

Influence of edible coatings on rye and rye-wheat bread quality

Oksana Shulga, Anastasia Chorna, Sergii Shulga

National University of Food Technologies, Kyiv, Ukraine

Abstract

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Corresponding author:

Oksana Shulga
E-mail:
shulgaos@ukr.net

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Introduction. The influence of edible coating on the quality of rye and rye and wheat bread in order to preserve the products of freshness and improve the nutritional value were studied.

Materials and methods. Samples of bread coating are made of potato starch, gelatin, flaxseed oil and water. The emulsion was applied to the bread by glazing. The control sample of the products was stored in a stretch film (rye bread) and in a package of synthetic polymer materials. The study of changing the characteristics of bread was made during the period of more than 24 hours. Organoleptic properties, the number of crumbs, water absorbing by crumb, and the structural and mechanical characteristics of the bread crumb were determined.

Results and discussion. The coating does not affect the shape of the products, allows to level the surface and makes it shiny, gives the colors a yellowish tint, does not affect the taste, because the coating itself has a neutral taste, it is easy to chew, the smell remains unchanged. The edible coating is an effective packaging material since the moisture of the products decreases slowly and at the same level with synthetic packing materials. The moisture preservation of products in the edible coating can be attributed to the vapor permeability of the coating, which is 4.77 mg/(m·h·kPa). The thickness of the coating is 0.540±0.005 mm. The thickness of the bread bags is 0.030 mm. The ability to absorb water by the bread crumb stored in synthetic material is slightly higher. The bread in the edible coating has crumbles as well as the bread stored in synthetic packaging. Freshness of products in edible coating for 48 hours of storage is higher by 3 % compared to products in synthetic packaging, at the end of storage (72 hours) – is greater by 2 % in the product in synthetic packaging. The moisture content of coating is 72 %, after drying and forming the coating on the bread surface, the moisture content of the coating is 5 %.

Conclusions. Edible coating is a complete environmental replacement of synthetic packaging for rye and rye-wheat bread.

Introduction

One of the tasks of the baking industry is improving the quality of the raw materials and to expand the range of products.

The following materials are used for packaging bread: paper, wax paper, polyethylene, bioreferenced polypropylene, polypropylene, polyvinyl chloride, polymer compositions. Smart packaging used for long-term storage of bakery products. The bactericidal materials used to prevent the molding products, which contains the surface layer of a polymer film with antiseptic and plasticizer [2].

Rye bread differs from wheat bread by chemical composition: essential amino acids, non-crystalline polysaccharides, minerals, and vitamins. The brewing varieties of rye flour have lower energy value due to higher humidity [3].

Raising the nutritional value of bread is carried out in the following areas:

- production of bread from whole grains for the enrichment of natural vitamins and minerals;
- use of various nutritional supplements: dairy products (natural and dry milk, buttermilk, whey), soy and pea flour;
- addition of non-traditional raw materials for baking (using potato, corn starch and other products) [4].

The study of rye bread quality is relevant since rye bread reduces plasma cholesterol levels in hypercholesterolaemic pigs when compared to wheat at similar dietary fibre level [5].

Consumption of wholemeal rye bread increases serum concentrations and urinary excretion of enterolactone compared with consumption of white wheat bread in healthy Finnish men and women [6].

In addition, the study of components of rye is still ongoing, for example, in the article [7–10].

The results of study [11] show that rye bread can be used to decrease hunger feelings both before and after lunch when included in a breakfast meal.

One of the main indicators of consumer properties of bakery products is the duration of their preservation of freshness. The peculiarity of bakery products is a sharp deterioration of consumer properties during storage. The problems of extension of freshness, improvement of qualitative indicators by introducing special components, technology improvement and packaging are also relevant today.

To prolong the shelf-life of bread, use of non-traditional raw materials and additives, which, in addition to slowing down the process of drawing, increase the nutritional value of bread [12, 13]. It was established that the addition of 5 % of rye-malt extract and 0.04 % of the enzyme preparation «Novamil» increases the mass fraction of dextrin in bread, which helps to slow down the process of drawing of finished products and extends their storage up to 10 days, and the use of jets of ultrahigh-frequency radiation allows extend the storage of such bread up to 1 month [14]. A recipe for bread made from rye flour and second grade wheat with addition of 3 to 5 % of extruded rye flour has been developed. It allows to obtain high quality bread and with extended shekf-life according to the Patent 47514. The addition of maltogenic α -amylase and rye-malt extract significantly extends the shelf-life of rye-wheat bread. Combined use of starter and food ingredients increases the nutritional value, eliminates the probability of microbiological damage during storage, and prolongs the freshness of the products. The use of dry potato mashed potatoes in the form of grains in the production of bread made on a liquid pre-dough has the best qualitative and

organoleptic characteristics, as well as slow down the process of drawing in 1.5-2 times [15].

The introduction of soy flour improves the quality of bread, slows down staling and improves the amino acid composition of the product [16]. The use of the Jerusalem artichoke powder in the technology of bakery products as a food additive has positively effect, intensifying the fermentation, improving the quality of bakery products, giving them a functional orientation, and extending the storage [17]. It has been established that the rye bread formula with the addition of 5 % laminaria powder and 5 % anise to the mass of flour allows for a new functional product – rye bread with high content of minerals, in the first place such scarcity of modern Ukrainians as iodine and iron [18].

The expediency of using blueberries in the formulation of rye and wheat bread «Improved» to improve biological value has been developed and scientifically proved [19].

The new types of functional bakery products include: rye-wheat bread on hop sourdough with sprouted wheat grain «Family», rye-wheat bread on hop sourdough with sprouted wheat grains and pumpkin mashed potatoes «Seliansky», rye-wheat bread on hop sourdough from sprouted grain of wheat with a concentrate of leavened wort and milk thistle «Slavic» [20].

Residual oat flour, acquired during the production of β -D-glucan concentrate «Betaven», contained comparable amounts of dietary fiber as rye flour, and higher ash, crude fat and protein, as compared to both bread flours: wheat and rye [21].

The study [22] demonstrates that starch coating could be a simple, effective and practical application for reducing acrylamide levels in bread crust without changing the texture and crust color of bread.

Consequently, there is no development of biodegradable edible materials for rye and rye-wheat bread according to the above-mentioned literary data. In addition, the following ways to improve the nutritional value of products are made by placing the appropriate raw materials into the product at the dough preparation stage, which prevents the use of non-thermostable substances, such as vitamins C, F, etc.

Materials and methods

Samples of bread coating are made of potato starch – 5 %, gelatin – 15 %, urea (E 927b) – 3 %, flaxseed oil – 5 %, water – the rest (72 %). The coatings were prepared as follows: film formers – starch and gelatin were mixed in dry form, water was added and heated to dissolve gelatin and starch gelling, then added plasticizer – urea. The solution was cooled to 40 °C and flaxseed oil was added to a homogeneous emulsion. The emulsion was applied to the bread by glazing and held for 12 hours until it was completely dry.

The control sample of the products was stored in a stretch film (rye bread) and in a package of synthetic polymer materials at the temperature of 20 °C and a relative humidity of air not exceeding 75 %. According to the labeling of rye bread has a shelf life of 48 hours, and rye-wheat – no more than 5 days. The storage of products is no more than 72 hours for bread packed, but with the approval of the admissions committee, the storage of the packaged product can be set for more than 3 days. In this case, the storage is indicated in a standardized formulation that is subject to a state sanitary-and-epidemiological examination. The study of changing the characteristics of bread was made during the period of 24 hours longer than the specified time on the marking to check the suitability of replacing synthetic packaging with biodegradable edible and the possibility of lengthening the storage.

Organoleptic of bread were determined by tasting.

The freshness of bakery products was determined according to the methods given in the literature [23], according to the following indicators: the number of crumbs, water absorbing by crumb, and the structural and mechanical characteristics of the bread crumb on the penetrometer.

The thickness of the film was measured by a micrometer.

Results and discussion

The following organoleptic parameters: appearance: shape, surface, color; crumb; taste and smell monitor in the rye and rye-wheat flour bread.

In accordance with tasting application of the coating does not affect the shape of the products, allows to level the surface and makes it shiny, gives the colors a yellowish tint, does not affect the taste, because the coating itself has a neutral taste, it is easy to chew, the smell remains unchanged.

Reducing the humidity of products is the most characteristic indicator indicating the waning of products whose study results are shown in Table 1.

Table 1
Changing the moisture of bread products depending on the type of packaging

Storage, hours	Moisture, %			
	Rye bread		Rye-wheat bread	
	Synthetic film	Edible coating	Synthetic film	Edible coating
3	49.3±0.5		46.2±0.5	
24	47.2±0.5	46.9±0.5	44.5±0.5	44.7±0.5
48	45.4±0.5	45.2±0.5	43.0±0.5	43.3±0.5
72	43.8±0.5	43.3±0.5	41.4±0.5	41.6±0.5
96	-	-	39.8±0.5	40.0±0.5
120	-	-	38.4±0.5	38.5±0.5
144	-	-	37.9±0.5	37.7±0.5

The results presented (Table 1) show that the edible coating is an effective packaging material since the moisture of the products decreases slowly and at the same level with synthetic packing materials. The difference in the values of sample moisture lies within the error of the experiment. Consequently, edible coating helps maintain moisture inside the product.

The moisture preservation of products in the edible coating can be attributed to the vapor permeability of the coating, which is 4.77 mg/(m·h·kPa). The given value refers to the developed packaging material for materials with a high barrier to water vapor [24].

The thickness of the coating is 0.540±0.005 mm. The thickness of the bread bags is 0.030 mm.

The cost of synthetic packaging (bag with a clip) is 0.5 UAH (0.017 euro, may 2017), the coast of edible coating – 1.81 UAH (0.062 euro, may 2017). However, the use of edible coatings will solve the environmental problem of recycling synthetic packaging materials, which also requires investment. Without waiting for the onset of the biodegradable polymer

era, in April 2015, the European Parliament approved Directive 94/62/EU [25] on reducing the use of lightweight (<50 microns thick) and ultra light (<15 microns) plastic bags currently in the vicinity economic and technological reasons are subject to recycling in very limited quantities. It is said that until December 31, 2019, the annual consumption of light bags per capita should not exceed 90 pcs. and 40 pcs. until December 31, 2025. Package fees will be charged in all EU countries by the end of 2018. These measures can be commented rather rigid, because according to statistics in 2010, average Europeans use around 200 such bags annually. These measures can be commented rather rigid, because according to statistics in 2010, average Europeans use around 200 such bags annually [26]. In addition, some ingredients of edible coating can increase the nutritional value of products. The composition of the proposed edible coating includes flaxseed oil rich in vitamin F. This vitamin is not heat-resistant, therefore it is impossible to enrich the food with this anticholesteric vitamin that is subjected to heat treatment (baking in this case).

During the storage, natural polymers that are part of the grain products are aging and decrease the ability to absorb water [3, 27]. Crumb worse absorbs water in the case that aging is more intense. The results of the study of the change in the properties of absorb water are shown in Table 2.

Table 2

Changing the absorbing water by bread crumbs during the storage

Storage, hours	Absorbing water, % on solids			
	Rye bread		Rye-wheat bread	
	Synthetic film	Edible coating	Synthetic film	Edible coating
3	292±5		416±5	
24	245±5	239±5	348±5	353±5
48	217±5	208±5	311±5	305±5
72	182±5	177±5	282±5	273±5
96	-	-	254±5	249±5
120	-	-	240±5	234±5
144	-	-	218±5	207±5

Results of Table 2 show the ability to absorb water by the bread crumb stored in synthetic material is slightly higher, but the difference in values is within the error of the experiment. Consequently, the absorbing water by bread crumbs indicates the expediency of replacing the synthetic material with a biodegradable edible coating.

Aging of natural grain polymers will also increase the number of crumbs of products. The results of the study the number of crumbs are shown in the Table 3.

Table 3 shows that the bread in the edible coating has crumbles as well as the bread stored in synthetic packaging. This can be explained by the fact that the humidity of the products is kept at the same level regardless of the type of packaging. The difference in values for rye bread of 0.3% and 0.2% for rye and rye-wheat bread is within of experiment error.

Table 3

The number of crumbs changing during the storage

Storage, hours	The number of crumbs, %			
	Rye bread		Rye-wheat bread	
	Synthetic film	Edible coating	Synthetic film	Edible coating
3	2.2±0.1		0.4±0.1	
24	3.0±0.1	2.8±0.1	0.8±0.1	0.9±0.1
48	3.6±0.1	3.9±0.1	1.1±0.1	1.2±0.1
72	4.0±0.1	4.3±0.1	1.4±0.1	1.5±0.1
96	-	-	1.8±0.1	1.9±0.1
120	-	-	2.0±0.1	2.0±0.1
144	-	-	2.2±0.1	2.0±0.1

Another factor that characterizes freshness is the structural and mechanical properties are determined by a penetrometer.

The results of the study are presented in Table 4, 5 and Fig. 3, 4.

Table 4

Changes in the structural and mechanical properties of the crumb during the storage of rye bread

Storage, hours	Synthetic film			Edible coating		
	General deformation, units of the device	Plastic deformation, units of the device	Elastic deformation, units of the device	General deformation, units of the device	Plastic deformation, units of the device	Elastic deformation, units of the device
3	45.0	37.0	8.0	45.0	37.0	8.0
24	39.5	32.0	7.5	38.0	31.8	6.2
48	33.0	29.0	4.0	34.0	27.5	6.5
72	26.4	22.3	4.1	25.5	20.5	5.0

Results Table 4 show that the change in the deformation characteristics of rye bread varies at the same level regardless of packaging material type.

According to the results (Fig. 3) freshness of products in edible coating for 48 hours of storage is higher by 3 % compared to products in synthetic packaging. However, at the end of storage (72 hours) the freshness of products is greater by 2% in the product in synthetic packaging.

The structural and mechanical properties of rye-wheat bread (see Table 5), similar to rye bread, vary with the same intensity regardless of the type of packaging material.

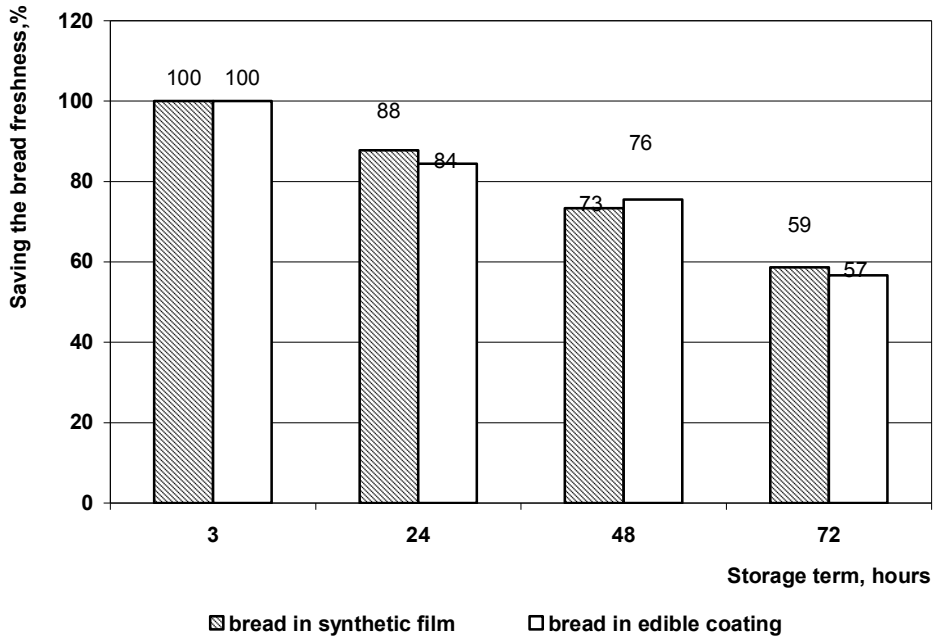


Figure 3. Preserving the freshness of rye bread depending on the packaging material type

Table 5
Change of structural and mechanical properties of the crumb during the storage of bread rye-wheat

Storage, hours	Synthetic film			Edible coating		
	General deformation, units of the device	Plastic deformation, units of the device	Elastic deformation, units of the device	General deformation, units of the device	Plastic deformation, units of the device	Elastic deformation, units of the device
0	51.5	43.0	8.5	51.5	43.0	8.5
24	43.5	35.2	8.3	43.3	34.8	8.5
48	41.5	34.0	7.5	39.5	31.7	7.8
72	33.5	25.0	8.5	36.8	29.6	7.2
96	30.2	22.6	7.6	33.4	26.8	6.6
120	28.1	21.2	6.9	27.9	21.8	6.1
144	26.8	20.0	6.3	25.5	19.7	5.8

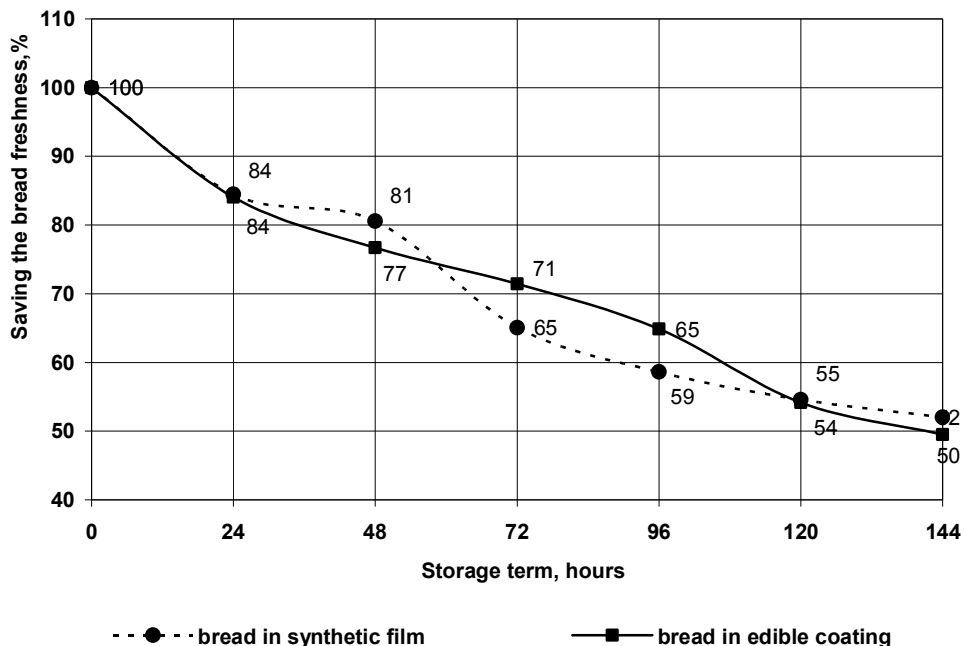


Figure 4. Saving the freshness of rye-wheat bread depending on the type of packaging material

Freshness of rye and wheat bread in edible coat is better than bread in synthetic packaging material. For example, for 72 hours, the bread in the edible coating is fresher by 5 % compared with bread in synthetic material. However, the difference in the values of freshness decreases to 2% at the end of storage.

The preservation of structural and mechanical properties and freshness of products were stored in the edible coating at the same level as products were stored in synthetic materials also due to barrier properties of edible coating. In addition, the edible coating includes moisture. At the coating stage, the moisture content is 72 %, after drying and forming the coating on the bread surface, the moisture content of the coating is 5 %. Therefore, it is logical to assume that during the drying of the coating on the surface of the product, part of the moisture is absorbed by bread, which will delay the aging of natural grain polymers, and thereby maintain the properties of bread at the level with packaging synthetic materials.

Conclusions

Replacing synthetic packaging material with biodegradable edible coatings have shown that it is quite expedient, since the organoleptic of products with edible coating do not deteriorate, and even improve due to leveling the surface and gaining gloss. Moisture of products in edible coating at the end of storage is maintained at the same level as for products in synthetic packaging: 43.8 % (in synthetic packaging) and 43.3 % (in edible coating) for rye bread and 37.9 % (in synthetic packaging) and 37.7 % (in edible coating) at

the end of storage of rye-wheat bread. The absorbing water the crumb, structural and mechanical properties and freshness for products in synthetic packaging and edible coating are at the same level at the end of storage, so edible coating is a complete environmental replacement of synthetic packaging for rye and rye-wheat bread.

References

1. (2007), I snova o hlebe, *Hlebopekarskoe i konditerskoe delo*, 2, p. 12.
2. Zakharevych V. B., Havva O. M., Yukhno M.I. (2012), Pakovalni materialy dlia khlibobulochnykh vyrobiv, *Kharchova nauka i tekhnolohiia*, 1(18), pp. 104-106.
3. Drobot V.I. (2002), *Tekhnolohiia khlibopekarskoho vyrobnytstva*, Lohos.
4. Omelchenko N. V. (2004), Tovaroznavstvo na pochatku novoho tysiacholittia, *Visnyk DonDUET*, pp. 18-21.
5. Lærke H. N., Pedersen C., Mortensen M. A., Theil P. K., Larsen T., Knudsen K. E. B. (2008), Rye bread reduces plasma cholesterol levels in hypercholesterolaemic pigs when compared to wheat at similar dietary fibre level, *Journal of the Science of Food and Agriculture*, 88(8), pp. 1385-1393.
6. Juntunen K. S., Mazur W. M., Liukkonekn K. H., Uehara M., Poutanen K. S., Adlerkreutz H. C., MykkaEnen H. M. (2000), Consumption of wholemeal rye bread increases serum concentrations and urinary excretion of enterolactone compared with consumption of white wheat bread in healthy Finnish men and women, *British Journal of Nutrition*, 84(6), pp. 839-846.
7. Vinkx C. J. A., Delcour J. A. (1996), Rye (*Secale cereale*L.) Arabinoxylans: A Critical Review, *Journal of Cereal Science*, 24(1), pp. 1-14.
8. Karppinen S., Liukkonen K., Aura A. M., Forssell P., Poutanen K. (2000). In vitro fermentation of polysaccharides of rye, wheat and oat brans and inulin by human faecal bacteria, *Journal of the Science of Food and Agriculture*, 80(10), pp. 1469-1476.
9. Bondia-Pons I., Aura A. M., Vuorela S., Kolehmainen M., Mykkänen H., Poutanen K. (2009), *Rye phenolics in nutrition and health*, *Journal of cereal science*, 49(3), pp. 323-336.
10. Kulawinek M., Jaromin A., Kozubek A., Zarnowskik R. (2008), Alkylresorcinols in selected Polish rye and wheat cereals and whole-grain cereal products, *Journal of agricultural and food chemistry*, 56(16), pp. 7236-7242.
11. Isaksson H., Fredriksson H., Olsson J., Åman P., Andersson R. (2009), Effect of rye bread breakfasts on subjective hunger and satiety: a randomized controlled trial, *Nutrition Journal*, 8(1), p. 39.
12. Goryacheva A. F., Kuzminskiy R. V. (1983), *Sohranenie svezhesti hleba*, Moscow.
13. Cauvain S. (2003), *Bread making: an overview*, In: Cauvain, S. (ed.). Bread making, improving quality, Woodhead Publishing Limited, Cambridge.
14. Drobot V. I., Sylchuk T. A. (2012), Doslidzhennia vplyvu dobavok na protses cherstvinnia khliba, *Kharchova nauka i tekhnolohiia*, 1 (18), pp. 56-58.
15. Drobot V. I. i dr. (1987), Primenenie kartofelnoy krupki v proizvodstve hleba, *Hlebopekarnaya i konditerskaya promyishlennos*, 6, pp. 34-38.
16. Drobot V. I. ta in. (2001), Suchasnyi stan i perspektyvy vykorystannia produktiv pererobky soi u khlibopekarskii, makaronnii, kondyterskii ta kharchokontsentratnii promyslovosti, *Naukovi pratsi ODAKht*, pp. 295-298.

17. Korkach H. V., Lebedenko T. Ye., Sokolova N. Yu. (2009), Vplyv poroshku topinambura na yakist khlibobulochnykh vyrobiv, *Naukovi pratsi ONAKhT*, 36 (1), pp. 137-140.
18. Sydorenko Yu. V., Stetsenko N. O. (2013), Doslidzhennia vplyvu poroshku laminarii ta anisu na kharchovu tsinnist ta yakist zhytnoho khliba, *Khranenye y pererabotka zerna*, 6 (171), pp. 76-79.
19. Bachynska Ya. O., Nepochatykh T. A. (2011), Doslidzhennia yakosti khliba zhytno-pshenychnoho «Borodynskoho» ta pidvyshchennia biolohichnoi tsinnosti khlibobulochnykh vyrobiv z vykorystanniam yahid chornytsti, *Prohresyvni tekhnika ta tekhnolohii kharchovykh vyrobnytstv restorannoho hospodarstva i torhivli*, pp. 274-281.
20. Peresichna S. M., Pakhomska O. V. (2013), Fyzyko-khimichni ta mikrobiolohichni pokaznyky khliba na khmelovii zakvastsi z poroslym zernom pshenytsi, *Naukovi pratsi ONAKhT*, 44 (1), pp. 147-150.
21. Gambuś H., Gibiński M., Pastuszka D., Mickowska B., Ziobro R., Witkiewicz R. (2011), The application of residual oats flour in bread production in order to improve its quality and biological value of protein, *Acta Scientiarum Polonorum Technologia Alimentaria*, 10(3), pp. 317-325.
22. Liu J., Liu X., Man Y., Liu Y. (2017), Reduction of acrylamide content in bread crust by starch coating, *Journal of the Science of Food and Agriculture*.
23. Drobot V. I. (2006), Laboratornyi praktykum z tekhnolohii khlibopekarskoho ta makaronnoho vyrobnytstv, *Tsentr navchalnoi literatury*.
24. Levarde G. (2006), Barernye plenki, *Upakovka*.
25. Directive 94/62/ EC (2015), as regards reducing the consumption of light-weight plastic carrier bags, Directive (EU) 2015/720 of the European Parliament and of the council, available at:
<http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015L0720>.
26. Savitskaya T.A. (2016), S'edobnyie polimernye plenki i pokryitiya: istoriya voprosa i sovremennoe sostoyanie (obzor), *Polimernye materialyi i tehnologii*.
27. Clarke C., Schober T., Dockery P., O'Sullivan K. and Arendt E. (2004), Wheat sourdough fermentation: effects of time and acidification on fundamental rheological properties, *Cereal Chemistry*.