Efficiency of using of the mineralized malts composition for the enhancement of food products by micronutrients

Alla Bashta[1], Nadija Ivchuk[1], Oleksandr Bashta[2]

1 – National University of Food Technologies, Kyiv, Ukraine
2 – National Aviation University, Kyiv, Ukraine

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Corresponding author:

AllaBashta
E-mail:
alla.sher.b@gmail.com

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Abstract

Introduction. The purpose of research is to obtain and investigate the composition of malts with high content of deficient micronutrients and enrichment with selected raw materials the rye-wheat bread.

Materials and methods. To obtain mineralized grain raw materials, maize and oat were germinated using solutions of zinc salt (ZnSO4) and chromium one $(CrK(SO_4)_2 \times 10H_2O)$ of different concentrations: 0.001%, 0.002%, 0.003%, 0.004%, and 0.005%. X-ray fluorescence analysis was used to determine the mineral composition of grain and malt and stripping voltammetry method to determine the zinc content.

Results and discussion. The optimum concentration of zinc salt in soaking water equaled 0.002%, at which the zinc content of the enriched maize increased by 6.7 times compared to the original grain. For the enrichment of grain with chromium ions, the chromium salt concentration in soaking water should not exceed 0.001%.

According to the X-ray fluorescence analysis the mineral content in enriched malt is increasing, the content of zinc increased by 6 times in comparison with the original, and content of chromium by 3 times, that indicate the possibility of the source raw material mineral composition correcting by soaking and germinating grain in aqueous solutions of microelement salts.

To enrich the food products with mineralized malts, rye-wheat bread was chosen as the traditional product in this work. Mineralized malts have a positive effect on the lifting power of yeast, and more so when zinc salts are added. This indicates a reduction in the duration of the technological process.

Studies of influence of the inserted mineralized malt's weight part on the quality indicators of rye-wheat bread showed that the optimal amount is the introduction of 10% by weight of flour.

Conclusions. The addition of such mineralized raw materials to food products formula will enrich them with biologically active substances, giving them functional properties.

Introduction

Functional food products based on fermented beverages are being developed most dynamically in the world market, and are based on fermented beverages and bakery products [1, 3, 4, 8, 9, 10].

Unlike many other products, bread products are able to provide the human body with a large amount of energy and almost all vital substances: proteins, carbohydrates, vitamins, minerals. Nutritional value of bread depends on the type and kind of flour, recipe additives and humidity of the product.

Compared to wheat flour products, rye bread differs favorably in the content of essential amino acids, minerals and vitamins. Therefore, having a lower energy value than wheat bread, it has a higher biological value, that is, it better provides the human body with the necessary substances [11, 12, 13, 14]. Despite the high nutritional value, according to the modern requirements of the nutrition science, bread products need to improve their composition. Bread do not have the optimal ratio of proteins and carbohydrates, calcium and phosphorus, insufficient micronutrient content, essential amino acids such as lysine, methionine, tryptophan.

The enrichment of food products, in particular the bakery products with high micronutrient content, is an urgent task. It is known that deficiency of micronutrients, especially such as zinc, chromium, selenium and others, today there is an acute issue [2, 5, 7, 15, 16, 17, 18]. The deficiency of microelements reduces the body's resistance to various diseases, accelerates the aging process, increases the negative impact of adverse environmental conditions, and prevents the formation of a healthy generation [6, 19, 20, 21, 22].

Systemic usage of malt stimulates metabolism and hematopoiesis, strengthens the immune system, compensates for vitamin and mineral deficiency, improves acid-base balance, and promotes intense digestion. When choosing malt composition, we were guided by the fact that the composition of these types of malt based on maize and oat makes it possible to exceed the shortage of certain valuable nutrients. Thus, vitamin E is found in maize malt in large quantities, while oat malt is rich in threonine and lysine, but lysine is deficient in wheat flour. Oat malt is especially valuable for its macro- and microelement content; while maize is the source of vitamins and the main raw material for the production of diet products.

It is known that it is expedient to carry out cereals mineralization by germination in the mineralized medium. Actually this method of grain processing that metal ions are incorporated into organic complexes that are easily digestible for the human body [23, 24, 25, 26].

The microelements are actively involved in the enzymatic processes that take place in the grain, promote its growth and development and are important in the functioning of the human body. Chromium is important for the prevention of diabetes and cardiovascular disease; it also regulates carbohydrate metabolism and blood glucose. Zinc shows immunomodulatory, anti-inflammatory, antimicrobial, antioxidant functions. It affects the activity of hypophysiotropic hormones, participates in the implementation of insulin biological functions, normalizing fat metabolism, hematopoiesis, as well as necessary for normal functioning of the hypophysis and pancreas.

The purpose of research is to obtain and investigate the composition of malts with high content of deficient micronutrients and enrichment with selected raw materials the rye-wheat bread.

Materials and methods

Materials

The subject of research is malt of cereals (maize and oat), salts of chromium and zinc, mineralized grain crop's malt, rye-wheat bread enriched with the composition of mineralized malts.

Methods

To obtain mineralized grain raw materials, maize and oat were germinated using solutions of zinc salt (ZnSO4) and chromium one ($CrK(SO_4)_2 \times 10H_2O$). Germination was carried out at a temperature of 17-18 °C. When required humidity of the grain (47%) reached, the soaking solution with salts was drained and the grain was left for germination, stirring and moistening it periodically with the same mineralized solutions.

In the process of raw materials, semi-finished products and finished product research there are used titrimetric, photocolorimetric, refractometric and sensory evaluation conventional methods of research [27]. X-ray fluorescence analysis was used to determine the mineral composition of grain and malt [28, 29] and stripping voltammetry method [27, 30] to determine the zinc content.

Results and discussion

Obtaining and researching the composition of mineralized malts

Current trends in consumption of products with reduced caloricity and increased nutritional value require innovative solutions in the process of creating a new range of bakery products. Vegetable raw materials with high nutritional and biological value include germinated grain products. The sprouted grain (malt) contains the entire set of ingredients needed for efficient nutrition: essential amino acids, carbohydrates (sugars, dextrins, dietary fiber), minerals, vitamins, dyes and polyphenolic compounds. The production of malt flour involves grain soaking, germination and drying.

To determine the zinc ions effect on the process of maltening of maize and oat grains there were used zinc sulfate solutions of different concentrations: 0.001, 0.002, 0.003, 0.004 and 0.005%.

The results of studies of the zinc ions effect on the intensity of maize and oats germination are shown in Figure 1 and Figure 2 respectively.

The data shows that germination energy 13–14% higher for oat and maize grains at 0.002% zinc salt concentration in comparison with pure water.

Zinc content of maize and maize malt was investigated by inversion voltammetry [27, 30]. With the chosen optimum concentration of 0.002% zinc salt in soaking water, it was determined that the zinc content of the enriched maize increased by 6.7 times compared to the original grain (Table 1). The zinc content of the grain does not exceed the maximum permissible concentration of 50 mg/kg.

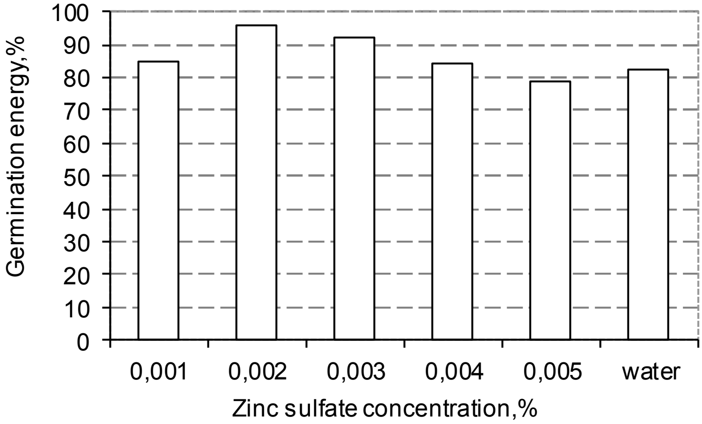

Figure 1. Investigation of zinc ions influence on the process of maize grain germination

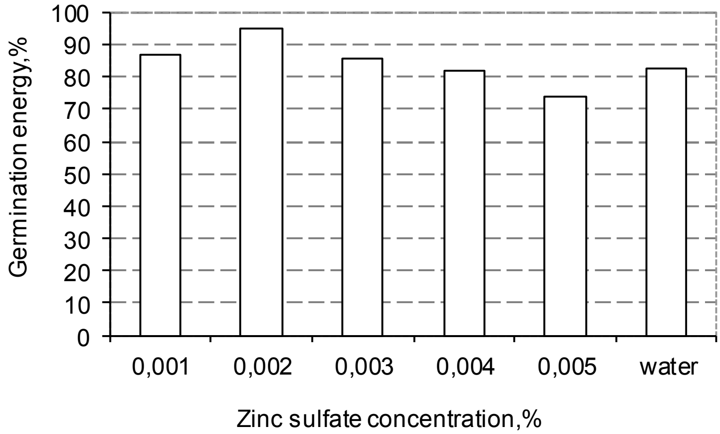

Figure 2. Investigation of zinc ions influence on the process of oat grain germination

Table 1

Investigation of zinc accumulation in maize

Name of the mineral	**Mineral content, mg/kg**	
	In the source grain	**In the enriched grain**
Zinc	1.7	11.4

The germination of oat and maize grains was studied using different concentrations of the chromium salt solutions $CrK(SO_4)_2 \cdot 10H_2O$ (Figure 3 and Figure 4).

The figures show that the 0.001%chromium salt concentration in the soaking water leads to an increase of the grain germination energy at 12–13 % compared with the intensity of germination in water. With increasing concentrations of chromium salt in soaking water (0.002–0.004%), the germination energy of maize and oat grains decreases. Therefore, for the enrichment of grain with chromium ions, the concentration of chromium salt in soaking water should not exceed 0.001%.

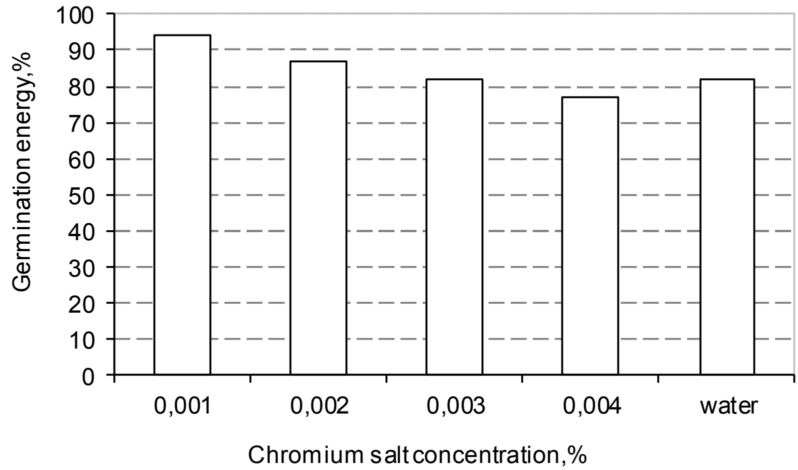

Figure 3. Investigation of chromium ions influence on the process of oat grain germination

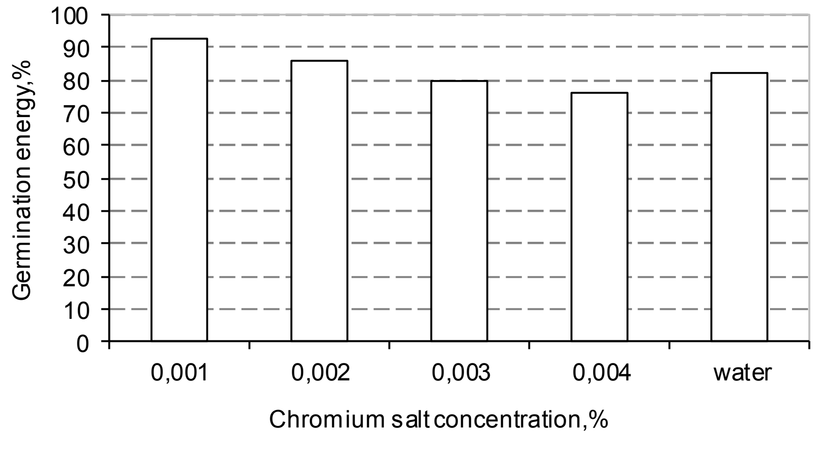

Figure 4. Investigation of chromium ions influence on the process of maize grain germination

X-ray fluorescence analysis was used to study the mineral composition of oat grains and malt [28, 29, 3130]. According to the X-ray fluorescence characteristics of oat grain, oat malt and mineralized oat malt [31], the results of the mineral accumulation study are given in Table 2.

From the analysis of results, it follows that the mineral content is increasing, the content of zinc in enriched malt increased by 6 times in comparison with the original, and that of chromium by 3 times.

Thus, the conducted studies indicate the possibility of the source raw material mineral composition correcting by soaking and germinating grain in aqueous solutions of microelement salts. The addition of such mineralized raw materials to food products formula will enrich them with biologically active substances, giving them functional properties.

The sensory and physicochemical parameters of the obtained mineralized malt were determined. According to the results, the obtained malts are in accordance with all indicators of the normative documents.

Table 2

Mineral content in oat grains and malt when enriched with zinc and chromium salts

Element	**Oatgrain**	**Oatmalt**	**Mineralized with zinc oat malt**	**Mineralized with chromium oat malt**
	Massconcentration, mg/kg			
Zn	1.87	2.07	11.72	2.18
Cr	0.19	0.71	0.67	2.25
K	113.67	144.55	148.32	135.12
Ca	56.60	60.49	66.40	59.72
Mn	1.31	1.75	1.64	1.58
Fe	2.27	2.49	2.55	2.48
Cu	0.67	0.67	1.10	0.82
S	374.15	497.30	430.33	490.35
Cl	69.59	97.34	109.50	129.46

Enrichment with composition of mineralized malt of rye-wheat bread

To enrich the food with mineralized malts, rye-wheat bread was chosen as the traditional product in this work. Bread is a food product made from flour of different grades with or without baker's yeast. Baker's yeast is adapted to live and grow in a water-flour environment. The bringing into the recipe of bread components that can adversely affect their vital activity is negatively affected on the technological process and quality of the finished product.

So far as selected minerals are active participants of biochemical processes in biological objects and they are active sites of enzymes, it was studied their effect on the activity of the fermentation microorganisms. The developed composition of the mineralized oat and maize malts (malts with a ratio of 1:1) in an amount of 5% there are used. The optimal determined concentrations of zinc salts (0.002%) and chromium salts (0.001%) were used for mineralization. Control was sample with oat and maize malt composition without mineralization.

Experiments (Figure 5) show that mineralized malts have a positive effect on the lifting power of yeast, and more so when zinc salts are added.

This is obviously due to the positive role of the studied metal ions in the activation of yeast cell enzymes, the accelerated synthesis of the cellular enzyme α-glucosidase, which causes the decomposition of maltose to glucose, which is rapidly fermented by the yeast cell, and activates other enzymes of cytoplasm. Alcohol fermentation is intensified as a result of enzyme activation [32].

A positive effect of the mineralized malt flour fraction from maize and oat, enriched (malts with a ratio of 1:1) with zinc and chromium sulfates, on the lifting power of yeast was also found (Figure 6, 7). Apparently, when proportion of malt flour increased the balls floating time is reduced as compared with the control. This indicates a reduction in the duration of the technological process.

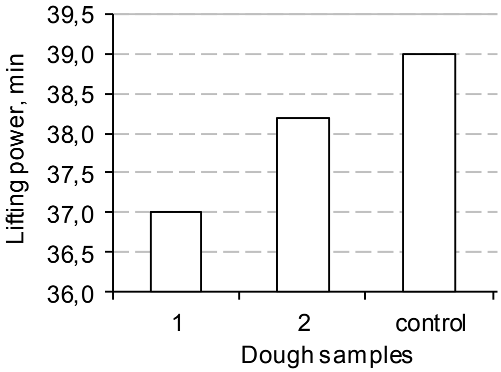

Figure 5. Dependence of baker's yeast lifting power on the addition of malt composition with zinc and chromium salts

1 – test sample with the addition of a malt composition with a zinc salt in soaking water concentration of 0.002%;
2 – test sample with the addition of a malt composition with a chromium salt in soaking water concentration of 0.001%;
Control – is a test sample with the addition of a malt composition without the use of salts.

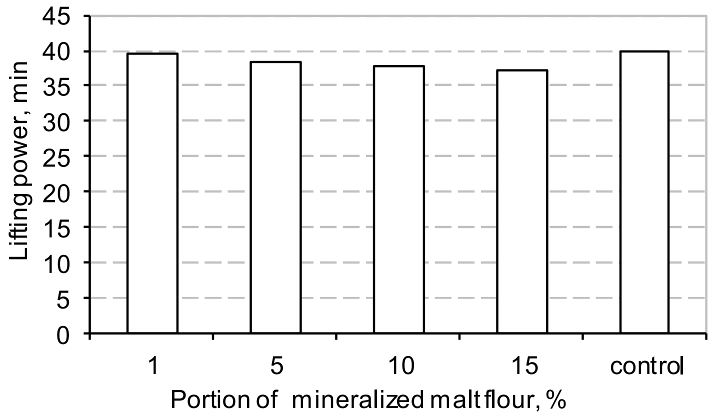

Figure 6. Determination the influence of the composition of malted maize flour with a zinc salt concentration of 0.002% on the yeast lifting power

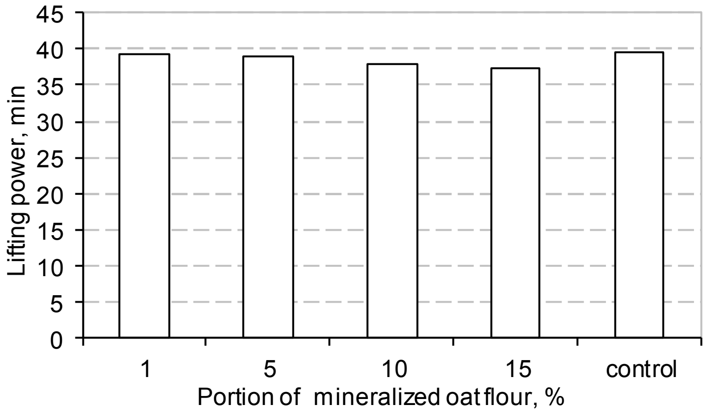

Figure 7. Determination the influence of the composition of malted oat flour with a chromium salt concentration of 0.001% on the yeast lifting power

The experiments of the bread samples baking were carried out to determine the optimal application dose of obtained mineral malts. Determined sensory and physico-chemical indicators of rye-wheat bread with the addition of 5%, 10% and 15% mineralized mixture of malts from oat grains and maize. The results are shown in the Table 3.

Table 3
Sensory and physico-chemical indicators of rye-wheat bread with the addition of mineralized mixture of malts from oats grain and maize (malts with a ratio of 1:1)

Indicators	Control (rye-wheatbread)	Rye-wheat bread with 5% mixture of malts	Rye-wheat bread with 10% mixture of malts	Rye-wheat bread with 15% mixture of malts
Sensoryindicators				
Appearance: Form Surface	Proper shape, without tears or cracks	Proper shape, without tears or cracks	Proper shape, without tears or cracks	Proper shape, there are small cracks in the crust
Crumbcolor	Brown	Brown	Brown	Brown
Crumbcondition	Baked, with no trace of undermixing; homogeneous, with well-developed porosity	Homogeneous, with well-developed porosity	Homogeneous, with well-developed porosity	Homogeneous, poorly developed porosity, slightly compacted
Tasteandsmell	Inherent to this type of products, without any foreign taste	Inherent to this type of products, without any foreign taste	Inherent to this type of products	Inherent to this type of products, with a noticeable taste of malt

Physico-chemicalindicators				
Specificvolume, cm3/ g	1.92	1.87	1.83	1.77
Humidity, %	45.4	45.5	45.6	46.0
Acidity, deg	6.4	6.5	6.6	6.7
Porosity, %	67	65	64	62

Studies of influence of the inserted mineralized malt's weight part on the quality indicators of rye-wheat bread showed that the optimal amount is the introduction of 10% by weight of flour, for which bread with satisfactory sensory and physico-chemical parameters is obtained.

The conceptual technological scheme of enriched bread with the stage of making the mixture of malt at the preparation of the ferment phase is developed. This will reduce the duration of fermentation and increase the biological value of the finished product.

The calculation method [33, 34, 35, 36] determined the content of macro- and micronutrients in rye-wheat bread before and after the introduction of mineralized malt in the amount of 10% by flour weight. It is found that enriched bread increases the protein content by 21%, it is possible to increase the content of such essential deficient amino acids as lysine and methionine, and accordingly improve the utilization coefficient, which shows the level of protein absorption of the product.Thus, the utilization coefficient was 63.8% in the enriched product and 59% in the base product.That is, by adding of selected enrichment protein digestibility increased, with the coefficient of excess amino acid composition, which characterizes the mass fraction of indispensable amino acids and used in the body irrationally, decreased to 12.5%. The goal of the micronutrients content increasing in the enriched finished product, including the microelements Zn and Cr by 2.4 and 1.8 times respectively, was also achieved.

Conclusions

As a result of grain germination, the content of biologically active substances is increased. The germination of grain in a mineralized environment also contributes to the accumulation of minerals in it. Studies have shown that the use of mineralized malt composition in bread technology is expedient, since it contributes to a significant improvement in the content of physiologically active ingredients which provide the health properties of bread.

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Ефективність використання композиції мінералізованих солодів для збагачення харчових продуктів мікронутрієнтами

Алла Башта[1], Надія Івчук[1], Олександр Башта[2]
1 – Національний університет харчових технологій, Київ, Україна
2 – Національний авіаційний університет, Київ, Україна

Вступ.Мета досліджень – отримання та дослідження складу солодів з підвищеним вмістом дефіцитних нутрієнтівта збагачення обраною сировиною житньо–пшеничного хліба.

Матеріали і методи.Для отримання мінералізованої зернової сировини зерно кукурудзи та вівса пророщували із застосуванням розчинів солей цинку ($ZnSO_4$) та хрому ($CrK(SO_4)_2 \times 10H_2O$) різних концентрацій: 0,001%, 0,002%, 0,003%, 0,004%, 0,005%. Для визначення мінерального складу зерна та солоду застосовували рентгенофлуоресцентний аналіз та метод інверсійної вольтамперометрії для визначення вмісту цинку.

Результати і обговорення. Оптимальна концентрація солі цинку у замочувальній воді склала0,002%, за якої вміст цинку у збагаченому зерні кукурудзи зріс у 6,7 разів в порівняні з вихідним зерном. Для збагачення зерна іонами хрому концентрація солі хрому у замочувальній воді не повинна перевищувати 0,001%.

За данимирентгенофлуоресцентного аналізу вміст мінеральних речовин у збагаченому солоді зростає, вміст цинку у порівнянні із вихідним солодом збільшується в 6 разів, а хрому в 3 рази, що вказує на можливість корегування мінерального складу вихідної сировини шляхом замочування і пророщування зерна у водних розчинах солей мікроелементів.

Для збагачення харчових продуктів мінералізованими солодами, за традиційний продукт в даній роботі було обрано житньо–пшеничний хліб. Мінералізовані солоди позитивно впливають на підйомну силу дріжджів, і в більшій мірі при додаванні солей цинку. Це свідчить про скорочення тривалості технологічного процесу.

Дослідження впливу масової частки внесених мінералізованих солодів на якісні показники житньо–пшеничного хліба, показали що оптимальною є кількість 10% до маси борошна.

Висновки.Додавання до рецептури харчових продуктів композиціїмінералізованих солодів дозволить збагатити їх біологічно активними речовинами, надаючи їм функціональних властивостей.

Ключові слова: *кукурудза, овес, солод, цинк, хром.*