Improving the nutritional value of grains by biological activation

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Abstract

Introduction. Cereal products are a source of carbohydrates, protein, macro and micronutrients, vitamins, enzymes, dietary fiber, phospholipids. Sprouting grains is one of the methods for biological activation.

Materials and methods. Grains of wheat, triticale and naked oats have been studied. Protein was determined by Bradford method, the starch content – by poalrimetric method. Fat was determined by exhaustive extraction with chemically pure hexane. Vitamins B_1, B_2, B_3, B_6 were determined by the method of fluorometry. Vitamins PP and E were determined colorimetrically. Determination of vitamin C was performed by a titration method.

Results and discussion. An important task in the process of preparing raw materials for health products is increasing their food and biological value. We proposed a regime of hydrothermal processing of grain at temperatures 12–16 °C. Under these conditions, activation of the enzyme complex, reduction of grain density and increase of its per unit volume; activation of the synthesis of vitamins and vitamin-like substance take place. In the process of biological activation of grain the bioavailability of proteins, carbohydrates, fat increases due to their partial hydrolysis. It has been studied, that the content of fibres,which is natural food sorbent, in biologically activated grains of wheat, naked oats and triticale is respectively 2,68, 2,34, 2,62%. It has been found that in the proposed processing of wheat, triticale and naked oats the quantity of vitamin C increased more than twice. The content of tocopherols increases tenfold, routine – 2,5–3 times. It was established that after hydrothermal treatment the total number of colony-forming units of mesophilic aerobic and facultative anaerobic microorganisms in native and dried corn samples is within the norms established by standards.

Conclusions. The results are of practical importance, as they allow to recommend the use of biologically activated wheat, triticale, naked oats for the production of food of health, functional and health-care purposes.

Introduction

Production of functional foods is a priority for all developed countries. The inclusion of functional foods to the daily diet will allow to improve physical and cognitive functions of organism, reduce the risk of many diseases, improve the genetic potential of humanity.

Grain raw materials is one of the main food basics for functional foods creation.

The aim of work is to research the increase of nutritional value of grain cereal crops through biological activation under the proposed regimes for its use in the creation of health food, functional and preventive nutrition.

Objectives of research:

- To propose mode of treatment of grain of cereals to increase its nutritional value;
- To explore the change in content of basic substances of grain in the proposed mode of treatment;
- To explore the change in content of vitamins in wheat, triticale and naked oats during processing;
- To determine the microbiological quality of grain, prepared by the proposed regime.

Analysis of the literature

Foods from whole grain cereals, which include shell of the grain aleurone layer and the germ contain powerful antioxidants – vitamin E, C, carotenoids, choline, folate; cofactors of antioxidant enzymes – microelements Se, Cu, Mg, food sorbents – cellulose, lignin, lignin [1].

Scientists studied the total number of phenolic compounds, flavonoid content and antioxidant activity of extracts of different fractions of grain cereals grinding. It has been established that the flour of various sizes has lower antioxidant potential than bran fractions (fine and coarse bran). The extract of barley had the highest values of antioxidant activity and polyphenol content [2].

Improving the quality of raw materials is an important task of the food industry.

Recently, new technologies of unconventional processing of grain cereals that provide germination process have been developed.

Sprouting as a method of biological activation, is used to increase the nutritional value of grain and other raw materials.

During germination of wheat, the bioavailability of dietary compounds is increased by partial hydrolysis of starch, protein, hemicellulose and cellulose; increase in content of vitamins, bioelements and other biologically active substances. In addition, the activity of some antialimentary active substances (inhibitors of enzymes, hemagglutinin) decreases during germination, which promotes full absorption of grain nutrients [3].

Due to utility of germinated grains, they were used to produce malt extracts from oats, barley, wheat, corn and peas. These products show a strong recreational effect on the human body, stimulate metabolism, improve efficiency, increase the activity of the body and its resistance to harmful factors [4].

Sprouted grain is a holistic living organism that possesses natural biological properties and is in the stage of maximum vitality. Sprouted grain is a natural biogenic product that has high energy potential, the total antioxidant capacity of which is 3 –10 times higher (depending on culture) compared to the native grain.

Regular consumption of sprouted grain stimulates metabolism, hematopoiesis , improves immunity, compensates for vitamin and mineral deficiency, normalizes the acid-

alkaline balance, cleans the body of toxins, contributes to good digestion, increases potency and slows the aging process [5].

Sprouted grain wheat, which contains plant protein, is recommended to be included in the diet intended as general strengthening of the body and enhancing or restoring sexual activity in particular [6], reducing the risk of the emergence and development of cancer [7], enrichment of child's body in biologically active substances [8]. The consumption of sprouted grains improves reproductive function [9].

During properly organized process of germination of grain its basic nutrients – proteins, fats, carbohydrates – split under the influence of enzymes to form more simple components that are easily absorbed by the human body, with a significant increase in amounts of vitamins and vitamin-like substances. In addition, the germinated seeds contain some kind of natural food sorbents – cellulose, hemicellulose, lignin, which are indispensable components of food. That is why sprouted grain is used in many developed countries as a valuable supplement to the diet, which promotes recovery and longevity.

There are data on the significant increase in the content of carotenoids and vitamin E during germination of wheat, and the authors note that the maximum content of tocopherols is increased on the second day, and the amount of carotenoids on the seventh day of germination [10].

To improve the nutritional value of cereal grains and legumes, his soaking and sprouting in water, solutions of sorbic acid and sea salt is recommended to combine with the deep freeze, which contributes to the increase in number of reduced sugars [11].

Scientists say that the flour obtained from grain sprouted in sea salt solution contains more amino acids and fatty acids as a result of activity of enzymes. In addition, mineral composition is improved: the content of magnesium, calcium, potassium, iron, zinc, copper increases 14.8; 7.5; 3.0; 4.7; 4.2; 6.3 times respectively compared with ordinary wheat flour [12].

Sprouting for 48 hours improves the chemical composition of the fruit of the African yam, a combination of such raw materials with sprouted grain of corn allows to get a biologically valuable supplement to the diet [13].

Application of sodium selenate (Na_2SeO_4) during germination of rye allows to get grain enriched with this important microelement, besides, increases extractivity of received malt [14].

Analyzing the effect of duration of germination on the nutritional value of wheat, scientists found that after biological activation of wheat for 24 h the amount of vitamin E increases by 6.5 times, the amount of niacin (PP) increases by 1.3 times, the content of vitamins B_2 and C 6 increases respectively by 26 and 65%. The total number of amino acids decreases by 17.4% [15].

It has been investigated that B-group vitamins, vitamins C and E, β-carotene are accumulated in the process of grain sprouting gradually. The maximum increase in the content of folic acid by 3.6 times in germinated seeds of wheat and by 1.7–3.8 times in rye was fixed on the fifth day of germination [16].

It has been established that the rate of creating of vitamins E, C, B is maximum during the development of germ from burgeoning to the size of 2–3 mm, which indicates the feasibility of using sprouted grains for producing health foods in the initial stage of germination.

The use of biologically activated wheat in the bakery makes it possible to increase the biological value of bakery products [17].

The biologically activated wheat contains significant amounts of vitamins and fiber, so its use is appropriate for the enrichment of bread. During the germination of seeds redox

systems that have B vitamins in their structure are formed. It has been studied that the content of B vitamins, including B_1, B_2, B_5, B_6 5–10 times higher in sprouted wheat grain than in mature one. Also, vitamin C is synthesized during the process of grain sprouting. The inclusion of biologically activated wheat to bread recipe in amount of 15% allows to get a product with good organoleptic and technological characteristics [18].

A new kind of corn bread from sprouted wheat "Colossus", which has high quality, including increased specific volume of the bread pan, well-developed uniform crumb porosity, improved microbiological indicators, extended shelf life has been developed [19].

The influence of biological activation of grain cereals, including wheat, triticale, naked oats on the change of the content of its basic nutrients is a key issue; in literature no relevant data are available.

Materials and methods

The object of research is the grain of wheat, triticale and naked oats of such breeds as accordingly Myronivska 137, Molfar, Solomon of harvest of 2015 were used for studies.

Protein was determined by Bradford method [20], the starch content – by physical method. The physical method based on starch dissolving and determination of the solution poalrimetric deviation. Fat was determined by exhaustive extraction with chemically pure hexane. Vitamins B_1, B_2, B_3, B_6 were determined by the method of fluorometry. Vitamins PP and E were determined colorimetrically.

Determination of vitamin C was performed by a titration method. The method is based on extraction of vitamin C from the sample with solution of acid (hydrochloric, metaphosphoric acid or a mixture of acetic and metaphosphoric), followed by further titration potentiometrically or visually with solution of 2,6-dyhlorfenolindyfenolyat sodium**.**

Microbiological samples of grain of wheat, triticale and naked oats native and biologically activated was determined after drying to a moisture content of 11–12%.

With this aim the studied samples were plated on agar surface of nourishing source: meatpepton agar (detection of mesophilic aerobic and facultative anaerobic microorganisms) wort-agar (yeast and fungi).

Cups of crops were incubated for 2–3 days at 37 °C for determining the total number of microorganisms. Crops in the cup of the wort-agar medium for detection of fungi and yeast were incubated at a temperature of 28 °C for 5–7 days.

Results and discussion

Hydrothermal processing of grain is used in flour and cereal industries, the production of animal feed. It is known that hydrothermal processing of grain influences the anatomical, physical, chemical, structural, mechanical and biochemical properties of grain, changing its technological properties. Traditional modes of cold air-conditioning in the production of flour and grain provide moistening and long moistening – for 4–8 or 16–24 hr., depending on the type of wheat, to a moisture content of 15,5–17% at 20 to 40 °C. Under these conditions the scarifiering of endosperm, the formation of cracks in it; changing the thickness of the shells and aleurone layer, increasing of their flexibility and strength take place, the moisture of corn increases by 1,5–2%. These factors increase the degree of extraction of endosperm, flour yield, reduce energy consumption for grinding grain. In

cereal production the aim of hydrothermal treatment is to increase core strength, providing a higher yield of whole grains. So, hydrothermal treatment regimes include steaming under pressure and tempering of grain. The production of wheat cereals of cold conditioning is carried out at a temperature of 30–40 °C.

We proposed the regime of hydrothermal processing – cold air conditioning at temperatures 12–16 °C for 25–30 hours. Under these conditions, grain moisture increases by 30–35%, which leads to activation of the enzyme complex, decrease in grain density and increase in its per unit volume. As a result of the intensification of enzymatic processes a partial hydrolysis of carbohydrates and proteins, change of conformation of proteins, activation of the synthesis of vitamins and vitamin – like substances take place.

The relative change in weight of wheat, triticale and naked oats in the process of hydrothermal treatment has been investigated. Setting the intensity of mass change that characterizes the percentage of moisture absorbed by grain during each hour in the process of humidification showed that the highest intensity of grain swelling occurs within four hours of active humidification. This pattern of moisture absorption occurs during the first cycle of hydrothermal processing of grain. After reaching significance humidity of 30 – 35% of the swelling process slows down dramatically.

The change in content of essential nutrients of grain cereals in the proposed regime of hydrothermal processing has been investigated, the data are presented in table 1.

Table 1

The content of organic substances in major grain cereals

Cereals	Proteins,g	Fats, g	Starch, g	Cellulose, g
Native grains				
Wheat	12,5	1,72	68,04	2,45
Oat	16,8	5,3	40,52	2,26
Triticale	13,0	1,97	65,41	2,59
Biologically activated grain				
Wheat	10,8	2,52	54,36	2,68
Oat	14,2	6,52	34,61	2,34
Triticale	11,8	2,7	52,3	2,62

The decrease in the total number of proteins was marked iIn the process of biological activation of grain that is consistent with the literature and is explained by the removal of protein molecules from amino acids that take a direct part in metabolic processes occurring in plant tissues and cells. Fat content in the grain increases during processing, which is associated with the mutual conversion of carbohydrates proteins and fats. A significant decrease in the number of carbohydrates due to hydrolysis to sugars has been marked.

Dietary fiber is a complex of natural polysaccharides of plant origin, which have water-retaining, fat-connecting, gelling and sorption properties. Dietary fiber can adsorb toxic substances, heavy metals, radionuclides, bile acids, cholesterol. Fiber as one of the main components of dietary fiber is an activator of digestive enzymes, their stabilization occurs on its surface and enhances the activity of enzyme systems, improving detoxification processes.

It has been studied that fiber content in the biologically activated grain cereals of wheat, naked oats and triticale is respectively 2,68, 2,34, 2,62%.

Due to the high water-retaining capacity, fibers have positive effect on digestion, they occupy a significant volume of the intestine and increase its motility.

We investigated the water-retaining capacity of fiber of biologically activated wheat, oats and triticale. When the temperature rises the water-retaining capacity increases significantly. The research was conducted at room temperature and at 36 °C, to bring to the terms of stay of dietary fiber in the gastrointestinal tract of the human body. Figure 1 shows indicators of water-capacity of studied fiber grain cereals.

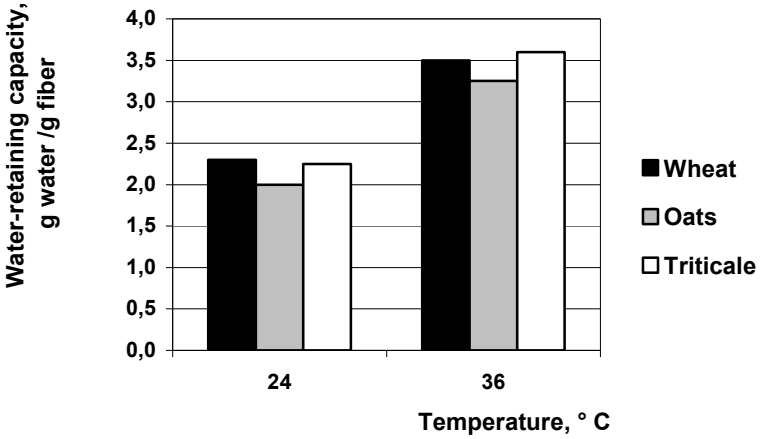

Figure 1. The water-retaining capacity of fiber of wheat, oats and triticale

So, from the received data we can conclude that for their waterhold ability dietary fibers of wheat, oats and triticale relate to water-retaining fibers that connect from 2 to 8 g water/g of fiber.

During the hydrothermal treatment under the proposed regime the change of content of vitamins that exhibit antioxidant properties of tocopherol, ascorbic acid, rutin has been researched (Tab. 2).

Table 2

The content of vitamins C, E, and P in grain cereals

Cereals	Vitamin P, mg%	Vitamin E, mg%	Vitamin C, mg%
Native grain			
Wheat	3,9	0,34	2,6
Oat	3,4	0,21	1,2
Triticale	4,5	0,47	2,3
Biologically activated grain			
Wheat	9,3	10,73	5,7
Oat	7,9	9,26	3,8
Triticale	9,2	10,82	4,1

Vitamin E (tocopherol) is found in a germ of grain. Its main role is to protect unsaturated fatty acids, which are important for the integrity of cell membranes, against free radicals. In human body, vitamin E improves blood circulation, prevents blood clots and is a synergist of vitamin A.

Vitamin C is a component of the oxidation-reduction systems, it prevents the formation of excess of oxidative free radicals, promotes the oxidation of cholesterol, involved in the synthesis of connective tissue structures and the formation of a number of hormones that positively affect most parts of the immune system.

Substances with P-vitamin activity strengthen capillary walls and thereby reduce their permeability. They are involved in tissue respiration, increase the effect of ascorbic acid.

Experimental studies have established that during the proposed preparation of wheat, triticale and naked oats vitamin C increases more than twice. The content of tocopherols increases tenfold, routine – by 2,5–3 times.

It has been investigated that during hydrothermal treatment under the proposed regime the content of water-soluble vitamins in grains of wheat, triticale and naked oats also significantly increases: the number of thiamine and riboflavin increases by 2–2,5 times; the content of pantothenic acid, pyridoxine, nicotinic acid and inositol increases by 1,5–2 times.

The total number of colony forming units of mesophilic aerobic and facultative anaerobic microorganisms (CFU MANFAnM) was determined in native and dried corn samples after hydrothermal treatment. The results of the research of microbiological indicators of grain are given in Table 3.

Table 3

Microbiological indicators of grain

A sample of grain	Microbiological parameters		
	Quantity MAFAnM, CFU/g, not more	**Molds, CFU/g, not more**	**Pathogenic microorganisms, including Salmonella in 25 g**
Cereal grains, normative values	$5 \cdot 10^3$	50	Not allowed
Grain of wheat	$2 \cdot 10^2$	30	Not found
Grain of oat	$3 \cdot 10^2$	25	Not found
Grain of triticale	$2 \cdot 10^2$	21	Not found
Grain of wheat, biologically activated	$3 \cdot 10^2$	25	Not found
Grain of oat, biologically activated	$2 \cdot 10^2$	20	Not found
Grain of triticale, biologically activated	$3 \cdot 10^2$	20	Not found

As a result of studies it has been found that microbiological fertilizing of native wheat, triticale and naked oats and biologically activated is not higher than permissible values of microbiological fertilizing, therefore the grain after the proposed treatment is secure raw materials for food production in terms of microbiological purity.

Conclusions

It has been established that during hydrothermal processing of grain of wheat, triticale, naked oats by the proposed regime its food and biological value increases through the partial conversion of the main components – proteins, fats and carbohydrates in a more accessible for assimilation form; a significant increase in content of vitamins, especially those that exhibit antioxidant properties, B vitamins. Biologically activated grain cereals with intact structure, without separation of membranes are a source of natural food sorbents. The received results are of practical importance, as they allow to recommend the use of biologically activated wheat, triticale, oats for the production of health, functional and health-care purposes foods.

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