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FORTIFICATION OF MILLET PORRIDGE

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Daily nutritional products fortified with natural additives containing biologically active compounds can be classified as functional food products. Millet is a valuable cereal crop that is characterized by a low glycemic index and contains essential amino acids, polyphenols, vitamins, potassium, magnesium. In addition, millet products can help reduce cancer risk and are recommended for individuals with celiac disease, diabetes, or gluten intolerance. This study examines millet porridge samples fortified with Jerusalem artichoke, quince, and plum pieces. The samples were assessed for their macro- and microelement composition, sensory attributes and organoleptic qualities. The analysis reveals that all samples exhibit a high nutritional value. However, the sample containing Jerusalem artichoke stands out with the most favorable data, excellent organoleptic properties, and a higher content of macro- and microelements. The mineral content of millet porridge was determined by using two following methods: Mass spectrometry with inductively coupled plasma (ICP-MS) and Scanning Electron Microscopy (SEM). The evaluated millet porridge samples exhibited significant nutritional value, containing essential macro- and microelements, such as: calcium (9.05-9.77 mg/kg), potassium (16.29-21.17 mg/kg), phosphorous (15.52-17.28 mg/kg), magnesium (4.11-4.59 mg/kg), sulfur (0.49-0.66 mg/kg), silicon (0.46-0.62 mg/kg), and other elements.

Keywords: millet porridge; topinambour; quince; plum; millet.

ОБОГАЩЕНИЕ ПШЕННОЙ КАШИ

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Продукты повседневного питания, обогащенные натуральными добавками с биологически активными соединениями, относятся к функциональным продуктам питания. Просо – очень ценная зерновая культура, характеризующаяся низким гликемическим индексом и содержащая незаменимые аминокислоты, полифенолы, витамины, калий, магний и др. Кроме того, продукты из пшена позволяют снизить риск рака, рекомендуются при целиакии, страдающим диабетом и непереносимостью глютена. В представленной работе исследованы образцы пшенной каши, обогащенной кусочками топинамбура, айвы и сливы. Образцы оценивали по макро- и микроэлементному составу, сенсорным показателям и органолептическим качествам. Анализ показывает, что все образцы имеют высокий уровень пищевой ценности. Однако образец с топинамбуром показал наиболее предпочтительные результаты, отличные органолептические показатели и большее содержание макро- и микроэлементов. Минеральный состав пшенной каши определяли двумя методами: масс-спектрометрией с индуктивно-связанной плазмой (ИСП-МС) и сканирующей электронной микроскопией (СЭМ). Оцененные образцы пшенной каши обладали значительной пищевой ценностью, содержали такие незаменимые макро- и микроэлементы, как: кальций (9,05-9,77 мг/кг), калий (16,29-21,17 мг/кг), фосфор (15,52-17,28 мг/кг), магний (4,11-4,59 мг/кг), сера (0,49-0,66 мг/кг), кремний (0,46-0,62 мг/кг) и другие элементы.

Ключевые слова: пшенная каша, топинамбур, айва, слива, просо.

ТАРЫ БОТҚАСЫНЫҢ БАЙЫТУЫ

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Биологиялық белсенді қосылыстары бар табиғи қоспалармен байытылған күнделікті қоректік өнімдерді функционалды тамақ өнімдері деп атайды. Тары – өте бағалы дәнді дақыл, ол төмен гликемиялық индексімен сипатталады және құрамында алмастырылмайтын аминқышқылдары, полифенолдар, витаминдер, калий, магний және т.б. бар. Сонымен қатар, тары өнімдері қатерлі ісік қаупін азайтуға мүмкіндік береді, целиакия ауруы, қант диабеті және глютенге төзбеушілікпен ауыратындарға оны тұтынуға кеңес беріледі. Ұсынылған жұмыста топинамбур, айва және қара өрік бөлшектерімен нығайтылған тары ботқасының үлгілері зерттелген. Үлгілер макро- және микроэлементтердің құрамы, сенсорлық және органолептикалық қасиеттері бойынша бағаланды. Талдау барлық үлгілердің тағамдық құндылығының жоғары деңгейін көрсетеді. Дегенмен, топинамбур бар үлгі ең қолайлы нәтижелерді, тамаша органолептикалық қасиеттерді және макро- мен микроэлементтердің жоғары мөлшерін көрсетті. Тары ботқасының минералды құрамы келесі екі әдіс арқылы анықталды: индуктивті байланысқан плазмасы бар масс-спектрометрия (ICP-MS) және сканерлеуші электронды микроскопия (SEM). Қарастырылған тары ботқасының сынамалары маңызды макро- және микроэлементтерден тұратын тағамдық құндылықты көрсетті: кальций (9,05-9,77 мг/кг), калий (16,29-21,17 мг/кг), фосфор (15,52-17,28 мг/кг), магний, (4,11-4,59 мг/кг), күкірт (0,49-0,66 мг/кг), кремний (0,46-0,62 мг/кг) және басқа элементтер.

Негізгі сөздер: тары ботқасы, топинамбур, айва, алхоры, тары.

Introduction

Today, one of the most fundamental directions in the development of all branches of the food industry is considered to be the production of functional food products. This is mainly due to the several factors, such as improved societal well-being and education; a rising concern regarding biological and chemical contamination in food; prevalence of chronic conditions; reduced physical activity among population that leads to excessive intake of unhealthy foods with high-cholesterol content [1]. Also, at the moment, great attention is paid to the safety of food products [2]. The production of food products that have been fortified with one or more functional food additives is an effective method of producing food products that have additional properties. Functional food additives can also be represented by enriched food concentrates [3]. Food additives by their main purpose are divided into the following categories: additives that enhance flavor and visual appeal of food products; additives that boost the biological and nutritional value; additives that alter product texture and extend its durability, alongside those that enrich the body with dietary fiber [4].

Currently, determining the appropriate quantity of plant ingredients is a key challenge in creating functional food products.

During the research conducted by scientists, the medicinal qualities of food products that were produced with the help of medicinal and spicy-aromatic components were studied. Researchers have observed that water infusions of specific plant component compositions demonstrated a significant hepatoprotective effect during the study. In addition, it is noted that herbal infusions, in the concentrations of plant raw materials contained in them, cannot compete in their effectiveness and effect with such a popular brand of hepatoprotectors "Carsil" and other similar medicines, but they have the necessary properties to normalize the functioning of the liver.

The results of these studies were used to develop recommendations of recipes for the production of alcoholic balms. Studies conducted using various components of medicinal and spicy-aromatic plants has yielded extensive insights into their functional effects. This has facilitated the development of innovative approaches to enhance everyday food with essential macro- and microelements, dietary fiber, and a variety of vitamins. Dietary fiber is a significant component of many healthy diets, having a significant impact on various physiological processes [6]. Data from various countries that extensively implement micronutrient enhancement in food products indicate that it effectively addresses deficiencies in B vitamins, vitamin D, iodine, and iron in the body [7].

The other study explores the impact of different cooking methods on the flavor and texture of millet porridge. The authors identified volatile compounds, particularly esters, and texture analysis revealed a significant reduction in hardness after 40 minutes of cooking. The study also demonstrated that the optimal sensory quality of porridge was achieved when cooked for 30 minutes. These findings provide practical

insights for improving the taste and texture of millet porridge [8]. The next study evaluates the effects of different drying methods on the biochemical and fuctional properties of millet porridge. The study found that freeze-drying method retained the most moisture, fat, and carbohydrates, while tray-drying preserved the most protein [9]

Millet is a very valuable cereal crop. The various types of fiber found in millet grains of all varieties have a positive effect on blood sugar levels. The introduction of a large amount of fiber in the base product helps to remove toxic and carcinogenic substances from the body, which in turn is a significant advance in the development of functional food products. In addition, millet is characterized by a low glycemic index, which makes it attractive for people suffering from diabetes and gluten intolerance [10].

In addition to its other benefits, millet has also been found to have significant nutritional value, compared to other major cereals such as rice and wheat. In addition, millet contains proteins that are a good source of amino acids and necessary for human body, although some amino acids, such as lysine and threonine, are not enough in millet, which is compensated by the high content of methionine [11].

Pearl millet stands out for its high protein content of 14.5%, comparable to that of wheat. In addition, millet contains vitamins that are important for the human body: vitamin A and vitamin B. A diet that includes millet helps maintain blood pressure due to the presence of potassium and magnesium. Millet is enriched with polyphenols and tannins, which reduce the risk of developing various types of cancer in those who include millet in their diet. Another advantage of millet is that it does not contain gluten, which makes it suitable for people suffering from celiac disease [12].

Millet is also popular in Kazakhstan, where the following Kazakh national desserts, such as “talkan” and “tary” are made from millet using special technologies. Millet, in addition to its many advantages, contributes to the normalization of cholesterol levels in the blood. Millet also has a high iron content, which has a positive effect on the level of hemoglobin. Therefore, in the presence of anemia, it is recommended to consume millet porridge. Recently, the production of bread enriched with millet flour has gained popularity [13].

Various studies related to the processing of millet have come to encouraging conclusions regarding its potential use in the manufacture of a variety of foods that promote a healthy diet. Many scientists have made efforts to develop processed foods, such as extruded foods, cereals, and many types of flour [14].

A biscuit enriched with a mixture of millet, rice, soy, and chickpea flour has more developed porosity, which differs from a biscuit baked from flour with medium gluten. The rationale for choosing flour mixes was their suitability for people with celiac disease. An increase in the composition of millet flour mixtures led to a decrease in the effective viscosity, which affected the quality of biscuits. During baking, a stronger expansion of the dispersed phase was observed. As a result, an increase in the porosity of the sponge product was observed in the product [15].

Also, with the help of millet grains, puddings are made for functional purposes. The resulting food concentrate has high organoleptic characteristics, having a pronounced taste and aroma of the main and additional raw materials. The content of fat and protein in comparison with the closest analog increased the content of dietary fiber, as well as the content of proteins increased by 17.7% [16].

Topinambour, a plant in the Asteraceae family, is a tuberous root vegetable. It is important to note the useful substances that make up topinambour, one of which is inulin, which is a natural prebiotic, that promotes the development of the intestinal microbiota. Also, topinambour contains fructooligosaccharides, useful substances that have a low caloric content. Natural polysaccharide – pectin, which is contained in topinambour, has the following useful qualities: removes toxins from the body, helps reduce blood pressure and hunger, is useful for diarrhea. The mineral composition of topinambour is as follows: potassium, calcium, phosphorus, magnesium, sodium, and zinc.

Topinambour is similar in composition to potatoes, it contains a low amount of fat, but the fiber content of topinambour is very high compared to other tubers. Based on fructose and fructose polymers, topinambour tubers contain a unique carbohydrate complex. Among them, the most common and well-known is inulin. The high content of inulin in topinambour makes it attractive for people with diabetes. Also, the inclusion of topinambour in the diet contributes to a significant reduction in cholesterol levels in the blood. In addition, topinambour is used for diseases of the cardiovascular system [17].

Quince is a fruit crop that belongs to the genus Rosaceae. For many years, quince has been used to strengthen the immune system, for digestive problems, and as a natural antidepressant. Quince is a low-calorie fruit, only 57 calories per

100 grams. The fiber contained in the pulp of quince contributes to the effective functioning of the gastrointestinal tract, as well as the composition of quince includes tannins-epicatechin and catechin. In addition, quince, due to compounds that inhibit the activity of immune cells responsible for allergic reactions, facilitates the course of seasonal allergy [18].

Currently, the population views fruits not only as sources of important nutrients but also recognizes their healing effects due to phenolic substances, which possess antioxidant properties. Before using the product, it is important to consider its antioxidant activity [19]. Various fruits, such as apples, are known to contain phenolic substances. Also, plum has a very high concentration of phenolic substances in its composition [20].

Plums contain a significant amount of minerals, but their main value lies in their vitamin composition. Even after processing, plums retain vitamin P. They are also rich in vitamin C, which strengthens the immune system effectively. The presence of B vitamins in plums can improve the functioning of the human central nervous system. Additionally, regardless of their taste, all plum fruits contain a substantial amount of fiber [21].

Materials and research methods

The object of research is samples of millet porridge enriched with plant components in accordance with the requirements and standards of GOST 34054-2017.

Basic and additional raw materials

The following components were used for the production of millet porridge:

-millet grains in accordance with GOST 572-2016 (Ground millet grains. Technical specifications) [Federal Agency for Technical Regulation and Metrology, 2016];

-granulated sugar in accordance with GOST 33222-2015 (White sugar. Technical specifications) [Federal Agency for Technical Regulation and Metrology, 2015];

- milk in accordance with GOST 31450-2013 (Drinking milk. Technical specifications) [Federal Agency for Technical Regulation and Metrology, 2013]

-food salt in accordance with GOST R 51574-2018 (Food salt. General technical conditions) [Federal Agency for Technical Regulation and Metrology, 2018];

- topinambour in accordance with GOST 32790-2014 (Fresh topinambour. Technical specifications) [Federal Agency for Technical Regulation and Metrology, 2014];

- quince in accordance with GOST 21715-2013 (Fresh quince. Technical specifications) [Federal Agency for Technical Regulation and Metrology, 2013];

- plumin accordance with GOST 21920-2015 (Fresh plum for industrial processing. Technical specifications) [Federal Agency for Technical Regulation and Metrology, 2015].

Organoleptic characteristics

In accordance with GOST 34054-2017, organoleptic characteristics of samples were analyzed, including color, smell, taste, consistency and appearance.

Sensory assessment

Sensory analysis is performed in order to study in more detail the organoleptic properties of millet porridge with additives. Food products were evaluated using the point scale. Sensory evaluation of aroma, taste, color, appearance, and consistency was performed on a five-point scale. During the sensory assessment color was determined by using refractive light without extraneous shades; smell and taste were determined by pronounced taste and frequency of odors.

There are five levels of indicators: four of them are positive and the fifth level was considered as unsatisfactory.

Composition of macro- and microelements

The mineral content of porridge samples was determined through the following analytical techniques: inductively coupled plasma mass spectrometry (ICP-MS) and scanning electron microscopy. ICP-MS enables the determination of both metallic and non-metallic elements, ranging from lithium (Li) to uranium (U), at 10-10% concentrations. This method relies on utilizing an inductively coupled plasma as an ion source and mass spectrometer for the separation and identification of ions within an argon atmosphere. As per the guidelines outlined in GOST 26929-94, ash samples were meticulously prepared to analyze their chemical compositions [22].

Production of millet porridge with additives

Due to the high potassium content, millet porridge is suitable for people with heart disease, and thanks to B vitamins B, fatigue and irritation are reduced. Also, this porridge thanks to dietary fiber normalizes the activity of the gastrointestinal tract, and also has a lipolytic effect [23].

Millet grains are cleaned of excess impurities and go through the washing process, then the grains are steamed for 25 minutes. Granulated sugar and salt were sieved using metal-woven sieve. Topinambour, quince and plum were inspected, removing impurities and spoiled fruits, then the fruits were washed and peeled and cut. Milk enters the digester and is brought to a boil. After that, millet grains, sugar and salt arrive, and with the help of a stirrer, it is mixed for 20 minutes.

Five minutes before cooking, an additive is added in the form of topinambour, quince or plum pieces. Further, in order to ensure bacteriological safety, the finished porridge undergoes a sterilization process.

Research and discussion

Organoleptic parameters of additives

Topinambour, quince or plum pieces were used as additives for the production of millet porridge. First, the organoleptic parameters of the supplements were studied. The consistency of the three additives was homogeneous without sediment. The color of the additives was as follows: bright lemon for quince, yellow-brown for topinambour and purple for plum. Topinambour had a slightly sweet smell, while quince and plum had a sweet-tart aroma.

Sensory analysis

Control and experimental samples of millet porridge were examined using sensory analysis methods by allotting scores using a five-point scale based on the subsequent criteria: aroma, taste, appearance, color, and consistency. Using the results of sensory evaluation of control and experimental samples of millet porridge, diagrams were constructed for five indicators. The sensory assessment of the control sample of millet porridge is shown in Figure 1.

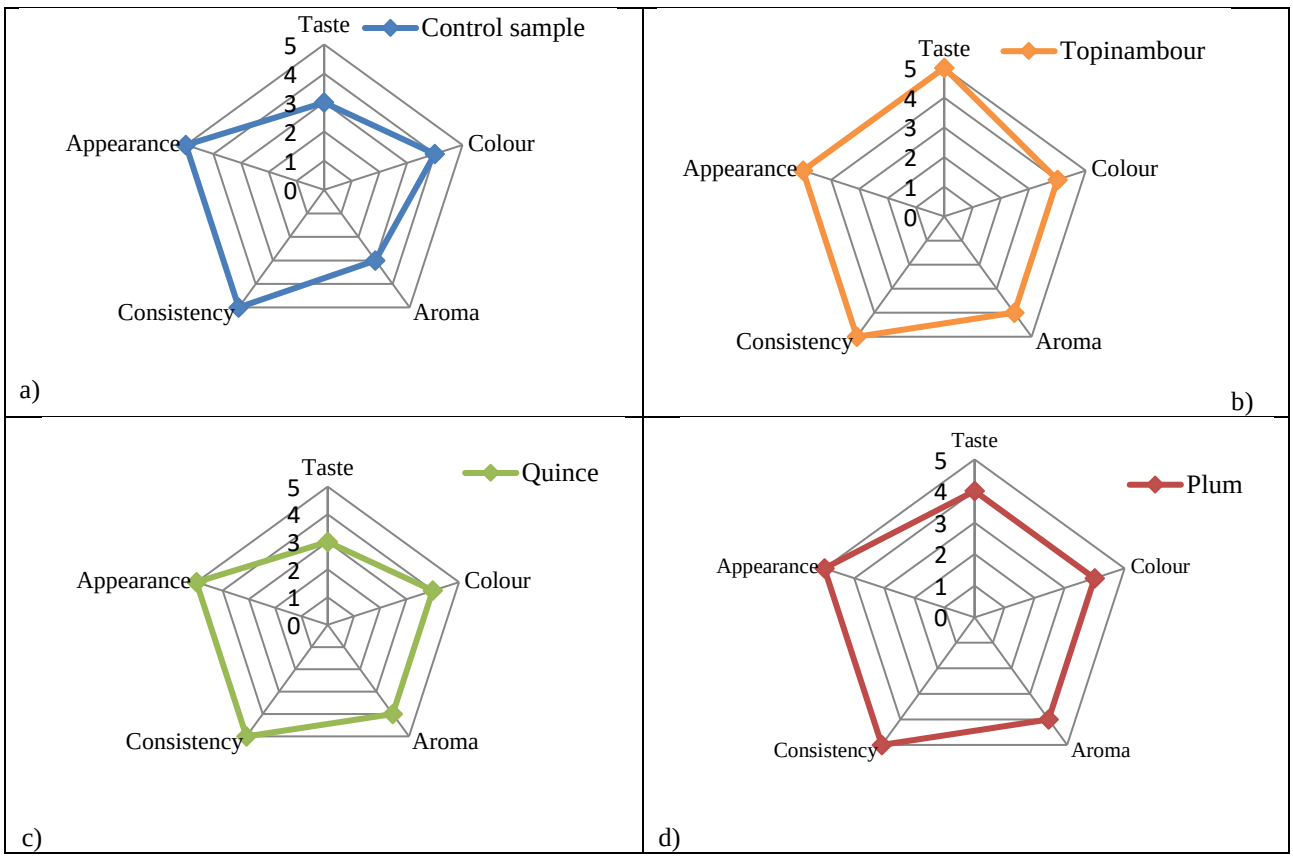

Figure 1. Sensory assessmentof millet porridge samples:(a) control, (b) with topinambour, (c) with quince, (d) with plum

The control sample of millet (Figure 1a) porridge consists of: millet grain, milk, sugar and salt. The color and appearance are characteristic of millet porridge with a acceptable aroma. Millet porridge has a homogeneous viscous consistency and a neutral taste. The average score of the controlsample is 4 points.

In the sample with the addition of topinambour (Figure 1b) a pleasant aroma and taste of topinambour are available. Theconsistency is homogeneous and viscous, and the appearance is characteristic of millet porridge. The average score of a sample of millet porridge with the addition of topinambour is 4.6 points.

The sample containing quince (Figure 1c) has a faint citrus taste and aroma peculiar to quince. The color of the sample is characteristic of millet porridge. The appearance and consistency did not change compared to the control sample.The average score of a sample of millet porridge with quince is 4.2 points.

A sample of millet porridge containing plum (Figure 1d) has a faint sweet-tart smell and taste. The sample also has a homogeneous viscous consistency. The colour of this sample is light

yellow which is typical for this type of porridge. The average score of millet porridge enriched with plums is 4.4 points.

Based on the scores acquired from the sensory analysis of the samples, the overall sensory assessment of the samples of millet porridge was established. The average score was obtained by the following formula:

$$S_b = \Sigma_b : K \quad (1)$$

Where S_b – the overall score of the sensory evaluation;
Σ_b – total score for the 5 criteria of quality
K – number of indicators, K=5.

Further, the formula determines the overall sensory assessment of millet porridge by organoleptic parameters:

$$S_b = (4 + 4.6 + 4.2 + 4.4) : 5 = 3{,}44$$

Organoleptic evaluation of millet porridge with vegetable additives

Organoleptic parameters of the experimental samples and the control sample were evaluated in accordance with the requirements of GOST 34054-2017, the results are presented in Table 1.

Analysis of the results of organoleptic assessment of experimental and control samples showed that the samples meet the requirements for food concentrates in terms of parameters such as colour, odor taste, consistency, and appearance.

Table 1. Organoleptic characteristics of millet porridge samples

Indicators	Indicators according to GOST	Samples of millet porridge			
		Control sample	topinambour	quince	plum
Appearance and consistency	Homogeneous viscous mass. Stratification is not allowed.	Homogeneous viscous consistency	Homogeneous viscous consistency	Homogeneous viscous consistency	Homogeneous viscous consistency
Taste and smell	Characteristic of porridges of the same name with the taste and aroma of the added components corresponding to this product; lack of extraneous smell and taste	Moderately sweet smell, milky taste, without extraneous odor and taste	Sweet taste, moderate topinambour smell, without extraneous odor and taste	Moderate citrus aroma, milky taste, without extraneous tastes	Sweet-tart aroma, milky taste, without extraneous taste
Colour	Various shades of yellow	Light Yellow	Yellow	Light Yellow	Light Yellow

Macro-and microelement composition of millet porridge samples with additives

The macro- and microelement composition of millet porridge with plant additives were obtained by using inductively coupled mass spectrometry is presented in Figure 2-5. Comparative analysis of the experimental and control samples showed that sample without plant additives contains the following macro- and microelements: sodium, calcium, potassium, phosphorous, chlorine, magnesium and other elements

Table 2 shows the macro-and microelement composition of the control sample of millet porridge.

Table 2. Mineral elements contents in the millet porridge samples

Mineral element	Milletporridgesamples			
	Control, mg/kg	Topinambour, mg/kg	Quince, mg/kg	Plum, mg/kg
Carbon	14.26	5.19	5.48	7.74
Oxygen	37.20	39.32	40.18	38.66
Sodium	2.41	1.99	2.93	3.24
Magnesium	4.11	4.40	4.59	4.18
Silicon	0.55	0.51	0.46	0.62
Phosphorus	15.52	17.28	16.38	16.14
Sulfur	0.62	0.66	0.52	0.49
Potassium	16.29	21.17	20.01	18.35
Calcium	9.05	9.49	9.45	9.77
Chlorine				0.82

The content of potassium (21.17), phosphorus (17.28) and sulfur (0,66) in the sample containing topinambouris the highest amongst the othersamples including the control samples. The plum sample has highest contents of sodium (3.24), silicon (0.62) and calcium (9,77), but also has lowest amount of magnesium (4.18), phosphorous (16,14), sulfur (0,49) and potassium (18,35) among the samples with additives. The sample with plum additive also contains chlorine (0,82). The quince sample has a balanced content of macro-and microelements.

It is worth noting that in the samples with additives, the content of these elements significantly increased, which in turn proved the nutritional value of these studied samples of food concentrate. The sample with topinambour showed more decent results compared to other samples. The sample containing topinambour has the highest amounts of potassium, phosphorous, and sulphur. Potassium and phosphorous are essential minerals for various bodily functions, including muscle and nerve function, and also bone health. While the sample containing plum has higher amounts of other minerals compared to topinambour, the amounts of potassium and magnesium are the lowest amongst other samples that contain additives.

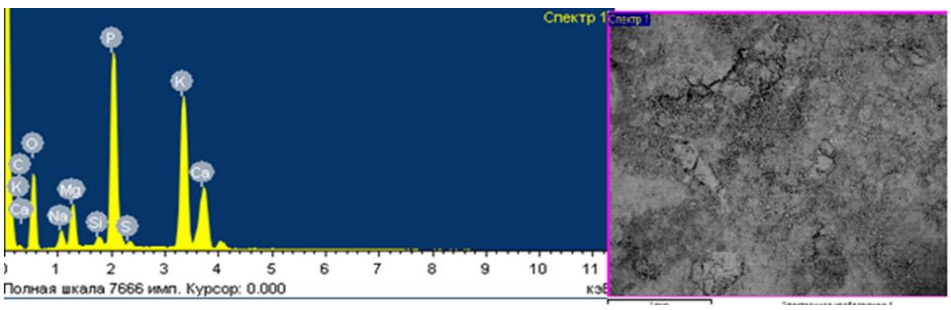

Figure 2. Macro-and microelement composition of Sample 1 (control)

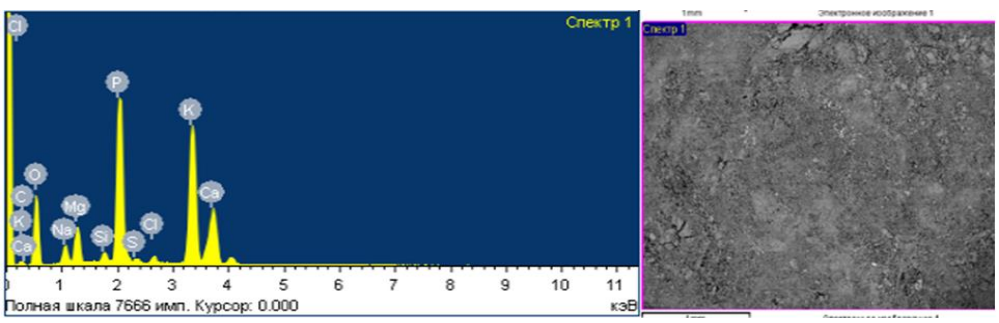

Figure 3. Macro-and microelement composition of Sample 2 (topinambour)

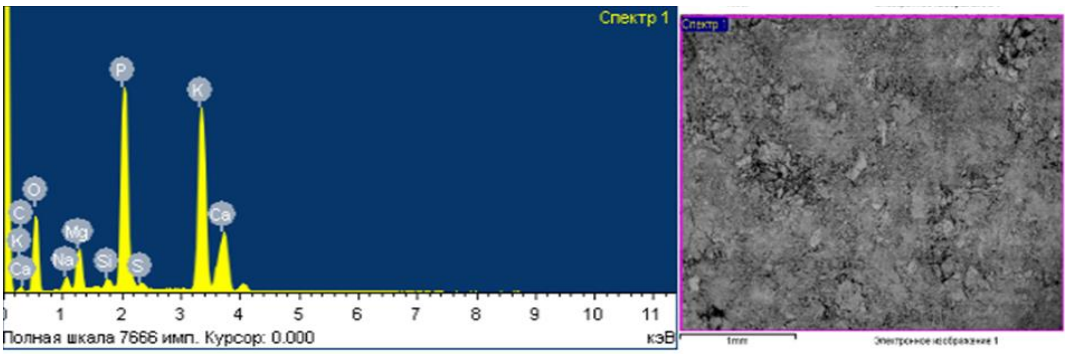

Figure 4. Macro-and microelement composition of Sample 3(quince)

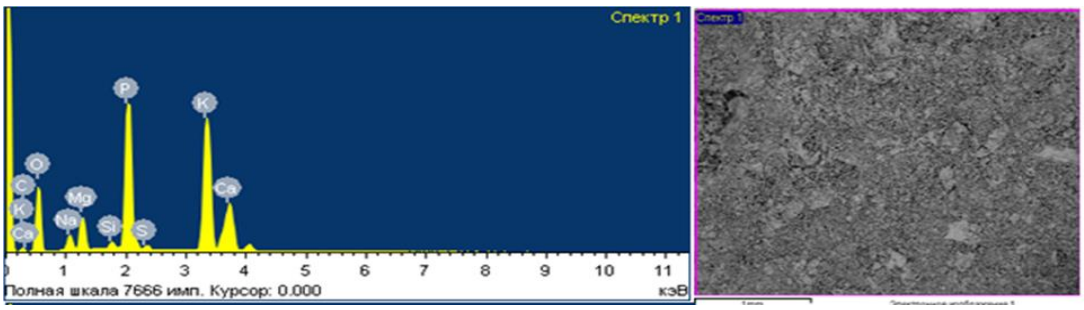

Figure 5. Macro-and microelement composition of Sample 4 (plum)

Conclusion

Food additives by their main purpose are divided into the following categories: food additives that change the consistency and increase the shelf life of the product; food additives that improve the aroma, appearance and taste; additives that replenish human body with dietary fiber as well as increase the biological and nutritional value. The application of natural plant additives, such as topinambour, plum and quince in the composition of millet porridge allow developing new fortified food products for functional purposes. The evaluation of the millet porridge samples through sensory and organoleptic analysis confirms their compliance with GOST standards for porridge. The analysis revealed that samples fortified with plant additives possess elevated nutritional value, containing vital macro- and microelements: calcium (9.05-9.77 mg/kg), potassium (16.29-21.17 mg/kg), phosphorous (15.52-17.28 mg/kg), magnesium (4.11-4.59 mg/kg), sulfur (0.49-0.66 mg/kg), silicon (0.46-0.62 mg/kg), and other elements.

REFERENCES

1. Селиванская И.А. Современное питание и функциональные продукты (2014). *Зерновые продукты и комбикорма*, Т. 55, №3, (2014). -С. 23-27.

2. Алибеков Р. С., Юнусова А. А., Бахтыбекова А. Р. Безопасность пищевых продуктов и система ХАССП в производстве обогащенного творога. //*Вестник Алматинского технологического университета*. №. 4, (2016).-С. 48-53.

3. Шегельман И. Р., Суханов Ю. В., Васильев А. С. Некоторые аспекты производства обогащенных пищевых продуктов. //*Научные исследования: теория, методикаипрактика*. (2018). -С. 148-149.

4. Капитонов В.С. *Разработка технологии пищевых концентратов быстрого приготовления на основе растительного сырья автореф. дис. канд. наук:* Красноярск, 2014. -23 с

5. Кунакова Р. В. и др. Здоровое питание XXI века: функциональные продукты питания и нутригеномика. //*Вестник Академии наук Республики Башкортостан.*Т. 21, №3, (2016): -С. 5-14.

6. Попов В. С., Сергеева С. С., Барсукова Н. В. Функциональные и технологические свойства зерна овса и перспективный ассортимент продуктов питания на его основе. //*Вестник Казанского технологического университета.* Т. 19, № 16, (2016): -С. 147-151.

7. Коденцова, В. М. Обогащение пищевых продуктов массового потребления витаминами и минеральными веществами как способ повышения их пищевой ценности. //Пищевая промышленность. № 3, (2014): -С. 14-18.

8. Liu, X., Wang, S., Pan, M., Tian, A., Chen, K., Qu, W., Ma, A. Effect of cooking methods on volatile compounds and texture properties in millet porridge. *Food Chemistry: X,23,* (2024). pp. 101652.

9. Sivasubramaniyan, V., Govindarajan, N., Senthilkumar, N. V. K., Kabeer, S. Effect of drying methods on the biochemical and functional qualities of ready to mix traditional pearl millet porridge (Pennisetumglaucum). *International Journal of*

Nutrition, Pharmacology, Neurological Diseases,*14*(3), (2024). pp. 337-342.

10. Зотиков В. И., Сидоренко В.С., Грядунова Н.В., Вилюнов С.Д. “Потенциал проса вновых рыночных условиях”. //*Зернобобовые и крупяныекультуры*. Т. 1, № 45, (2023): -С. 5-11.

11. Saleh A. S. M., Zhang Q., Chen J., Shen Q., “Millet grains: nutritional quality, processing and potential health benefits” Comprehensive reviews in food sciece and food safety. Vol. 12, no. 3, (2013): pp. 281-295.

12. Bombom A., Kaweesi T., Walugembe F., Bhebhe S., Maphosa M. “Millets: Traditional “Poor Man’s” Crop or Future Smart Nutri-Cereals?”. Millets-RediscoverAncientsGrain. (2023): pp. 1-15.

13. Кажибаева Г. Т., Мухамеджанова А. С., Исаева К. С. Использование проса в производстве функциональных продуктов питания. //*Пищевые инновации и биотехнологии*. – (2020): -С. 38-40.

14. Jaybhaye R. V. Pardeshi I. L., Vengaiah P. C., Srivastav P. P. Processing and technology for millet based food products: a review. //*Journalofreadytoeatfood*. Vol. 1, no. 2. (2014): pp. 32-48.

15. Баженова Т. С., Баженова И. А., Барсукова Н. В. Применение пшенной муки в производстве безглютенового бисквита. /*XXI век: итоги прошлого и проблемы настоящего плюс*. Т. 7, № 2, (2018): -С. 39-42.

16. Стаценко Е. С., Корнева Н. Ю. Новая технология пищевого концентрата-пудинга функционального назначения. //*Дальневосточный аграрный вестник*. Т. 3, № 47, (2018): -С. 103-109.

17. Shariati M. A., Khan M. U., Hleba L., de Souza, C.K. Topinambour: Nutritional Value and its application in food products: An updated treatise. //*Journal of microbiology, biotechnology and food sciences*. Vol. 10., no. 6. (2021): pp. 4737-e4737.

18. Елисеева Т. Польза айвы – факты и доказанные наукой целебные свойства //*Журнал здорового питания и диетологии*. Т. 3, №. 17, (2021). -С. 27-31.

19. Алибеков Р.С., Габрилянц Ж., Алибекова Ж., Норов Ж. Антиоксиданты природного происхождения // *Промышленные технологии и инжиниринг (2018). Международная научно-практическая конференция, Шымкент, 28 ноября 2018 года*. Т. 2. (2018): – *С.*144-147.

20. Шингисов А. У., Кантуреева Г. О., Еркебаева С. У. Исследование минерального состава и физико-химических показателей сливы сорта "Венгерка Домашняя", культивируемой в южных регионах Казахстана. //*Успехи современного естествознания*. № 12. (2014): - С. 141-146.

21. Косаурова Л. К., Плынская Ж. А. “Особенности витаминного состава сливы”//Наука и образование: опыт, проблемы, перспективы развития. (2015): - С. 149-150.

22. Томпсон, М.М. и Уолш, Д.Н. Руководство по спектрометрическому анализу с индуктивно-связанной плазмой, М. Недра, 1988. – 78 с.

23. Спандияров, Е, Саржанова Г. С. “Определе-ние угла естественного откоса толокна "Тары""//*Механика и технологии*. Т. 2, № 44, (2014): -С. 110-114.

REFERENCES

1. Selivanskaya I. A. “Sovremennoe pitanie i funkczional`ny`e produkty` [Modern nutrition and functional products]”. *Journal of Grain Products and Mixed feed*, Vol. 55, no 3, (2014): pp. 23-27. – (In Russian)

2. Alibekov R. S., Yunusova A. A., Bakhtybekova A. R. “Bezopasnost` pishhevy`kh produktov i Sistema KhASSP v proizvodstve obogashhennogo tvoroga [Food safety and the HACCP system in the production of enriched cottage cheese]”. *Bulletin of Almaty Technological University*. no. 4, (2016): pp. 48-53. – (In Russian)

3. Shegelman I. R., Sukhanov Yu. V., Vasiliev A. S. “Nekotory`e aspekty` proizvodstva obogashhenny`khpishhevy`kh produktov [Some aspects of fortified food production]”. *Scientific research: theory, methodology, and practice*. (2018): pp. 148-149. – (In Russian)

4. Kapitonov V. S. *Development of technology of fast food concentrates based on vegetable raw materials* [*Razrabotka tekhnologii pishhevy`kh konczentratov by`strogo prigotovleniya na osnove rastitel`nogo sy`r`ya.]* Krasnoyarsk, 2014. – (In Russian)

5. Kunakova R. V., Zainullin R. A., Khusnutdinova E. K., Yalaev B. I. “Zdorovoe pitanie XXI veka: funkczional`ny`eprodukty` pitaniya i nutrigenomika [Healthy food of the XXI century: functional food products and nutrigenomics]”. *Bulletin of the Academy of Sciences of the Republic of Bashkortostan*. Vol. 21, no. 3, (2016): pp. 5-14. – (In Russian)

6. Popov V. S., Sergeeva S. S., Barsukova N. V. “Funkczional`ny`e i tekhnologicheskie svojstva zerna ovsa i perspektivny`j assortiment produktov pitaniya na ego osnove [Functional and technological properties of oat grain and a promising range of food products based on it]”. *Bulletin of Kazan Technological University*. Vol. 19, no. 16, (2016): pp. 147-151. – (In Russian)

7. Kodentsova V. M. “Obogashhenie pishhevy`kh produktov massovogo potrebleniya vitaminami i mineral`ny`mi veshhestvami kak sposob povy`sheniya ikh pishhevoj czennosti [Fortification of food products of mass consumption with vitamins and minerals as a way to increase their food value]”. *Food Industry*. no. 3, (2014): pp. 14-18. – (In Russian)

8. Liu, X., Wang, S., Pan, M., Tian, A., Chen, K., Qu, W., Ma, A. Effect of cooking methods on volatile compounds and texture properties in millet porridge. *Food Chemistry: X*,*23*, (2024). pp. 101652.

9. Sivasubramaniyan, V., Govindarajan, N., Senthilkumar, N. V. K., Kabeer, S. Effect of drying methods on the biochemical and functional qualities of ready to mix traditional pearl millet porridge (Pennisetumglaucum). *International Journal of Nutrition, Pharmacology, Neurological Diseases*,*14*(3), (2024). pp. 337-342.

10. Zotikov V. I., Sidorenko V. S., Gryadunova N. V, Vilyunov S. D. “Potenczialprosa v novy`khry`nochny`khusloviyakh [Potential of millet in new market conditions]”. *Legumes and cereals*. Vol. 1, no. 45, (2023): pp. 5-11. – (In Russian)

11. Saleh A. S. M., Zhang Q., Chen J., Shen Q., “Millet grains: nutritional quality, processing and potential health benefits” Comprehensive reviews in food sciece and food safety. Vol. 12, no. 3, (2013): pp. 281-295.

12. Bombom A., Kaweesi T., Walugembe F., Bhebhe S., Maphosa M. “Millets: Traditional “Poor Man’s” Crop or Future Smart Nutri-Cereals?”. Millets-Rediscover Ancients Grain. (2023): pp. 1-15.

13. Kazhibaeva G. T., Mukhamedzhanova A. S., Isaeva K. S. “Ispol`zovanie prosa v proizvodstve funkczional`ny`kh produktov pitaniya [The use of millet in the production of functional food products]”. *Food innovation and biotechnologies*. (2020): pp. 38-40. – (In Russian)

14. Jaybhaye R. V. Pardeshi I. L., Vengaiah P. C., Srivastav P. P. “Processing and technology for millet based food products: a review”. *Journal of ready to eat food*. Vol. 1, no. 2, (2014): pp. 32-48.

15. Bazhenova T. S., Bazhenova I. A., Barsukova N. V. “Primenenie pshennoj muki v proizvodstve bezglyutenovogo biskvita [Application of millet flour in the production of gluten-free biscuit]”. *XXI century: the results of the past and the problems of the present*. no. 2, (2018): pp. 42. – (In Russian)

16. Statsenko E. S., Korneva N. Yu. “Novaya tekhnologiya pishhevogo konczentrata-pudinga funkczional`nogo naznacheniya [New technology of food concentrate-pudding of functional purpose]”. *Far Eastern Agricultural Bulletin*. Vol. 3, no. 47, (2018): pp. 103-109. – (In Russian)

17. Shariati M. A., Khan M. U., Hleba L., de Souza, C. K. “Topinambour: Nutritional Value and its application in food products: An updated treatise”. *Journal of microbiology, biotechnology and food sciences*. Vol. 10, no. 6, (2021): pp. e4737-e4737.

18. Eliseeva T. “Pol`za ajvy`–fakty` i dokazanny`e naukoj czelebny`e svojstva [The use of quince-facts and proven healing properties]”. *Journal of Healthy Nutrition and Dietetics*. Vol. 3, no. 17, (2021): pp. 27-31. – (In Russian)

19. Alibekov R. S., Gabriliyants Z., Alibekova Z., Norov Z. “Antioksidanty` prirodnogo proiskhozhdeniya [Antioxidants of natural origin]” *Industrial Technologies and Engineering (2018): V International Scientific and Practical Conference, Shymkent, November 28, 2018*. Vol. 2, (2018): pp. 144-147. – (In Russian)

20. Shingisov A.U., Kantureeva G. O., Yerkebayeva S. U. “Issledovanie mineral`nogo sostava i fiziko-khimicheskikh pokazatelej slivy` sorta "Vengerka Domashnyaya", kul`tiviruemoj v yuzhny`kh regionakh Kazakhstana [Investigation of the mineral composition and physic-chemical parameters of the “Hungarian House” plum variety cultivated in the southern regions of Kazakhstan]”. *Advances in modern natural science*. no. 12, (2014): pp. 141-146. – (In Russian)

21. Kosaurova L. K., PlynskayaZh. A. “Osobennosti vitaminnogo sostava slivy` [Features of the vitamin composition of plums]”. Science and education: experience, problems, and development prospects. (2015): pp. 149-150. – (In Russian)

22. Thompson M. M., Walsh D. N. (1988). Rukovodstvo po spektrometricheskomu analizu s induktivno-svyazannoj plazmoj [*Guide to spectrometric analysis with inductively coupled plasma]*, Moscow, Nedra, 1988. – (In Russian)

23. Spandiyarov E., Sarzhanova G. S. “Opredelenie ugla estestvennogo otkosa tolokna "Tary`" [Determination of the natural slope angle of oatmeal “Tary”]. *Mechanics and technologies*. Vol. 2, no. 44., (2014): pp. 110-114. – (In Russian).

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ГАЛЕТ ӨНДІРІСІНДЕ ПЕКТИН КОНЦЕНТРАТЫНЫҢ ЖӘНЕ ТҰТАС ҰНТАҚТАЛҒАН ҰННЫҢ ОҢТАЙЛЫ МӨЛШЕРЛЕМЕСІН НЕГІЗДЕУ

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Құрамында пектинді заттары бар өнімдердің маңызды биологиялық белсенді қасиеттерінің бірі – пектиннің комплекс түзгіш қасиеті, ол қасиет пектиннің радиоактивті және ауыр металдар иондарымен өзара әсеріне негізделген. Қант қызылшасынан алынған пектиннің этерификация дәрежесі төмен (31,4%), ал комплекс түзуші қасиеті жоғары (270 мг Pb2+/г) екендігі дәлелденген, ол дегеніміз жаңадан шығарылған пектинқұрамдас өнімді, ауыр металдармен тығыз хелатты байланыс түзе алатын, табиғи детоксикант ретінде қолдануға ұсынуға болады деген сөз. Галетаға арналған қамырды дайындау үшін және зерттеу жұмыстарын жүргізу үшін бірінші сортты бидай ұны, Будан 237 сортты жүгері дәндерін және