
NUTRITIONAL SCIENCE

DOI: <https://doi.org/10.23649/jae.2019.1.9.13>

Ponomareva E.I.¹, Krivosheev A.Y.², Lukina S.I.³, Alekhina N.N.⁴, Smirnykh A.A.*⁵

^{1,3,4} Federal state budget educational institution of higher education «Voronezh state university of engineering technology», Voronezh, Russian Federation

² IP «Zarutskii S.N.», Voronezh, Russian Federation

⁵ Military training and scientific center of military-air forces named after professor N. E. Zhukovsky and Yu. A. Gagarin, Voronezh, Russian Federation.

* Corresponding author (aas_07@mail.ru)

Received: 15.04.2019; Accepted: 25.04.2019; Published: 29.04.2019

DEVELOPMENT AND STUDY OF SALT-FREE BREAD STICKS FOR DIETETIC NUTRITION

Research article

Abstract

The article proposes the development of salt-free bread sticks for chloride-free diet. The results of studies of the chemical composition of non-traditional raw materials are presented: linseed flour and grape seed oil, the use of which allows increasing the content of protein, dietary fibers, vitamins, minerals, polyunsaturated fatty acids in the formulation of products. The influence of table salt and non-traditional types of raw materials on organoleptic, physicochemical parameters of finished products, their microstructure is determined. The use of an enzyme composition in the formulation of salt-free bread sticks is proposed with the aim of leveling the absence of salt. The results of the determination of antioxidant activity and nutritional value of products are presented. The data obtained will contribute to the expansion of the assortment of dietary bakery products of increased nutritional value.

Keywords: bread sticks, enzyme composition, linseed flour, grape seed oil, quality indicators, nutritional value, chloride-free diet.

Пономарева Е.И.¹, Кривошеев А.Ю.², Алехина Н.Н.³, Лукина С.И.⁴, Смирных А.А.*⁵

^{1,3,4} ФГБОУ ВО «Воронежский государственный университет инженерных технологий», Воронеж, Россия

² ИП «Зарутский С.Н.», Воронеж, Россия

⁵ Военный учебно-научный центр военно-воздушных сил «военно-воздушная академия имени профессора Н.Е. Жуковского и Ю.А. Гагарина», Воронеж, Россия

* Корреспондирующий автора (aas_07@mail.ru)

Получена: 15.04.2019; Доработана: 25.04.2019; Опубликована: 29.04.2019

РАЗРАБОТКА И ИССЛЕДОВАНИЕ БЕССОЛЕВЫХ ХЛЕБНЫХ ПАЛОЧЕК ДЛЯ ДИЕТИЧЕСКОГО ПИТАНИЯ

Научная статья

Аннотация

В статье рассматривается разработка бессолевых хлебных палочек для ахлоридного питания. Приведены результаты исследований химического состава нетрадиционных видов сырья: муки льняной и масла из виноградных косточек, применение в рецептуре изделий которых позволяет повысить содержание белка, пищевых волокон, витаминов, минеральных веществ, полиненасыщенных жирных кислот. Определено влияние соли поваренной пищевой и нетрадиционных видов сырья на органолептические, физико-химические показатели готовых изделий, их микроструктуру. Предложено применение ферментной композиции в рецептуре бессолевых хлебных палочек с целью нивелирования отсутствия соли. Представлены результаты определения антиоксидантной активности и пищевой ценности изделий. Полученные данные будут способствовать расширению ассортимента диетических хлебобулочных изделий повышенной пищевой ценности.

Ключевые слова: хлебные палочки, ферментная композиция, мука льняная, масло из виноградных косточек, показатели качества, пищевая ценность, ахлоридное питание.

1. Introduction

Introduction text, formula example below:

Bread sticks are oblong-round shaped bakery products with low moisture content (9-10%) made from yeast dough and having a fragile structure. They are distinguished by their original taste characteristics, high consumer characteristics, long shelf life and can serve as an alternative to traditional bread. Bread sticks are a popular product in many countries of the world and their assortment includes more than 40 items.

However, despite a large selection of different types of bread sticks, there are practically no products for preventive, dietary and therapeutic nutrition. For example, for people with arterial hypertension, cardiac and renal insufficiency, nephropathy, chloride-free diet is recommended, which requires a restriction of the intake of salt, water, simple carbohydrates with food and provision of all the necessary vitamins and minerals [1, 2, 3]. Therefore, the development of new types of chloride-free products (without salt and its reduced content in the recipe) is an urgent and timely task in bakery. In order to expand the range of products and increase their nutritional value, the use of non-traditional raw materials of plant origin is promising: linseed flour and grape seed oil, characterized by a high content of biologically active substances. Their use in the diet improves the balance of vitamins, amino acids, polyunsaturated fatty acids, macro- and microelements, dietary fiber and has a positive effect on human health.

To improve the structural and mechanical properties of bakery products and to level out the decline in the quality of bakery products, technological auxiliaries, in particular enzyme preparations, are used due to the removal of salt from the formulation [4, 5, 6, 7]. They make it possible to optimize the shape stability of dough pieces during proofing and baking, to provide the necessary crumb porosity structure, coloring of the crust, taste and aroma of products [7-11].

The aim of the work was to study the quality and nutritional values of bread sticks for dietary salt-free nutrition using non-traditional raw materials and enzyme composition.

2. Materials and methods

Raw materials used in the work are produced in the Central Black Earth region of the Russian Federation in accordance with the normative and technical documentation: first grade wheat flour - according to GOST (Russian National Standard) R 52189-2003, linseed flour - according to TU (Russian Technical Specifications) 9290-434-02068106-2016, pressed baker's yeast - according to GOST R 54731-2011, table salt - according to GOST R 51574-2000, white beetroot crystal sugar - according to GOST 33222-2015, starch syrup - according to GOST R 52060-2003, margarine of MT grade - according to GOST 32188-2013, sunflower oil - according to GOST 1129-2013, grape seed oil - of TU-9141-0015811041-2003, potable water – as per SanPiN (Russian Sanitary Rules and Regulations) 2.1.4.1074-01 enzymatic composition consisting of amylase and xylanase - GOST 54330-2011.

The objects of the study were samples of bread sticks:

1 – "Grissini", made from first grade wheat flour with 5.5 % yeast, 1.5 % salt, 1 % sugar, 1% syrup, 2.5 % margarine and 2.5 % sunflower oil (control) [12];

2 – "Dream", prepared with the replacement of 15 % of wheat flour with linseed flour, with the exception of salt, sugar, margarine and sunflower oil from formulation and additional use of 1 % syrup and 5 % grape seed oil;

3 – "Fantasy", prepared similarly to sample 2 with additional application of 0.5 % enzyme composition.

Recipe ingredients and water based on the dough moisture of 37.0 % were dosed by mass, the dough was mixed in a laboratory dough mixer, fermentation was carried out for 20 minutes in a thermostat at 30 °C. The forming of the dough pieces was carried out in the form of sticks 150 mm in length and 10-15 mm in width and sent to the proofing cabinet for final proofing at a temperature of 40 ± 1 °C and a relative humidity of 80-85 % for 30 minutes. Baking of samples were carried out in an electric oven for 10-12 minutes at a temperature of 220-230 °C with humidification of the baking chamber.

The chemical composition of the raw materials was analyzed according to the following methods: the mass fraction of protein according to GOST 10846-91, fat according to GOST 32905-2014, water-soluble carbohydrates according to GOST R 51636-2000, dietary fiber according to GOST 31675-2012, minerals (potassium, calcium, magnesium, phosphorus, iron, zinc, selenium) - according to GOST 32343-2013, GOST 26657-97, GOST R 55449-2013, vitamins (thiamine, riboflavin, pantothenic acid, pyridoxine, nicotinic acid, tocopherol) - according to GOST 29138 -91, GOST 29139-91, GOST 31483-2012, GOST 53494-2009, GOST 29140-91, GOST R 54634-2011, amino acid composition of the protein - ion exchange chromatography on AAA T-339 analyzer (MIKROTECHNA, Czech Republic), the content of tryptophan - according to the method of Lorenzo-Andrew and Frandzen. Biological value of proteins was determined by calculation method by comparing the amino acid composition of the studied protein with the reference amino acid scale of the ideal protein (hen egg protein) established by FAO/WHO.

Quality of finished products was assessed by organoleptic parameters: shape, size, surface, color, internal state, fragility, taste and smell according to GOST 5667-65 using the profile method and scoring. In the tasting tests, experts - technologists with at least 3 years of experience took part.

Physicochemical parameters for bread sticks were determined: humidity - according to GOST 21094-75, strength - according to GOST 8494-96, swelling coefficient, calculated on the basis of increase in mass of each sample after its swelling in water [13]. The microstructure of the bread sticks was studied in the electron emission mode using JSM-6380 LV electron microscope (Japan).

The nutritional and energy value of the products were calculated according to the generally accepted method on the basis of the chemical composition of the raw materials and the degree of preservation of the main food nutrients. Antioxidant activity was characterized by the total content of antioxidants determined by TsvetYauza-01-AA analyzer (JSC NPO Khimavtomatika, Russia).

Experimental studies were carried out in triplicate, the obtained data were processed using mathematical statistics using a standard package of applied programs. The experimental error did not exceed 5 %.

3. Results and discussion

At the first stage of the work, a study was made of the chemical composition of non-traditional raw materials used in the formulations of salt-free bread sticks. Linseed flour, obtained by disintegration-wave grinding, is characterized by the following content of basic nutrients, g/100 g of product: protein – 36.0; fat - 11.0; digestible carbohydrates – 13.1; dietary fibers – 30.0. Compared with the first grade wheat flour, the protein content in linseed flour is 3.4 times higher, dietary fiber - 6 times, carbohydrates - 5 times. Fat contained in linseed flour is a source of polyunsaturated fatty acids of omega-3 and omega-6 family (with a predominant content of linoleic acid) [14]. The total proportion of essential amino acids in the linseed flour protein is 51 % of the protein weight, which determines the value of its biological value above the average (55 %).

Comparative evaluation of two types of flour in terms of quantitative and qualitative composition of micronutrients showed (Figure 1) that linseed flour in comparison with wheat one is characterized by a higher content of magnesium (15 times), phosphorus (8 times), thiamine (7 times), potassium and zinc (5 times), selenium (4 times), vitamins B2, B5, B6 (2 times).

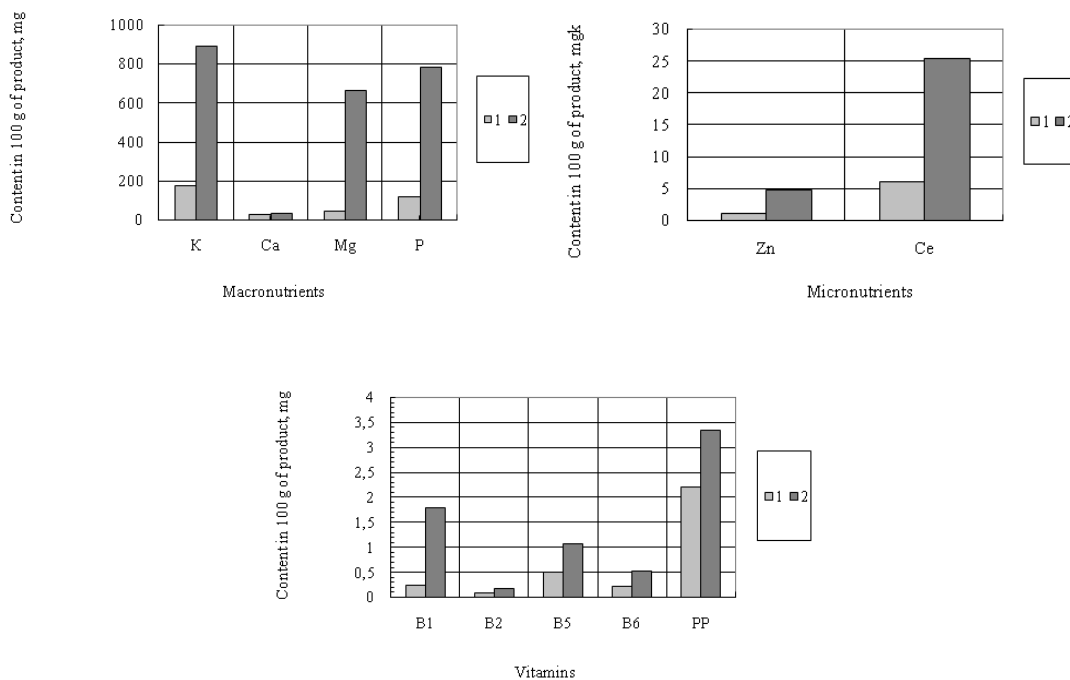


Figure 1 – The content of minerals and vitamins in the first grade wheat flour (1) and linseed (2)

Due to their high nutritional value, products with linseed flour are recommended in the diet to prevent the development of various diseases of digestive, cardiovascular and muscular systems, the formation of thrombi and atherosclerotic plaques, to lower blood pressure and cholesterol in the blood, clean the body from toxic substances, radionuclides, heavy metal salts.

It is advisable to use grape seed oil as a fat component in the formulation of bread sticks instead of sunflower oil and margarine. It is a representative of the linoleic type with a high content of polyunsaturated fatty acids (up to 71 %) and natural antioxidants [15]. Inclusion of it in the formulation of products will help improve the work of the heart and the vascular system, the gastrointestinal tract, cleanse the body of free radicals, strengthen immunity.

At the second stage of the work, the influence of the non-traditional raw materials and table salt on the organoleptic and physicochemical parameters of the bread sticks was determined (Table 1). According to the results of trial baking, it was found that the use of linseed flour and grape seed oil, as well as the exclusion of salt from formulation, reduced the score of products.

Sample No. 2 was characterized by an excessively fragile structure, a bland, insufficiently pronounced taste, odor and organoleptic parameters were estimated at 49.5 points.

Table 1 – Quality indicators of bread sticks

Quality indicators	Value of quality indicators of samples		
	No. 1 ("Grissini")	No. 2 ("Dream")	No. 3 ("Fantasy")
Organoleptic indicators			
Appearance:			
shape	Round, without dents	Round, with the presence of a small flat portion on the side lying on the oven band	Round, without dents
surface	Smooth, without blisters and cracks		
color	Brown	Dark gray, with bran particles	Light brown, with bran particles
Internal state	Loose, baked, with a uniform structure, without signs of impurities	less loosened, baked, with a relatively uniform structure, without signs of impurities	Well loosened, baked, with a uniform structure, without signs of impurities
Fragility	Fragile, easily cracking with a crunch	Very fragile, cracking with a crunch	Fragile, easily cracking with a crunch
Taste	Intrinsic to this type	Flavorless, inadequate	With a pleasant taste of linseed flour
Smell	Intrinsic to this type	Not quite pronounced flavor	With a pleasant taste of linseed flour
Score	70.5	49.5	65.0
Physical and chemical indicators			
Moisture, %	9.0	9.0	9.0
Coefficient of swelling, cond. units.	1.55	1.34	1.48
Strength, N.	840	570	870

The physicochemical parameters also had lower values: the swelling ratio decreased by 13.5 %, strength - by 47 % compared to sample No. 1. This is due to the absence in the formulation of bread sticks of the table salt promoting the strengthening of gluten proteins, loosening the structure of products, improving their taste and aroma.

Sample No. 3 with added amylase and xylanase enzymes included in the enzyme composition showed improved organoleptic and physicochemical parameters as compared to sample No. 2, and came closer to the control (sample No. 1) based on the values obtained.

The results of the analysis of tasting tests of bread sticks are given in the form of profilograms (Figure 2). Control samples ("Grissini" bread sticks) were rated "excellent", samples No. 2 ("Dream") were recognized as "satisfactory", samples No. 3 ("Fantasy") - as "good", closer to "excellent".

The use of the enzyme composition (sample No. 3) increased the swelling ratio by 10 % and strength by 1.5 times compared to sample No. 2. In addition, sample No. 3 had the highest strength. The improvement of its quality indicators is explained by the fact that under the action of enzymes (amylase and xylanase) there is a more complete hydrolysis of starch. The microphotographs shown in Figure 3 show that the interporal walls of the bread sticks consist of a continuous mass of coagulated protein and several small partially gelatinized starch grains.

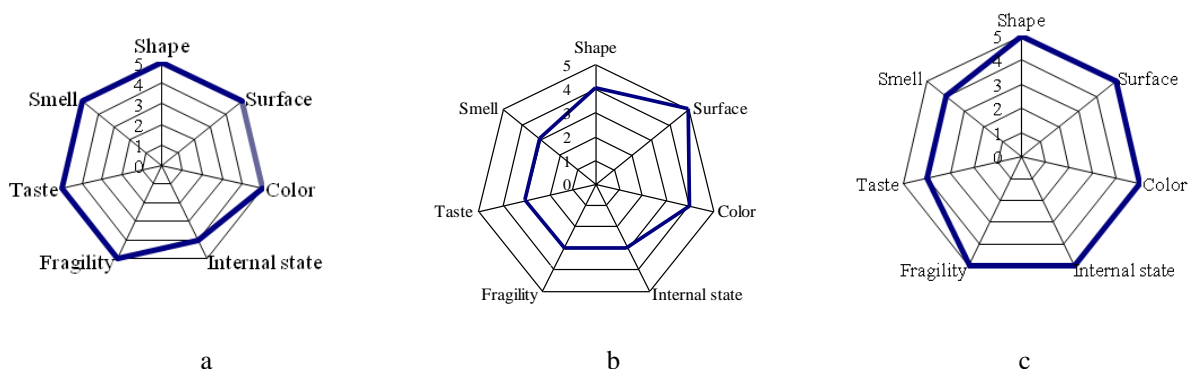


Figure 2 – Profilograms of organoleptic quality indicators of the bread sticks samples: a – No. 1 (Grissini), b – No. 2 ("Dream"), c – No. 3 ("Fantasy")

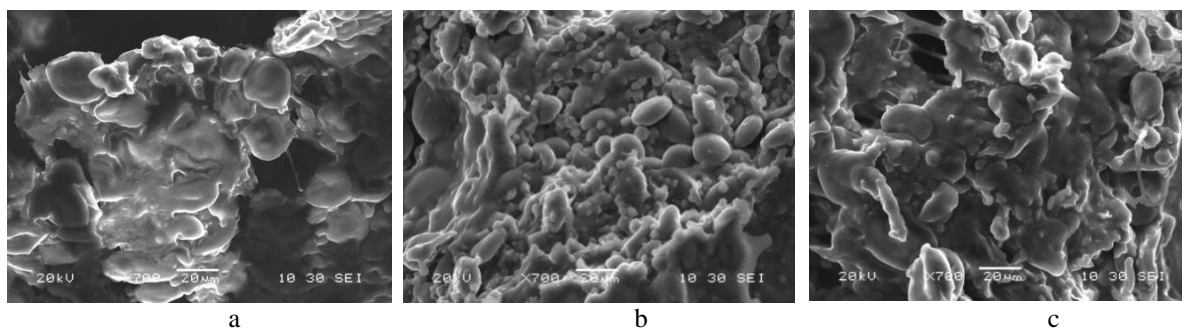


Figure 3 – Microstructure of the samples of bread sticks (1 × 700):
a – No. 1 ("Grissini"); b – No. 2 ("The Dream"); c – No. 3 ("Fantasy")

At the third stage of the work, the nutritional value of the investigated bread stick types was assessed according to the indices: the content of the main nutrients, the degree of satisfaction of the daily requirement, biological and energy value (Table 2).

It was found that salt-free bread sticks (samples No. 2 and 3) were characterized by increased protein content (by 32 %), fat (by 22 %), dietary fiber (by 1.9 times), and reduced carbohydrate (by 13 %). It is established that consumption of 100 g of these products will ensure the satisfaction of the daily demand for magnesium by 30 %, phosphorus by 25 %, thiamine by 31 %, riboflavin by 39 %, tocopherol by 25 %, and selenium by 11 %.

The biological value of protein increased by 9.8 %, energy value decreased by 49 kJ (10 kcal) in comparison with Grissini products (sample No. 1). In the experimental samples, the total content of antioxidants was increased by an average of 4 times compared with the control sample. The increase in antioxidant activity is associated with the use of linseed flour products, rich in natural antioxidants - group B vitamins, tocopherol, selenium, zinc, and grape seed oil containing chlorophyll with high antioxidant activity in formulations [16].

Table 2 – Characteristics of nutritional value of bread sticks

Indicator	The recommended level of daily consumption according to TR TS 022/2011	Sample No. 1 ("Grissini")		Samples No. 2 ("Dream") and No. 3 ("Fantasy")	
		Content, g (mg), in 100 g of product	Meeting the daily needs, %	Content, g (mg), in 100 g of product	Meeting the daily needs, %
Protein, g	75	10.9	15	14,4	19
Fat, g	95	5.8	6	7.1	8
Carbohydrates, g	430	68.8	16	60.0	14
Dietary fiber, g	30	4.3	14	8.0	28
Macronutrients, mg:					
potassium	3500	186	5	270	8
calcium	1000	27	3	60	6
magnesium	400	35	9	120	30
phosphorus	800	121	15	203	25
Micronutrients:					
iron, mg	14	0.3	2	0.4	3
zinc, mg	15	0.9	6	1.3	9
selenium, µg	70	5.0	7	8.0	11
Vitamins:					
thiamine, mg	1.4	0.25	18	0.44	31
riboflavin, mg	1.6	0.10	7	0.63	39
pantothenic acid, mg	6	0.30	5	0.40	7
pyridoxine, mg	2	0.19	9	0.22	10
biotin, µg	50	1.80	4	1.40	2
tocopherol, mg	10	1.58	16	2.50	25
Antioxidants (total), mg	-	0.15	-	0.62	-
Biological value of protein, %	-	52.4	-	62.2	-
Energy value, kJ/kcal	10467/2500	1587/378	15	1538/368	15

4. Conclusions

As a result of the conducted studies, it has been established that the use of amylase and xylanase enzyme composition in the production of salt-free bread sticks can improve their organoleptic characteristics (shape, color, internal state) and increase the physico-chemical characteristics (swelling ratio and strength). It has been revealed that the additional use of non-traditional raw materials in their recipe provides harmonious taste, aroma of products, increases their antioxidant activity, biological and nutritional value. Chloride-free products with the combined use of the enzyme composition, linseed oil and grape seed oil are recommended in people's diets to improve the effectiveness of treatment and prevention of kidney and heart failure, hypertension, and osteoporosis. The obtained data will promote the expansion of the assortment of dietary bakery products of increased nutritional value.

Conflict of Interest

None declared.

Конфликт интересов

Не указан.

References in English

1. Drevin, A.V. Taranova, E.S. Non-traditional raw materials for the production of bakery products of functional purpose. *J. Baking of Russia*. 2016, 1, 20-21.
2. Flander, L., Salmenkallio-Marttila, M., Suortti, T., Autio, K. Optimization of ingredients and baking process for improved wholemeal oat bread quality. *Food Science and Technology*. 2007, 40 (5), 860-870.
3. Stabrovskaya, O.I., Romanov, A.S., Korotkova, O.G. Multicomponent mixtures for the production of bakery products. *Food Processing: Techniques and Technology*. 2009, 2, 30-33.
4. Alexander, W.M. α -Amylase, Limit Dextrinase, and α -Glucosidase Enzymes in Barley and Malt. *Critical Reviews in Biotechnology*. 2016, 5 (2), 117-128. DOI: 10.3109/07388558709086972.
5. Karolien, D., Joye, I.J., Bram, P., Christophe, M. Pyranose Oxidase from *Trametes multicolor* Impacts Dough and Bread Microstructure. *Cereal chemistry*. 2014, 91 (4), 414-417. DOI: 10.1094/CCHEM-11-13-0248-N.
6. Arte, E., Katina, K., Holopainen-Mantila, U., and Nordlund, E. Effect of Hydrolyzing Enzymes on Wheat Bran Cell Wall Integrity and Protein Solubility. *Cereal chemistry*. 2016, 93 (2), 162-171. DOI: 10.1094/CCHEM-03-15-0060-R.
7. Kolupaeva, T.G. Novozymes enzyme preparations for replacement of food additives with E index. *Bread products*. 2013, 4, 14-16.
8. Budnik, L.T., Scheer, E., Sherwood, B.P., Baur, X. Sensitising effects of genetically modified enzymes used in flavour, fragrance, detergence and pharmaceutical production: cross-sectional study. *Sociological methodology*. 2016, 74 (1), 1-7. DOI: 10.1136/oemed-2015-103442.
9. Steffolani, M.E., Ribotta, P.D., Pérez, G.T., Puppo, M.C. Use of Enzymes to Minimize Dough Freezing Damage. *Food and Bioprocess Technology*. 2012, 5 (6), 2242-2255. DOI 10.1007/s11947-011-0538-2.
10. Bobyshev, K.A., Matveeva, I.V. Effect of glucose oxidase enzyme preparation on the properties of dough and the quality of bread from wheat flour. *Bread products*. 2014, 7, 25-27.
11. Petrichenko, V.V., Ivanov, M.G., Ponomareva, E.I., Voropaeva, O.N. Investigation of the effect of the use of enzoway 5.02 technological auxiliary for hydrothermal processing of wheat grain on the properties of dough and bread. *Bread products*. 2015, 5, 34-35.
12. Production of dietary crackers, bread sticks and crispy bread. <https://studfiles.net/preview/3549045/page:5/> (date of reference 17.12.2017).
13. Zhuravlev, A.A., Lukina, S.I., Ponomareva, E.I., Roslyakova, K.E. Optimization of technological parameters of preparation of dough for rusks of high nutrition value. *Foods and Raw materials*. 2017, 5 (1), 81-90. DOI: 10.21179/2308-4057-2017-1-73-80.
14. Minevich, I.E., Zubtsov, V.A., Tsyganova, T.B. Use of flax seeds in bakery. *Bread products*. 2008, 3, 38-40.
15. Bokshan, E.V., Darmogray, R.E., Dzera, V., Choliy, L.F., Stein, T. Grape seed oil is a promising raw material for pharmaceutical and cosmetic products. <http://provisor.com.ua/archive/2000/N5/oil.php> (date of reference 17.12.2017).
16. Chlorophyll: health benefits, sources. <https://herbcart.ru/xlorofill-polza-dlya-zdorovya-istochniki/> (date of reference 24.12.2017).