UDC 664.681.1:633.13:613.2
DOI: 10.15587/2312-8372.2019.176090

Tsykhanovska I.

THE FORMATION OF FUNCTIONAL AND TECHNOLOGICAL PROPERTIES OF THE DOUGH AND QUALITY INDICATORS OF OATMEAL COOKIES WITH THE USE OF «MAGNETOFOOD» FOOD ADDITIVE

Об'єктом дослідження є технологія вівсяного печива з використанням харчової добавки «Магнетофуд». Перспективними поліпшувачами харчових систем (зокрема, тістових кондитерських мас) є нанодобавки, котрим притаманний широкий спектр функціонально-технологічних властивостей, в силу специфічності їх фізико-хімічних характеристик внаслідок наномасштабного розміру і квантово-механічних ефектів. З метою вивчення впливу харчової добавки «Магнетофуд» на функціонально-технологічні властивості тіста та показники якості вівсяного печива добавку «Магнетофуд» вводили у рецептурну суміш у вигляді жирової суспензії на етапі «розтирання масла». Встановлено, що введення харчової добавки «Магнетофуд» у рецептуру вівсяного печива у кількості 0,1; 0,15; 0,2 % до маси рецептурної суміші у вигляді жирової суспензії (у порівнянні з контролем) сприяє:

– збільшенню вологості тіста на (1,2±0,2) %, граничного напруження зсуву тіста на (20±2) Па та пластичної в'язкості тіста на (2,2±0,4) кПа·с;

– зменшенню густини тіста на (0,6±0,1) г/см³;

– збільшенню вологості вівсяного печива на (2,25±0,1) %, намочуваності печива на (10±2) %, виходу печива на (2,0±0,5) % та середнього значення бальної оцінки печива за органолептичним аналізом на (1,0±0,1) бали;

– покращенню розжовуваності печива на (0,4±0,2) бали;

– зменшунню густини печива на (0,10±0,02) г/см³, крошливості печива на (0,9±0,2) %, втрат при термообробці на (1,8±0,2) % та лужності печива на (0,3±0,1).

У порівнянні з аналогічними відомими покращувачами харчових систем нанооб'єкти, до яких відноситься нанопорошок «Магнетофуд», мають величезний потенціал і несуть в собі безліч важливих фундаментальних відкриттів, нових функціонально-технологічних властивостей і перспективних технологічних застосувань. Взаємодія наночастинок «Магнетофуд» з біополімерами – це комплекс складних хімічних реакцій. Результатом є формування просторових наноструктур, які суттєво впливають на функціонально-технологічні властивості сировинних компонентів і напівфабрикатів. У харчових системах такі добавки, зокрема «Магнетофуд», проявляють антиоксидантні, бактеріостатичні, сорбційні, емульгуючі, структуроутворюючі, волого- і жироутримуючі властивості. Завдяки цьому забезпечується можливість отримання високих значень досліджених показників.

Ключові слова: *харчова добавка «Магнетофуд», вівсяне печиво, вівсяно-пшеничне тісто, показники якості.*

Received date: 27.05.2019
Accepted date: 19.06.2019
Published date: 30.08.2019

1. Introduction

The confectionery industry is an industry that requires a large amount of resources to expand the range of products taking into account the wishes of the consumer.

In recent years, there has been a tendency in the technology of flour confectionery products to develop and introduce into the production of confectionery products using various food additives – improvers.

Therefore, the introduction of the Magnetofood food additive ($FeO \cdot Fe_2O_3$ or Fe_3O_4) into the recipe composition of flour confectionery products [1, 2]. Since it is able to form new functional and technological characteristics of flour confectionery products, in particular oatmeal cookies, by:

– nanoscale scales [3];
– unique physicochemical properties [4].

Magnetofood is a highly dispersed powder with a particle size (70...80) nm [5], therefore it has a large specific surface and chemical potential [6]. Due to Fe (II), Magnetofood exhibits reducing properties and can be used as an antioxidant additive that prevents the oxidation of fats and fat-containing products and thereby improves their quality and shelf life [7]. The interaction of Magnetofood nanoparticles with biopolymers (proteins, proteids, carbohydrates, lipids) is a complex of complex chemical reactions [8]. The result is the formation of spatial nanostructures, which significantly affect the functional and technological properties of raw materials and semi-finished products and quality indicators of finished products [9].

2. The object of research and its technological audit

The object of research is the technology of oatmeal cookies using the Magnetofood food additive. To improve the technology and obtain high-quality products with a long shelf life of freshness, various technological methods are used, including the introduction of food improvers. Promising improvers of food systems (in particular, flour confectionery masses) are nano-additives, which have a wide range of functional and technological properties, due to the specificity of their physicochemical characteristics due to nanoscale size and quantum-mechanical effects.

This makes it necessary to conduct comprehensive research: functional-technological, physico-chemical, structural and mechanical properties of the dough and quality and safety indicators of finished products.

3. The aim and objectives of research

The aim of research is the formation of functional and technological properties of the dough and quality indicators of finished products in the technology of oatmeal cookies using the Magnetofood food additive.

To achieve this aim it is necessary to solve the following tasks:

1. To study the effect of the Magnetofood food additive on the functional-technological, physicochemical, structural and mechanical characteristics of oat-wheat dough and on the organoleptic quality indicators of finished products.
2. To establish a rational amount of Magnetofood dietary additive and develop an oatmeal cookie formulation with Magnetofood.

4. Research of existing solutions of the problem

To improve the functional and technological properties of dough confectionery masses and quality indicators of finished products in the production of flour confectionery products, the following are widely used:

– a variety of nutritional additives and improvers [10]:
– vitamin and mineral premixes [11];
– vitamins – antioxidants, dietary fiber, micronutrient additives of protective action [12].

A narrow focus is an important disadvantage of these ingredients.

Recently, specialists in the confectionery industry have been using various bioadditives from plant materials (ginseng, Jerusalem artichoke, sea buckthorn, etc.). Thanks to their use, the consumer characteristics of the finished products become better and the water- and fat-soluble ability of the dough confectionery masses increases [13]. The disadvantages of these additives are low functionality in terms of texture and physico-chemical properties of finished products.

Various polysaccharide additives derived from natural ingredients: citrus fiber; plant-derived hydrocolloids, cellulose ethers [14], have also gained popularity in the production of flour confectionery products. Thanks to such additives, it became possible to create low-calorie foods that retain the structural-mechanical and organoleptic characteristics of traditional analogues. However, they do not secure sufficient cookie porosity.

Hydrocolloids:

– banana and apple powders;
– sea buckthorn meal;
– guar and xanthan gums [15];
– polydextrose – a polysaccharide consisting of glucose polymers with low molecular weight [10] is used to stabilize and provide the desired viscosity or consistency.

They also contribute to improving the water holding capacity of dough semi-finished products and quality indicators of finished products. But their influence on the technological properties of the dough confectionery masses and finished products is insufficient.

To improve the rheological properties and increase the water-holding capacity of the dough confectionery mass, natural powdery components obtained from dairy and egg products are used [11]. Their disadvantage is the lack of multifunctionality.

Recently, various food additives obtained from recycled products have found application in the production of flour confectionery:

– leather, hooves, feathers [12];
– offal [13];
– seeds, bran [16];
– milk whey [17] and others.

However, these dietary additive are characterized by a narrow focus and do not exhibit a complex effect.

In order to improve the water holding capacity of the dough confectionery masses and finished products, bioadditives of various origin are used based on:

– wheat [18];
– soybeans, chickpeas [19];
– enzymes, microalgae, etc.

However, the yield and structural-mechanical indicators (porosity and shape stability) of finished products do not improve.

In recent years, organic compounds of plants, in particular phenols, have been used to increase the water holding capacity of dough confectionery masses [20]. Their disadvantages are insufficient stability of quality indicators due to the instability of organic compounds.

Thus, an analysis of literary sources shows a lack of data on the use of nanopowder ingredients in the technology of flour confectionery products. To create new functional and technological properties of flour confectionery products with improved consumer characteristics and indicators of carelessness, the Magnetofood food additive can be proposed. In food systems, Magnetofood exhibits a water-retaining, fat-soluble, fat-emulsifying and stabilizing effect [7, 9].

5. Methods of research

In the work, the effect of the Magnetofood food additive on the functional and technological properties of the dough and the quality indicators of finished products are investigated. Subjects of research are prototypes of oatmeal cookies based on traditional recipe No. 198 [21] and are given in Table 1.

Table 1

Formulations of traditional oatmeal cookies (control) and Cossack oatmeal cookies with different mass fraction of Magnetofood food additive (FA) (experiment)

Raw material	Raw material costs per 100 kg of finished products, kg			
	Prototypes			
	No. 1 – control	No. 2 with 0.1 % of Magneto-food FA	No. 3 with 0.15 % of Magneto-food FA	No. 2 with 0.2 % of Magneto-food FA
Premium wheat flour	38.1	38.1	38.1	38.1
Oatmeal	16.1	16.1	16.1	16.1
Granulated sugar	30.7	30.7	30.7	30.7
Butter	14.2	14.2	14.2	14.2
Drinking soda	0.6	0.6	0.6	0.6
Salt	0.3	0.3	0.3	0.3
Fat suspension Magnetofood DA	–	0.2	0.3	0.4

Note: Magnetofood food additive was introduced in the form of a fat suspension (the ratio of the components of the suspension is Magnetofood: butter=50 wt. %: 50 wt. %) At the stage of «grinding oil» in an amount of 0.2; 0.3; 0.4 kg per 100 kg of the recipe

In the process of performing the experimental work, standard and generally accepted research methods were used:

– rheological properties of the dough were determined on a Brabender farinography (Germany) according to DSTU 4111.1-2002 (ISO 5530-1:1997.MOD) and on a rotational viscometer Volarovich RV-8 (Russia) in accordance with the procedure given in [22, 23];
– humidity of the dough semi-finished products and finished cookies was determined by the accelerated gravimetric method according to DSTU 4910:2008 [23];
– study of the adhesion strength of the dough is based on the method of uniform separation [23];
– determination of the strength properties of the dough was carried out on the AR-4/1 penetrometers (Russia) by the method of immersion of the cone with an opening angle of the cone of 30° and 60° according to the standard method [23];
– determination of cookie hardness was carried out by the stamping method [23, 24];
– alkalinity was determined by titration with an indicator according to DSTU 5024:2008;
– urination, crumbling and chewing was determined according to DSTU 5023:2008 and [23, 24];
– mass of baked products was determined in accordance with DSTU EN 45501:2007, and the packs were determined in accordance with [23, 25].

6. Research results

Table 2 shows the effect of the Magnetofood food additive on the structural-mechanical and physicochemical properties of prototypes of dough masses.

The data in Table 2 shows that the introduction of Magnetofood additives in the prescription composition in an amount of (0.10–0.20) % by weight of the prescription composition contributes (compared to the control):

– increase the dough moisture by (1.2±0.2) %, the ultimate shear stress of the dough by (20±2) Pa and the plastic viscosity of the dough by (2.2±0.4) kPa·s;
– a decrease in the dough density by (0.6±0.1) g/cm^3 and the adhesive strength of the dough by (16...24) % of the steel surface.

Table 2

Physicochemical and structural-mechanical properties of dough masses with various mass fractions of the Magnetofood food additive ($n=5$, $p\leq 0.05$)

Indicator	Prototypes of dough masses			
	Sample 1	Sample 2	Sample 3	Sample 4
Moisture content, %	24.5±0.2	25.5±0.2	25.9±0.2	25.7±0.2
Density, g/cm^3	1.25±0.1	1.21±0.1	1.18±0.1	1.20±0.1
Plasticity (ultimate shear stress), Pa	510±2	530±2	534±2	532±2
Adhesive strength (steel), kPa	2.5±0.1	2.1±0.1	1.9±0.1	2.0±0.1
Plastic viscosity, kPa·s (at $\gamma=0.02$ s^{-1})	7.4±0.4	9.2±0.4	9.8±0.4	9.6±0.4

This dynamics of the change of indicators is explained by the «clusterophilicity», the structure-forming and stabilizing ability of Magnetofood nanoparticles.

Table 3 shows the effect of the Magnetofood dietary additive on the quality indicators of prototypes of oatmeal cookies.

Table 3

Quality indicators of oatmeal cookies with various mass fractions of the Magnetofood dietary additive ($n=5$, $p\leq 0.05$)

Indicator	Prototypes of oatmeal cookies			
	Sample 1	Sample 2	Sample 3	Sample 4
Moisture content, %	5.6±0.1	7.6±0.1	8.0±0.1	7.9±0.1
Alkalinity, %	2.0±0.1	1.8±0.1	1.6±0.1	1.6±0.1
Density, g/cm^3	0.56±0.02	0.48±0.02	0.44±0.02	0.45±0.02
Wet, %	138±2	146±2	150±2	149±2
Crumbling, %	1.6±0.2	0.8±0.2	0.6±0.2	0.5±0.2
Fluidity, points	4.5±0.2	4.8±0.2	5.0±0.2	4.9±0.2
Yield, %	89.4±0.5	91.0±0.5	91.7±0.5	91.5±0.5
Losses during heat treatment, %	10.6±0.2	9.0±0.2	8.5±0.2	8.6±0.2

Data analysis of Table 3 shows that the introduction of the Magnetofood food additive in the amount of (0.10–0.20) % by weight of the recipe mixture increases the yield and improves the quality indicators of finished products compared to the control:

– humidity increases by (2.25±0.1) %; wet – by (10±2) %; fluidity – by (0.4±0.2) points; yield – by (2.0±0.5) %;
– density decreases by (0.10±0.02) g/cm^3; crumbling – by (0.9±0.2) losses during heat treatment – by (1.8±0.2) %; alkalinity – by (0.3±0.1).

An increase in the humidity of cookie samples using the Magnetofood food additive is associated with the structure-forming and stabilizing effect of Magnetofood nanoparticles. This helps to reduce the concentration movement of moisture from the layers of the central part of the dough pieces to layers with a lower concentration of moisture, that is, until crust, during baking. This trend will positively affect the change in the quality characteristics of cookies during storage. The decrease in the alkalinity of cookies is due to the amphoteric properties of the components of Magnetofood (Fe^{2+}, Fe^{3+}), which interact with components of the dough system, in particular NH_3, $NaHCO_3$. In addition, the ability of Magnetofood nanoparticles to structure formation, fat and water retention, fat and water retention, as well as moisture redistribution in the dough system improves texture and fluidity increases porosity, wetness and yield of finished products.

Fig. 1 shows micrographs of samples of oatmeal cookies.

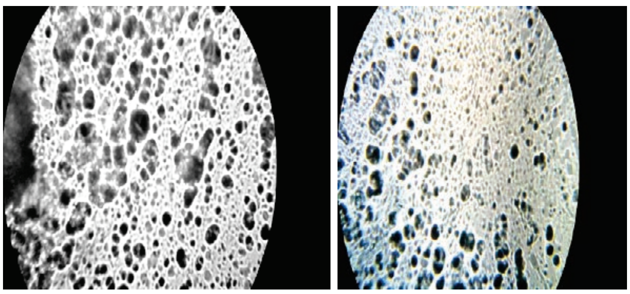

Fig. 1. The microstructure of oatmeal cookies:
a – sample 1 (control); *b* – sample 3 with 0.15 % of Magnetofood

From microphotographs it can be seen that sample 3 has a uniform fine-meshed structure, without voids (Fig. 1, *b*). And in the control sample (sample 1), let's observe time of large sizes (even voids), which are unevenly distributed over the volume of cookies (Fig. 1, *a*).

Fig. 2 shows the diagrams of the rational recipe composition of oatmeal cookies «Cossack» with the addition of the Magnetofood food additive.

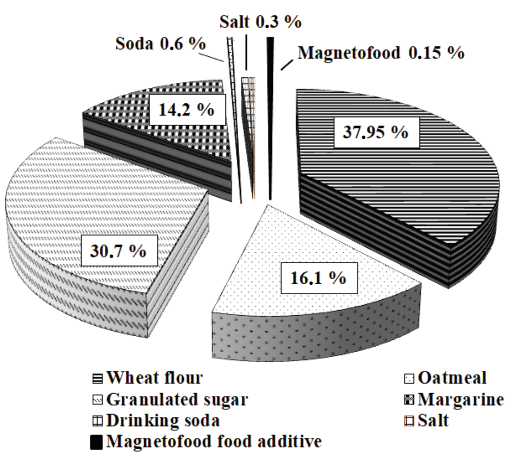

Fig 2. Diagram of the recipe composition of «Cossack» oatmeal cookies with a rational amount of the Magnetofood food additive – 0.15 % by weight of the recipe mixture

Table 4 shows the results of organoleptic analysis of prototypes of oatmeal cookies with different amounts of the Magnetofood food additive.

As can be seen from the data in Table 4, the addition of the Magnetofood food additive in an amount of (0.10–0.20) % by weight of the recipe improves the quality indicators. And the average value of the score by organoleptic analysis increases by (1.0±0.1) points compared with the control sample (Fig. 3).

Table 4

Organoleptic characteristics of prototypes of oatmeal cookies compared to control

Indicator	Prototypes of oatmeal cookies			
	Sample 1	Sample 2	Sample 3	Sample 4
Shape	Slight edge damage	Oval, with the inherent vagueness of this species, without dents, swelling and damage to the edge		
Colour	Straw	Uniform, light brown		Brown
Taste and smell	Insufficiently expressed	Pronounced, sweet taste, without extraneous taste and smell		
Surface	There are dents	Rough with winding cracks		
View of the fracture	Minor seals and voids	With a uniform porous structure, without voids, seals and traces of undermixing		

Fig. 3 shows the organoleptic profiles of prototypes of oatmeal cookies with the addition of a rational amount of the Magnetofood dietary additive – 0.15 % by weight of the recipe as compared to the control sample.

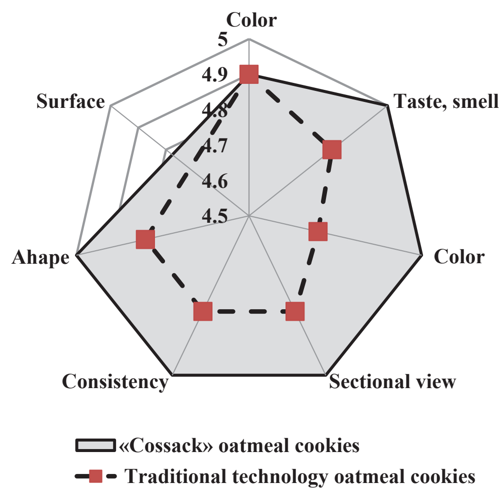

Fig. 3. The results of the organoleptic analysis of prototypes of oatmeal cookies «Cossack» with the addition of Magnetofood food additives compared with the control sample

The conducted studies have made it possible to scientifically substantiate the Cossack oatmeal cookie recipe. The rational amount of the Magnetofood dietary additive is 0.15 % by weight of the prescription mixture.

7. SWOT analysis of research results

Strengths. It has been established that the most strengths of flour confectionery products using the Magnetofood food additive are:
– uniqueness of the offer;
– patent protection;
– improvement of consumer characteristics;
– lengthening the shelf life of freshness, resource conservation;
– cost reduction and optimization of the weight and volume of finished products due to coordination and electrostatic interactions, water and fat-soluble abilities of nanoparticles (which helps to reduce losses during heat treatment and increase yield).

ISSN 2226-3780

Weaknesses. The weaknesses of research include:
– low consumer awareness of new products and manufacturers' risks when introducing new flour confectionery products, in particular the complexity of the calculation;
– increase in energy consumption for the production of food additives.

Opportunities. According to the strategic prospects of promoting a new flour confectionery products on the market, they are mainly due to the growth of the nanotechnology and nanoproducts market, as well as the demand for introducing the results of nano-research into the food sector.

Threats. The main threats to the sale of products using the Magnetofood food additive are the low level of financing of innovative projects and the unresolved nature of technology transfer issues.

8. Conclusions

1. It is found that the introduction of the Magnetofood dietary additive in the oatmeal cookie recipe in an amount of 0.1; 0.15; 0.2 % by weight of the prescription mixture in the form of a fat suspension (compared with the control) contributes to:

1) in prototypes of dough masses:
– increase the dough moisture content by (1.2±0.2) %, the ultimate shear stress of the dough by (20±2) Pa and the plastic viscosity of the dough by (2.2±0.4) kPa·s;
– decrease in dough density by (0.6±0.1) g/cm^3;

2) in the experimental samples of oatmeal cookies:
– increase in humidity by (2.25±0.1) %, wet – by (10±2) %, yield – by (2.0±0.5) % and the average score by organoleptic analysis at (1.0±0.1) point;
– improvement of fluidity – by (0.4±0.2) points;
– decrease in density at (0.10±0.02) g/cm^3, crumbling – by (0.9±0.2) %, losses during heat treatment – by (1.8±0.2) % and alkalinity – by (0.3±0.1).

2. The rational content of the Magnetofood food additive has been established – 0.15 % by weight of the prescription composition. The composition of Cossack oatmeal cookies with the Magnetofood food additive is compiled.

The obtained results give reason to recommend the Magnetofood food additive as a stabilizer, structure-forming agent and improver of flour confectionery products.

References

1. TU U 10.8-2023017824-001:2018. *Dobavka kharchova na osnovi oksydiv zaliza «Mahnetofud». UKND 67.220.20. DKPP 10.89.19. Derzhprodspozhyvsluzhba Ukrainy.* Vysnovok derzhavnoi sanitarno-epidemiolohichnoi ekspertyzy No. 6020123-20-2/25702 vid 12.06.2018 r.
2. Tsykhanovska, I. V. et. al. (2018). *Pat. No. 126502 UA. Kharchova dobavka «Mahnetofud». MPK (2016.01) A23L 13/40, A23L 33/10.* Published: 25.06.2018, Bul. No. 12, 4.
3. Tsykhanovska, I. V. et. al. (2018). *Pat. No. 126507 UA. Sposib oderzhannia kharchovoi dobavky «Mahnetofud». MPK (2018.01) V82Y 40/00, V82V 1/00, V82V 3/00.* Published: 25.06.2018, Bul. No. 12, 4.
4. Tsykhanovska, I., Barsova, Z., Demidov, I., Pavlotskaya, L. (2015). Investigation of the oxidative and thermal transformations processes in the system «oil – lipids-magnetite suspension». *Prohresyvni tekhnika ta tekhnolohiyi kharchovykh vyrobnytstv restorannoho hospodarstva i torhivli, 1 (21),* 353–362.
5. Yevlash, V. V., Niemirich, O. V., Vinnikova, V. O. (2006). Zbahachennia prianykiv lehkozasvoiuvanym hemovym zalizom. *Prohresyvni tekhnika ta tekhnolohii kharchovykh vyrobnytstv restorannoho hospodarstva i torhivli, 1 (3),* 258–264.
6. Tsykhanovska, I., Evlash, V., Alexandrov, A., Lazarieva, T., Bryzytska, O. (2018). Substantiation of the interaction mechanism between the lipo- and glucoproteids of rye-wheat flour and nanoparticles of the food additive «Magnetofood». *Eastern-European Journal of Enterprise Technologies, 4 (11 (94)),* 61–68. doi: https://doi.org/10.15587/1729-4061.2018.140048
7. Tsykhanovska, I., Evlash, V., Oleksandrov, O., Gontar, T. (2018). Mechanism of fat-binding and fat-contenting of the nanoparticles of a food supplement on the basis of double oxide of two- and trivalent iron. *Ukrainian Food Journal, 7 (4),* 702–715. doi: https://doi.org/10.24263/2304-974x-2018-7-4-14
8. Tsykhanovska, I., Evlash, V., Alexandrov, A., Lazarieva, T., Svidlo, K., Gontar, T. et. al. (2018). Substantiation of the mechanism of interaction between biopolymers of ryeandwheat flour and the nanoparticles of the magnetofood food additive in order to improve moistureretaining capacity of dough. *Eastern-European Journal of Enterprise Technologies, 2 (11 (92)),* 70–80. doi: https://doi.org/10.15587/1729-4061.2018.126358
9. Tsykhanovska, I., Evlash, V., Alexandrov, A., Lazareva, T., Svidlo, K., Gontar, T. et. al. (2018). Investigation of the moisture-retaining power of rye-wheat gluten and flour with polyfunctional food supplement «Magnetofood». *EUREKA: Life Sciences, 2,* 67–76. doi: https://doi.org/10.21303/2504-5695.2018.00611
10. Chaudhry, Q., Castle, L., Watkins, R. (Eds.) (2010). *Nanotechnologies in Food. Nanoscience & Nanotechnology Series.* Royal Society of Chemistry. doi: https://doi.org/10.1039/9781847559883
11. Polumbryk, M. O. (2011). Nanotekhnolohiyi v kharchovykh produktakh. *Kharchova promyslovist, 10,* 319–322.
12. Renzyaeva, T. V., Poznyakovskiy, V. M. (2009). Vodouderzhivayushchaya sposobnost' syr'ya i pishchevyh dobavok v proizvodstve muchnyh konditerskih izdeliy. *Hranenie i pererabotka sel'hozsyr'ya, 8,* 35–38.
13. Bird, L. G., Pilkington, C. L., Saputra, A., Serventi, L. (2017). Products of chickpea processing as texture improvers in gluten-free bread. *Food Science and Technology International, 23 (8),* 690–698. doi: https://doi.org/10.1177/1082013217717802
14. Buldakov, A. (2008). *Food Additives: Reference Book.* Moscow, 280.
15. Martins, Z. E., Pinho, O., Ferreira, I. M. P. L. V. O. (2017). Food industry by-products used as functional ingredients of bakery products. *Trends in Food Science & Technology, 67,* 106–128. doi: https://doi.org/10.1016/j.tifs.2017.07.003
16. Lai, W. T., Khong, N. M. H., Lim, S. S., Hee, Y. Y., Sim, B. I., Lau, K. Y., Lai, O. M. (2017). A review: Modified agricultural by-products for the development and fortification of food products and nutraceuticals. *Trends in Food Science & Technology, 59,* 148–160. doi: https://doi.org/10.1016/j.tifs.2016.11.014
17. Dziki, D., Różyło, R., Gawlik-Dziki, U., Świeca, M. (2014). Current trends in the enhancement of antioxidant activity of wheat bread by the addition of plant materials rich in phenolic compounds. *Trends in Food Science & Technology, 40 (1),* 48–61. doi: https://doi.org/10.1016/j.tifs.2014.07.010
18. Torres-León, C., Rojas, R., Contreras-Esquivel, J. C., Serna-Cock, L., Belmares-Cerda, R. E., Aguilar, C. N. (2016). Mango seed: Functional and nutritional properties. *Trends in Food Science & Technology, 55,* 109–117. doi: https://doi.org/10.1016/j.tifs.2016.06.009
19. Bharath Kumar, S., Prabhasankar, P. (2014). Low glycemic index ingredients and modified starches in wheat based food processing: A review. *Trends in Food Science & Technology, 35 (1),* 32–41. doi: https://doi.org/10.1016/j.tifs.2013.10.007
20. García-Segovia, P., Pagán-Moreno, M. J., Lara, I. F., Martínez-Monzó, J. (2017). Effect of microalgae incorporation on physicochemical and textural properties in wheat bread formulation. *Food Science and Technology International, 23 (5),* 437–447. doi: https://doi.org/10.1177/1082013217700259
21. *Retseptury na pechen'e* (1988). Moscow: MTRSFSR, 247.
22. Royter, I. M., Demchuk, A. P., Drobot, V. I. (1977). *Novye metody kontrolya hlebopekarnogo proizvodstva.* Kyiv: Tehnika, 191.
23. Pashchenko, L. P., Sanina, T. V., Stolyarova, L. I. et. al. (2007). *Praktikum po tehnologii hleba, konditerskih i makaronnyh izdeliy (tehnologiya hlebobulochnyh izdeliy).* Moscow: Kolos, 215.
24. DSTU 4910:2008. *Vyroby kondyterski. Metody vyznachennia masovykh chastok volohy ta sukhykh rechovyn* (2008). Vzamen HOST 5900-73; vved. 2009-01-01. Kyiv: Derzhspozhyvstandart Ukrainy, 14.
25. GOST 24901-2014. *Pechen'e. Obshchie tehnicheskie usloviya* (2015). Moscow: Standartinform, 12.

Tsykhanovska Iryna, *PhD, Associate Professor, Department of Food and Chemical Technologies, Ukrainian Engineering Pedagogics Academy, Kharkiv, Ukraine, e-mail: cikhanovskaja@gmail.com, ORCID: http://orcid.org/0000-0002-9713-9257*