62.
25. Vilela, C., Kurek, M., Hayouka, Z., Röcker, B., Yildirim, S., Maria Dulce, A.C., Nilsen-Nygaard, J., Kvalvåg Pettersen, M., Freire, C.S.R. (2018). A concise guide to active agents for active food packaging. Trends in Food Science and Technology, 80, 212-222.
26. Wang, L., Wu, Z., Cao, C. (2019). Technologies and fabrication of intelligent packaging for perishable products. *Applied Sciences*, *9* (22), 48-58.
27. Xing, Y., Li, X., Xu, Q., Jiang, Y., Yun, J., Li, W. (2010). Effects of chitosan-based coating and modified atmosphere packaging (MAP) on browning and shelf life of fresh-cut lotus root (*Nelumbo nucifera* Gaerth). *Innovative Food Science and Emerging Technologies, 11* (4), 684-689.
28. Yam, K.L., Lee, D.S. (2012). Emerging food packaging technologies: An overview. In *Emerging Food Packaging Technologies*. Eds. K.L. Yam, D.S. Lee, Woodhead Publishing Limited, Philadelphia, pp. 1-9.
29. Yousefi, H., Su, H.M., Imani, S.M., Alkhaldi, K.M., Filipe, C.D., Didar, T.F. (2019). Intelligent food packaging: A review of smart sensing technologies for monitoring food quality. *ACS Sensors, 4* (4), 808-821.

ПОТЕНЦИЈАЛ УПОТРЕБЕ ИНТЕЛИГЕНТНЕ АМБАЛАЖЕ ЗА ПАКОВАЊЕ ПРЕХРАМБЕНИХ ПРОИЗВОДА НА ТРЖИШТУ АП ВОЈВОДИНЕ

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Сажетак: Циљ рада је анализа потенцијала употребе интелигентне амбалаже за паковање хране на тржишту АП Војводине. У теоријском делу рада приказана су основна својства интелигентне амбалаже и њен значај у процесу паковања прехрамбених производа. Посебно је наглашена комуникација интелигентне амбалаже и упакованог производа са финалним потрошачима кроз употребу различитих сензора, уређаја за прикупљање и пренос података и индикатора. На бази теоријске анализе дефинисана су екстерна ограничења и предности од употребе интелигентне амбалаже за финалне потрошаче и учеснике ланца снабдевања прехрамбених производа. У емпиријском делу рада спроведено је истраживање на два стратума. Први стратум обухватио је 117 финалних потрошача који су испитивани о значају интелигентне амбалаже за њихове навике, одлуке и очекивања у процесу куповине хране. У другом стратуму, који чине учесници ланца снабдевања, на узорку од 51 привредног субјекта, анализирани су екстерни фактори ограничења и очекиване предности примене интелигентне амбалаже при паковању хране на тржишту АП Војводине. Резултати истраживања су показали да су навике и очекивања финалних потрошача статистички значајно повезани са употребом интелигенте амбалаже у процесу куповине хране. Са друге стране, екстерна ограничења и очекиване предности за учеснике ланца снабдевања статистички значајно утичу на имплементацију интелигентне технологије у паковање хране. На бази добијених резултата, дефинисан је сет мера и подстицаја које надлежне институције и менаџмент ланца снабдевања морају предузети како би се искористио потенцијал интелигентне амбалаже у паковању хране. Сугестије за будућа истраживања наведене су у раду.

Кључне речи: *интелигентна амбалажа, паковање хране, прехрамбени производи, ланац снабдевања, потрошачи, куповне навике, АП Војводина*

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