

Qualitative indicators of grain flakes of functional purpose

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Abstract

Keywords:

Activation
Wheat
Triticale
Oats
Flakes

Introduction. Cereal raw materials are an important basis for the food industry. The research was carried out on the possibility of using a whole biologically activated grain of cereals to create functional food products.

Materials and methods. Compoundings of grain mixes of flakes and ready-made products on their basis is investigated. Protein was determined by Biuret method, starch content by polarimetric method. Fat was determined by the method of exhaustive extraction with chemically pure hexane. Vitamin E and substances with P-vitamin activity are determined colorimetrically. Vitamin C was carried out using a titrimetric method. The microbiological indices of the studied samples were determined by sowing them surface on agarized nutrient media.

Results and discussion. The influence of temperature regime and duration of cold conditioning of grain on its biological value is determined. With change of temperature regime to 12–18 °C and the duration of conditioning of 24–30 h, the content in the grain of all water-soluble vitamins increases by 2–2,5 times, the amount of tocopherol grows by 5–7 times, the amount of substances with P-vitamin activity increases in 2,5 times.

The dependence of basic physical and technological parameters of grain flakes and organoleptic properties of finished products from their component composition is investigated. Increase in a mass fraction of oats to 50% leads to increased viscosity of porridge, due to an increase in the content of hemicellulose, decreases crumbility. Increasing the mass fraction of wheat grain to 35% leads to a more rigid structure of porridge, which is explained by the higher density of shell parts of wheat grain, compared with other components.

The degree of maintenance of the daily needs of the adult population in the macronutrients, at the expense of consumption of 100 grams of flakes, is: proteins – 18–22%, fats – 5–7%, carbohydrates – 13–16%, food fibers – 13,5%.

Taking into account the daily requirement of adult population in vitamins, 100 g of flakes mix allows you to meet the need for vitamin E by 67–76%; P by 17,4%.

The total number of colony-forming units of mesophilic aerobic and facultative-anaerobic microorganisms in fresh samples of mixes of flakes and after their storage does not exceed $2 \cdot 10^3$ per g product, mold mushrooms and pathogenic microorganisms are absent.

Conclusions. Biologically activated grain of cereal cultures of wheat, bare grain oats and triticale is a source of valuable nutrients, for creation of mixes of flakes of functional purpose.

Article history:

Received
03.09.2018
Received in revised
form 19.10.2018
Accepted
28.03.2019

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DOI:

10.24263/2304-
974X-2019-8-1-3

Introduction

Cereal products are the main and irreplaceable components of food ration [1], they contain a number of essential substances necessary for providing of the normal functioning of man organism [2]. The leading place of food products on a grain basis in the feed puts the goal of the technologists to achieve a higher level of their functional significance [3]. Scientists investigate the possibility of application new non-traditional types of raw materials, processing methods for improving the quality of food products [4].

Wide distribution is acquired by flakes and groats of quick-cooking [5]. The interest of consumers in this type of products is explained by the possibility of reducing their cooking time and the best food and taste properties, in comparison with traditional groats [1]. The classic type of cereals for the production of flakes is an oat [6]. Lately for the production of flakes apply the row of other cereal cultures – rye, wheat, barley, and also corn, millet, buckwheat as well [5]. This allows you to expand the assortment of products, increase its food value.

One of the most useful and delicious types of cereal products are mueslis, basis of that are the flakes of a several cereals, complemented by fruit and vegetable components [7]. So fairly successful are products that provide a combination of cereal flakes with different original fillings, which is from 30% to 50% of the product [5].

The literature does not contain data on the possibility of production of flakes based on biologically activated grain of wheat, bare grain oats and triticale.

Literature review

By a base product that is basis for the production of flattening groats and flakes there are groats not ground up. Flakes produce from the groats of top grade at their additional cleaning, steaming-out and flattening [6].

Studies have found that regular consumption of whole grains and products on its basis contributes to reducing the risk of diseases of the cardiovascular [1] and digestive systems of the body, the development of diabetes [2]. Such influence is caused by the presence in the whole-grain products of a number of biologically active components: vitamins, mineral compounds, food fibers [7] that can increase the immunity and adaptive capacity of a person, improve the activity of the gastrointestinal tract, organs and systems, and reduce the development of metabolic syndrome [3]. It is proved that valuable difficult complexes contained in whole grain products are more useful than the separate isolated components [4]. The peripheral parts of the grain, the shell and the aleurone layer, the germ contain much more valuable micronutrients than the starch endosperm, in particular vitamins and vitamin-like compounds, phenolic compounds, phytosterols, lignans, and dietary fibers [8] that are characterized by high biological activity [9]. It is also known that the proteins of the aleuronic layer and the germ have a higher nutritional value, compared to the grain endosperm proteins [10].

Foods on the basis of grain cereals are the important dietary sources of antioxidants [2]. The authors have investigated that the content of phenolic compounds, in particular rutin, quercetin, phenolic acids in grain, not cleaned from shells, is significantly higher, antioxidant activity is also 2-4 times higher than that of grain cleaned from shells [11]. The total content of antioxidants in whole-wheat products exceeds 3,5–6 times the corresponding value in fruits and vegetables [12].

Clinical trials by Swiss physicians have shown that whole grains groats reduce the risk of oral and pharyngeal cancers, esophagus and larynx, unlike refined grain products that can contribute to this disease [13].

Scientists confirm the protective role of whole grains products that contain food fiber and the necessary mineral compounds, in particular magnesium, in relation to development of diabetes, especially in the elderly [3]. Clinical researches have shown that low concentration of magnesium in plasma of blood are associated with insulin resistance; it is proved that wholegrain products significantly reduce glycemia [14].

The Polish scientists have analyzed the assortment of the most popular cereal wheat breakfasts. It is marked that these products are made from the grain released from shells were characterized by low protein content (about 6,2%), subzero content squirrel (close 6,2%), low total fiber content (6,49%) and soluble dietary fibers [5].

Sprouting of grain and seeds is used to soften the core, increasing the nutritional value, reducing anti-alimentary substances and improving the functional composition of proteins [6]. The germination process should be short-lived and carried out at low temperatures, as it results in the degradation of β -glucans that significantly affect blood cholesterol and glucose, activity of the cardiovascular system, are antibacterial, antitumor, radioprotective properties [15]. So with the germination of oats grain for 72 h, the content of β -glucans is reduced by 40-45% [15].

Germination assists the increase of bioavailability of food compounds, by their partial hydrolysis, mineral substances of whole grain of Fe and Zn, mastering of that is complicated through the presence of natural inhibitors [16], and also to the decline of activity of present antialimentary substances, such as inhibitors of enzymes, hemagglutinins, etc. [17].

Scientists propose to receive flour of high nutritional value, in particular, with improved amino acid, mineral and fatty acid composition of grains germinated in solutions of sea salt [18].

In order to increase the nutritional value of products, biologically activated grain of wheat is recommended for use in bread technology [19]. Scientists from Belarus developed a number of methods for processing biologically activated grain, for the production of flour, groats and other products of high food value [20]. Technology of flakes is worked out from red rice, that envisages the use of whole grain soaked during a few days, that assists the increase of food value and comprehensibility of raw material [21].

The objectives of the work is the scientific and practical ground of the expediency of using a whole biologically activated grain of wheat, bare grain oats and triticale to create a mixture of flakes of high food value.

Task of researches are the following:

- to propose regimes for the preparation of grain of cereal cultures to increase its nutritional value;
- to ground expediency of application of the biologically activated grain-growing raw material for modeling and creating mixtures of flakes of functional purpose;
- to investigate the influence of the composition of the formula of a mixture of flakes on the basis of biologically activated grain of wheat, triticale, and bare grain oats on the basic physical and technological parameters of the product;
- to determine the organoleptic parameters and the nutritional value of grain flakes;
- to investigate the basic indexes of quality of flakes on the basis of biologically activated grain;
- to calculate the provision of day's norm in vitamins and basic substances due to the consumption of mixture of grain flakes;
- to define the indexes of microbiological stability of the product.

Materials and methods

Materials

During realization of experimental researches used grain of wheat, triticale and bare grain oats, respectively, sorts Mironivska 137, Molfar, Solomon [22], to the harvest of 2017; made standards of mixtures of flakes.

Methods of determination of nutrition value of flakes.

Preparation of investigated samples of flakes envisaged grain cleaning, washing and disinfection, hydrothermal treatment at 12–16 °C in three cycles, each of which included the intensive moistening of grain for 4 hours, followed by evaporation for 4 to 6 hours, the total duration of 26–30 h. [23], rolling of grain, drying at a temperature of 40–45 °C to a humidity of 12–14%; combination according to the formulation [6]. Humidity of the investigated samples was determined by drying to a constant mass for temperatures 105 °C [6]. Protein content was determined by Biuret method [24], which is based on the properties of proteins in an alkaline environment to form a blue-violet color with a biuret reagent whose intensity is determined on a spectrophotometer; starch – polarimetric method [25]. Fat was determined by the method of exhaustive extraction with chemically pure hexane [26]. Vitamins E and P were determined colorimetrically [27], determination of vitamin C was performed by titrimetric method. The method is based on extracting vitamin C from the test sample with an acid solution (chloride acid, metaphosphorus or a mixture of acetic and metaphosphoric) followed by titration visually or potentiometrically with sodium 2,6-dichlorophenolindophenolate solution [28].

Method of determination of microbiological indicators of flakes

The microbiological indexes of mixture of flakes determined in the prepared samples, humidity of that folded 11-12%. For this purpose, the samples studied were planted superficially on agarified nutrient media: meat-peptic agar (detection of mesophilic aerobic and facultative anaerobic microorganisms – MAFAnM), wort-agar (yeast and mushrooms). Cups with crops were incubated for 2 to 3 days at a temperature of 37 °C to establish a total amount m/o (MAFAnM). Crops on cups with an environment a wort-agar for the exposure of mushrooms and yeasts were incubated at 28 °C during a 5–7 days [29].

Results and discussion

Researches of influence of prescription composition of grain flakes on their indicators of quality

Scientists have shown that the consumption of grain products plays an important role in maintaining a normal body mass index, providing the body with energy, mineral compounds, vitamins, and lowering cholesterol levels in the blood [30]. Effective are biological methods of preparation of grain raw materials, which contribute to the increase of activity of native enzymes – soaking, sprouting, hydrothermal treatment at low temperatures, fermentation. Such treatment contributes to the highest natural degradation of anti-nutrients – phytate, inhibitors of digestive enzymes, increasing the bioavailability of macronutrients. The use of

biologically activated grain of cereals for the creation of products for health and functional purposes is a new progressive trend.

Traditional grain preparation includes hydrothermal treatment, in particular, cold conditioning, involves moisture of the grain and prolonged evaporation at a temperature of 30 to 40 °C. Hydrothermal treatment regimes include steam under pressure and grain tempering [31]. Such heating does not contribute to the synthesis of vitamins in the grain.

We have scientifically substantiated and proposed the use of significantly lower temperatures in the cold condition of grain – 12–18°C. The process of treatment it is recommended to conduct in three cycles, each of which involves intensive humidification of grain for 4 hours, followed by evaporation for 4 to 6 hours, the total duration of 24–30 h, which contributes to increasing of humidity of grain to 30–35%. Such preparation causes activation of the enzyme complex. As a result of the intensification of enzymatic processes, increasing the bioavailability of carbohydrates and proteins, activating the synthesis of vitamins and vitamin-like substances [15]. Due to the activation of the enzyme complex, biological changes occur in the structure of the grain, it begins to sprout, is in the so-called "awakened state" [20]. By this treatment, the content of valuable micronutrients increases significantly, which is related to the internal biological processes in the plant organism.

Our previous investigations have shown that for this treatment, the content of all water-soluble vitamins increases by 2–2,5 times, the amount of tocopherol increases 5-7 times, depending on the culture and sort of grain; substantially increases the content of vitamin-like substances, in particular, substances with P-vitamin activity, inositol, in comparison with grain native [32].

Taking into account principles of health feed, the row of compounding of mixtures of flakes is worked out with the use of grain of wheat, bare grain oats and, triticale. Including our experimental data and applying the calculated method of food combinatorics, the percentage content of the formulation components of the mixture is calculated, which provides the highest amount of vitamins B, vitamins C and E, inositol in the finished product.

Prepared prototype finished products and studied their basic quality indicators (Table 1).

The influence of the amount of components of the mixture of flakes on the quality parameters of the finished product is investigated. It has been experimentally found that flakes obtained from the grain mixture, which include 30–45% oats, 20-30% wheat and 35-40% triticale are as friable, have a pleasant taste and a smell of cooked flakes. An increase in the mass fraction of oat to 50% leads to an increase in the viscosity of porridge, due to an increase in the content of hemicellulose, the scatteriness decreases, which is not expedient. Increasing the mass fraction of wheat grain up to 35% leads to a more rigid structure of porridge, which is explained by the higher density of the shell parts of wheat grain compared to the bare grain of oats and triticale, which is not appropriate.

It was investigated that the ratio of the main constituents of substances in developed grain flakes, which makes 12,2–12,7% (proteins): 3,8–4,4% (fats): 54,4–57% (carbohydrates) is more acceptable than in a number of cereals: manna, wheat, rice and the most popular types of cereal wheat breakfast [5, 33].

There was experimentally determined that the content of food fibers in developed grain flakes is 2.7 – 2.9%. It is researched that according to the water-holding ability, the data of the food fibers belong to the group of medium-water-binding, they have a positive influence on the processes of digestion, occupy a considerable volume in the intestine and increase its peristalsis [13]. The presence of food fibers, which are natural food sorbents, capable of adsorbing toxic substances, heavy metal salts, radionuclides, bile acids, and cholesterol, are an important factor in their functional action on the human body [34].

Table 1

Recipes of mixes of flakes and a characteristic of their nutritional value and organoleptic indicators

№	Recipe components			Nutritional value				Vitamin content, mg%.		Organoleptic indicators of the finished product
	Wheat	Oats bare grain	Triticale	Proteins	Fats	Carbo-hydrates	Energy value, kcal	E	P	
1	15	50	35	12,85	4,58	46,25	277,45	11,85	8,57	The porridge is viscous, not crumbly enough, the smell and taste is characteristic of this product
2	20	45	35	12,68	4,38	47,26	279,2	11,65	8,64	Porridge is a measure of crumbly, pleasant taste and a smell of cooked flakes
3	25	40	35	12,51	4,18	48,26	280,74	11,55	8,74	Porridge is a measure of crumbly, pleasant taste and a smell of cooked flakes
4	30	30	40	12,22	3,79	50,17	283,67	11,36	8,84	Porridge is a measure of crumbly, pleasant taste and a smell of cooked flakes
5	35	35	30	12,29	3,96	49,37	282,42	11,45	8,78	The porridge is hardened with slipping, the smell and taste is characteristic of this product

Determination of biological value and physical-technological indicators of quality of grain flakes

We have determined the content of vitamins in grain flakes. The developed product, due to the preliminary preparation of grain – biological activation, during which the grain sprouts, contains a significantly higher amount of antioxidants – vitamins C, E and substances with P vitamin activity, compared with traditional grain products. These data are consistent with studies by other scientists who have found a significant increase in the content of vitamins at grain germination [35, 36]. The flakes also contain vitamins of group B: thiamine – 0.48 to 0.62 mg%, riboflavin 0.25 to 0.32 mg%, pyridoxine 0.86 to 1.2 mg%, inositol 154 to 162 mg% nicotinic acid – 4.5–6.3 mg%.

The basic physical and technological parameters of quality of flakes mixes from biologically activated grain are determined (Table 2).

Table 2

Physical and technological indicators of grain flakes quality

№	Indicator	The ratio of the formulation components of the mixture flakes (wheat: oats: triticale),%.		
		20 : 45 : 35	25 : 40 : 35	30 : 30 : 40
1.	Humidity,%.	11,5	12,0	11,8
2.	Volumetric mass, g/l	420	426	438
3.	The middle particle size, mm	5,2	6,0	6,4
4.	The angle of the natural inclination, deg	64	62	65
5.	Angle of sliding on metal, deg	15	16	18
6.	Actual density, g / l	432	440	454
7.	Cohesiveness	1,1	1,2	1,4

It should be noted that the ratio of individual components of the mixture of flakes influences the physical and technological parameters [6]. All samples have a permissible value of humidity. The middle particle size of a mixture of flakes depends on the grain size of the raw material and is in the range acceptable for food products on grain basis [31]. The values of indexes of by volume mass and actual density indicate the high quality of the grain product. Optimum values of cohesiveness of grain mixtures characterize their ability to move freely when unloaded from containers and during transportation [6]. The obtained results correlate with the data, determined on the physical and technological parameters of corn flakes [37, 38].

Scientists note that whole grain products are essential for daily diets; they contain a unique set of nutrients that are prevention of cardiovascular disease and diabetes [37].

Using the norms of human physiological needs in the main nutrients and energy [39], the calculation of maintenance of the day's norm (DN) in vitamins and basic substances was made due to the consumption of a mixture of flakes from biologically activated grain. Quantitative indicators are given in tables 3,4.

Table 3

Providing daily need for vitamins per 100 g of a mixture of flakes

Vitamin	Content in a mixture of flakes, mg	Norms of consumption, mg		Maintenance DN, %.	
		Men	Women	Men	Women
E	11,5	17	15	67,6	76,6
P	8,7	50		17,4	17,4
C	4,2	70		6	6

Consequently, taking into account the day's requirement of adult population in vitamins, 100 g of mixture of flakes allows you to meet the need for vitamin E by 67–76% and vitamin P by 17,4% and vitamin C by 6%. The obtained results indicate that a mixture of flakes from biologically activated wheat, oats and triticale is a functional product [40]. These products are able to provide the body with vitamins antioxidants every day, which is important in antioxidant protection of the body [41].

Table 4

Nutritional and energy value of a mixture of flakes

Indicator	Mixture of flakes	Daily norms consumption		Ensuring day norm, %.	
		Men	Women	Men	Women
Proteins, g	12,4	67	55	18,5	22,5
Fats, g	4,03	68	56	5,92	7,19
Carbo- hydrates, g	Starch	52,7	392	13,4	16,4
	Food fibers	2,7	20	13,5	13,5
Energy value, kcal	327	2450	2000	13,34	16,35

It is established that the degree of ensuring of the day's needs of the adult population of the first group of labor intensity in the macronutrients, at the expense of consumption of 100 grams of cereal flakes is: proteins – 18–22%, fats – 5–7%, carbohydrates – 13–16%, food fibers – 13,5%. The presence of a significant amount of food fibers in the flakes is a positive factor, since these natural sorbents lower the level of cholesterol in the blood and the risk of development of tumors of the upper digestive and respiratory tract [13, 42, 43].

The total number of colony-forming units of mesophilic aerobic and facultative-anaerobic microorganisms (KFU MANFAnM) was determined in the finished mixture of flakes, as well as during storage of the product for 6 months. The results of microbiological studies are presented in Table 5.

As a result of the conducted research it was established that the microbiological seedability of mix flakes on the basis of biologically activated grain of wheat, triticale and oat does not exceed the values of permissible values of microbiological seedability [29], storage of mixtures of flakes during 6 months does not significantly impair their quality, these grain products are safe from the point of view of microbiological purity.

Table 5
Microbiological indicators of a mixture of flakes based on biologically activated grain

Sample	Microbiological indicators		
	MAFAnM, KFU / g, no more	Mold fung, KFU / g, not more	Pathogenic microorganisms, including Salmonella in 25 g
Cereals, normative value	$5 \cdot 10^3$	50	Not allowed
A mixture of flakes after drying	$3 \cdot 10^2$	Not found	Not found
A mixture of flakes after 6 months storage	$2 \cdot 10^3$	Not found	Not found

Conclusions

According to the results of analytical and experimental studies, the prescription composition of grain flakes on the basis of biologically activated grain of wheat, oats and triticale has been developed. This product has a functional purpose and is essential for a diet, since it enables you to satisfy your daily needs not only in the required macronutrients, but also in important vitamins and food fibers.

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