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JUSTIFICATION OF THE SELECTION OF CEREAL CROPS FOR THE PRODUCTION OF NEW CEREAL BEVERAGES

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One of the most important factors that has a negative impact on the health of the population of the Republic of Kazakhstan is a violation of the diet, due to insufficient consumption of high-grade proteins, vitamins, macro- and microelements and their irrational ratio.

In the Republic of Kazakhstan, cereals are produced in large volumes, but there is no production of beverages based on vegetable raw materials, although the production of plant-based milk is already widespread throughout the world. The use of local vegetable raw materials from different regions of the Republic of Kazakhstan in the production technology of cereal milk beverages is an actual and promising direction in the food industry.

The results of a study of the quality of the following selection grain crops of the Republic of Kazakhstan are presented: rice "Syr Suluy", "Aykerim" and "Marzhan"; oats "Duman", "Bitik", "Arman"; buckwheat "Shortandin", "Batyr" and "Saulyk".

The results of protein analysis in rice grains showed that the "Syr Suluy" variety has higher rates, which amounted to 7.96 %. In the studied samples of oat grains of the Duman variety, the mass fraction of carbohydrates is 2.8 %; 1.54 % higher than the varieties "Bitik" and "Arman". Protein analysis in buckwheat grains showed that the Shortandin variety (13.04 %) has higher rates.

Studies have shown that the studied samples of grain crops in terms of safety comply with the requirements of the Technical Regulations of the Customs Union "On safety of grain". The data obtained will be used to develop new technologies for cereal beverages

Keywords: grain crops, physical and chemical composition, amino acid composition, fatty acid composition, safety of raw materials

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1. Introduction

The proportion of the population requiring plant-based foods is increasing, either due to increasing problems associated with cow's milk intolerance [1] or due to changes in food preferences. It is important to note that for people with lactose intolerance, there are alternatives such as lactose-free products and the use of the lactase enzyme, however, for allergy sufferers and vegans, plant-based milk is the only choice [2].

Food allergy is an abnormal reaction to any type of food or its components when taken orally, leading to a complex of clinical manifestations due to immunological mechanisms, mediated or not mediated by IgE-immunoglobulin [3]. Usually, people with cow's milk allergy also have reactions to almost all types of animal milk [4], so people often choose to replace animal milk with alternatives such as plant-based milk replacer [5].

Milk substitutes are water-soluble extracts of legumes, cereals, etc., which resemble cow's milk in appearance, they are obtained as a result of decomposition, extraction in water and subsequent homogenization [6].

Rice is a food of great nutritional value, an excellent source of energy due to its high concentration of starch, proteins, minerals, vitamins, but has a low lipid content. Rice protein has good digestibility, hypoallergenicity, including the absence of glutenins [7].

Oats are rich in biological substances such as soluble dietary fiber, β-glucan, vitamin E and polyunsaturated fatty acids, and their consumption in the human diet has a beneficial effect on human well-being [8].

Plant-based beverages used as non-dairy milk substitutes are in high demand in the food market because they are lactose and cholesterol free. In addition, they have a similar appearance to animal milk. However, they have different sensory characteristics, kinetic stability and nutritional composition. Plant-based milk replacers can be defined as homogenized extracts of plant components such as cereals (oats, rice), pseudocereals (quinoa), nuts (almonds, cashew nuts) and seeds (sesame and sunflower) [9].

In addition, the production chain for plant-based milk replacers is environmentally friendly and contributes to lower carbon emissions than dairy products.

According to the forecasts of international market analysts, by the end of 2022, the market for plant-based milk substitutes will grow to 9 billion USD. Plant-based milk production site will add 7.1 % per year in value terms. In five years, sales in the segment of the production of plant-based beverages increased by 61 %, while cow's milk, on the contrary, decreased by 15 % [10].

The consumption of vegetable milk in the Republic of Kazakhstan will grow in the next 10 years and will be able to occupy 10–20 % of the market for traditional dairy products. The development of the segment is facilitated by lovers of a healthy lifestyle and a low threshold for entering the market. Nutritionists of the world note the trend of increasing the number of people experiencing intolerance to certain types of nutrients necessary for the normal functioning of the body.

This makes it necessary to expand the range of lactose-free products. The introduction of this technology into production will expand the range of products manufactured at food enterprises in the Republic of Kazakhstan. The next important factor in the work is the use of local plant materials from different regions of the Republic of Kazakhstan in the technology of production of grain beverages. In the Republic of Kazakhstan, cereals are produced in large volumes, but there is no production of beverages based on vegetable raw materials, although the production of plant-based milk is already widespread throughout the world. Based on the foregoing, it can be noted that the topic of production of a vegetable beverage from local varieties of raw materials is relevant not only in Kazakhstan, but also for other countries of the world, since the use of local raw materials is considered appropriate in terms of reducing the cost of production and each local raw material has the prospect of for export.

2. Literature review and problem statement

As an enriched base, mass consumption products are usually used. This approach allows, taking into account the introduction of additional raw materials, to balance products in terms of protein composition, increase the content of dietary fiber, vitamins and microelements to the recommended consumption rates [11]. The attitude of people, especially socially active segments of the population, to their own health has changed significantly. The desire to lead a healthy lifestyle forms the interest of consumers in a proper balanced diet, increases the demand for products with natural ingredients and dictates the rejection of artificial food additives.

Functional foods are foods or food ingredients that have a positive effect on human health in addition to their nutritional value. However, healthy foods are not medicines and cannot cure, but help prevent disease and aging of the body. Functional nutrition implies eating foods that increase the resistance of the human body to diseases and improve many physiological processes in the human body, which allows it to maintain an active lifestyle for a long time [12]. A person receives the greatest amount of food ingredients when consuming liquid food products – beverages, and it is especially important to use local natural resources in their manufacture.

The active development of plant milk production is associated both with individual intolerance to lactose or milk casein. And a growing number of consumers with active promotion of vegetarianism and the physiological preference for vegetable protein consumption, especially in gerodietetic nutrition [13]. However, this product was invented as an alternative to animal milk, including to solve the problem of protein deficiency in economically underdeveloped countries, and today it is becoming more and more popular.

In addition to direct consumption, vegetable milk is also used as the basis for the production of non-dairy probiotic and other products of the traditional dairy sector - cream, yogurt, cheese, ice cream, and others [14]. Scientific studies on lactose intolerance by most adults have also become popular. Calculations by ecologists indicating that meat and dairy farming causes harm to nature, disproportionate to its contribution to the human diet. The use of the "milk alternative" becomes part of the image of a modern person who cares about his/her health and the future of the planet.

Unlike industrially processed cow's milk, plant milk does not contain hormones, antibiotics and is rarely falsified.

The plant-based milk market is developing most dynamically in the United States, where, according to Global Market Research, in 2016 the share of non-dairy milk already accounted for 8 % of the market volume of all dairy products. According to analysts' forecasts, by the end of 2018, the value equivalent of the plant-based milk production segment reached 4.5 billion USD. In 2017, another round of growth in the plant-based milk market was recorded, and, as analysts suggest, the growth dynamics will continue in the coming years [15]. However, the vegetable milk market in the Republic of Kazakhstan is not developed, since there is no production of vegetable milk in the country.

The growth rate of the considered segment of the world market in the USA is about 15.5 % annually, in Europe - about 7 %. Given these rates, it is expected that by 2022 only in European countries this market will be equivalent to 9.5 billion USD [16]. According to other analysts' data, the world plant-based milk market was 13 billion USD in 2018 and by 2026, according to experts, it can reach a capacity of 35.8 billion USD with an average annual growth rate of about 13.6 %. In this regard, the issue of the production of vegetable milk from local raw materials in the Republic of Kazakhstan is considered relevant.

One of the first (historically) types of plant milk, soy milk, are gradually losing ground [17]. Factors such as duration, complexity, significant costs, production cycles, low separation of water-soluble protein and residual "bean taste", odor and bitterness have led to the complexity of the technology. Another factor that should be noted is the insufficiently high organoleptic characteristics of soy milk [18] and the saturation of the raw material market with processed products of genetically modified soybean varieties, which reduces consumer confidence in this product. In this regard, the consumer market and manufacturers are reorienting themselves to alternative types of raw materials, which make it possible to produce other analogues of milk on an industrial scale. For example: almond, from cereals and oilseeds, coconut and walnuts, peanuts, hazelnuts, cashews, from melon seeds [19]. They also focus on combined raw materials, such as rice-almond and rice-coconut (Riso Scotti, Italy), soybean-corn, soybean-coconut, soybean with chufa extract [20], multigrain beverages. The disadvantage of this technology for the production of vegetable milk is the duration of the technological process, the cyclicity, the destruction of vitamins due to the high heat treatment temperature.

Plant-based milk alternatives made from nuts and grains are becoming increasingly popular as they have a more palatable and even pleasant taste and smell compared to soy milk. As a result, literally over the past few years, almond and rice milk have taken the 2nd and 3rd places in the structure of sales of these beverages both in the USA and in European countries [21]. This is due to the fact that the consumer is gradually developing a new approach to the choice of food. Many strive to eat and at the same time receive only the proteins, fats, carbohydrates necessary for the body, as well as maintain and strengthen their health, reduce the risk of developing diseases, and even reduce weight.

Thus, manufacturers are faced with the task of finding new technological and product solutions, one of which is the creation of a new generation of food products – "functional products".

Not all varieties are suitable for the production of cereal beverages.

3. The aim and objectives of research

The aim of research is to identify the feasibility of using local raw materials based on the determination of the physicochemical composition and biological value of grain crops. This will enable the use of local grain raw materials in the production of functional grain beverages.

To achieve the aim, the following objectives were set:

– substantiate the expediency of using local grain crops in the new technology;

– investigate the chemical composition and safety quality indicators of selected crops;

– study the vitamin composition and indicators of the biological value of cereals.

4. Materials and methods of research

4. 1. Materials under study

Theoretical provisions and the main experimental studies were carried out in the laboratories of the Department of Technology and Standardization of the Kazakh University of Technology and Business, as well as in the Research Institute of Food Safety at the Almaty Technological University.

The objects of the study were:

– breeding varieties of rice Syr Suluy", "Aykerim" and "Marzhan" of the Kyzylorda region, Kazakh Research Institute of Rice named after. Zhakhaev;

– breeding varieties of oats "Duman" and "Bitik" of Akmola region; "Arman" of Kostanay region;

– breeding varieties of buckwheat "Shortandin" of Akmola region, Research and Production Center for Grain Farming named after A.I. Baraev; "Batyr" of Akmola region; "Saulyk" of Almaty region.

The selection of grains was carried out according to GOST ISO 24333-2017. Grain and products of its processing.

4. 2. Research methods indicators of the quality of grain crops

Evaluation of the nutritional value of grain crops was carried out according to standard research methods:

– mass fraction of fat was determined by the Soxhlet method;

– mass fraction of carbohydrates – by iodometric titration;

– mass fraction of protein – according to the Kjeldahl method, using an automated furnace for burning the distillation apparatus;

– mass fraction of water-soluble vitamins was determined by the method of capillary zone electrophoresis "Capel 105 M" [22];

– the mass fraction of amino acids was determined on the system of capillary electrophoresis "Capel 105 M";

– antioxidant activity was determined on the device "TsvetYauza-01-AA" by the amperometric method.

The content of heavy metals was determined on a KVANT-Z.ETA-T spectrometer with electric atomization by atomic absorption spectroscopy (ASS) [23].

5. Research results of indicators of the quality of safety and biological value of grain crops

5. 1. Justification of the expediency of using local grain crops in the new technology

Cereal crops are the basis of agricultural production. Grain is the main human food product, used in fodder production and as a raw material for many industries.

Based on the data of the Bureau of National Statistics of the Republic of Kazakhstan, an analysis was made of the gross harvest of the three main grain crops grown in the Republic of Kazakhstan over the past 5 years in all categories of farms [24]. Fig. 1 shows the dynamics of the gross harvest of oats in the Republic of Kazakhstan by region.

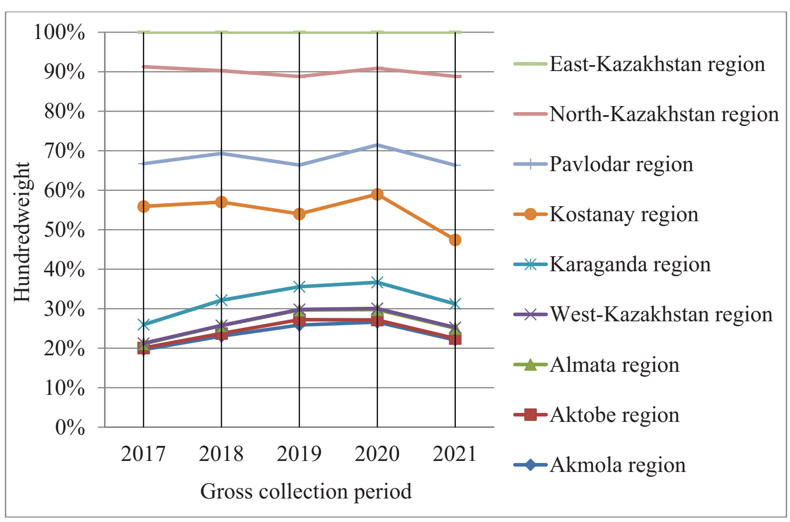

Fig. 1. Dynamics of the gross harvest of oats

As can be seen from Fig. 1, in the Republic of Kazakhstan, oats are grown in 9 regions. According to the National Bureau of Statistics in 2021, the following regions turned out to be the leaders in the collection: North Kazakhstan, Akmola and Pavlodar regions. So in Pavlodar region, starting from 2017 to 2021, the gross harvest with a variable small variation remains almost at the same level. However, compared to 2021 with 2017, there is a significant decline in gross harvest in Akmola and North Kazakhstan regions, by 72 % and 59 %, respectively. The areas with a low volume of oat cultivation include Aktobe, West Kazakhstan and Almaty regions.

Fig. 2 shows the dynamics of the gross harvest of buckwheat by region.

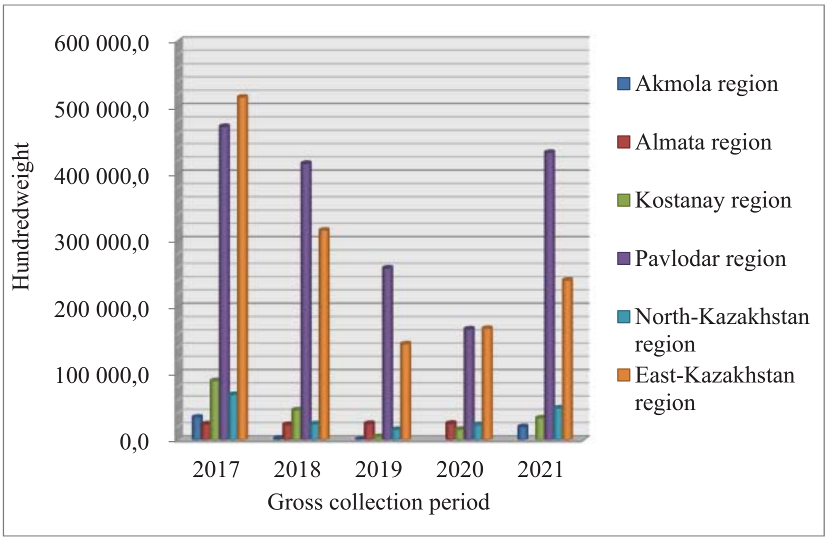

Fig. 2. Dynamics of the gross harvest of buckwheat

According to chart 2, it can be seen that the yield of buckwheat in 2021 increased to 51.6 % and 58.1 % compared to 2020 and 2019. In all regions, there are good indicators for the gross harvest of buckwheat for 2021. But there are two main leading regions for growing buckwheat – these are Pavlodar and East Kazakhstan regions. In Pavlodar region in 2021, the gross harvest increased by 258.4 % and 167.1 % compared to 2020 and 2019. In the East-Kazakhstan region, the gross harvest of buckwheat also increased by 143 % and 166 % compared to 2020 and 2019, respectively.

The dynamics of the gross rice harvest is shown in Fig. 3.

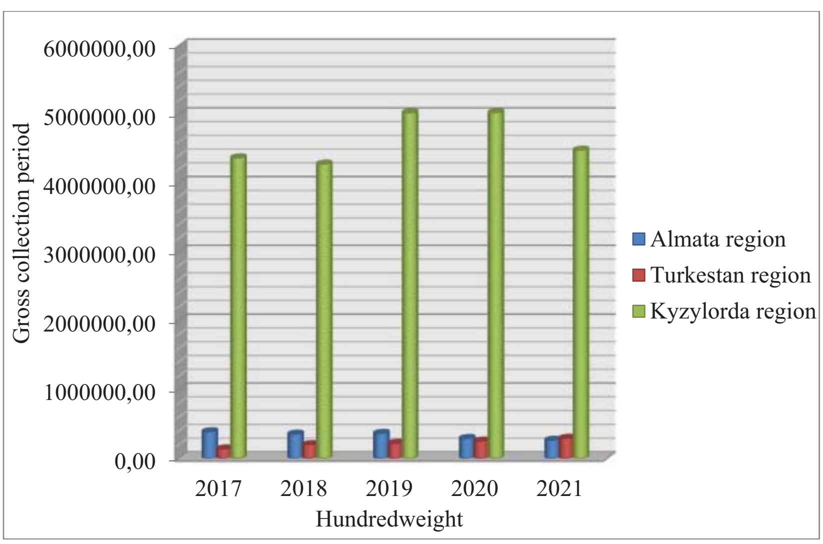

Fig. 3. Dynamics of the gross harvest of rice

According to Fig. 3 shows that in the Republic of Kazakhstan in three regions they are engaged in the cultivation of rice. The leader in the cultivation of rice is the Kyzylorda region, 88.9 % of the total gross harvest belongs to this region. Compared to 2017, in the Kyzylorda region in 2021 there is a significant increase in gross harvest, which amounted to 102.6 %. But in this area, in comparison with 2020, there is a slight decline in gross harvest by 89 %.

The analysis of statistical data showed that in the Republic of Kazakhstan there is a rather high volume of cultivation of rice and buckwheat, but additional cultivation volumes are needed for the production of oats.

5. 2. Results of the study of the chemical composition and quality indicators of grain crops

Tables 1–3 present the qualitative characteristics of the selected grain crops in comparison with the standard sample.

Table 1 presents the qualitative characteristics of rice grains in accordance with the requirements of regulatory documents.

Studies have shown that all the analyzed samples are in a healthy, non-heating state, the variation in humidity in the grain of rice was no more than 10 %. The conducted studies have shown that the analyzed samples of rice meet the requirements of regulatory documents, have high technological properties, which in the future can ensure the maximum yield of products during their processing.

The next step was to study the qualitative characteristics of oat grain in accordance with the requirements of GOST 28673-2019 "Oats. Specifications".

Studies have shown that the studied samples are in a healthy, non-heating state, the maximum moisture content in the grains of oats of the Arman variety was 13 %. The conducted studies have shown that oat samples meet the requirements of regulatory documents.

Qualitative characteristics of local varieties of buckwheat grains are presented in Table 3 according to GOST 19092-92 "Buckwheat. Procurement and supply requirements.

Analysis of the Table 3 allows to state that the studied buckwheat grains meet the requirements of regulatory documentation and can be used for research and development of the finished product.

The next step was to study the chemical composition of selected crops (rice, oats, buckwheat) to study the nutritional value of raw materials. Table 4 shows the chemical composition of breeding varieties of grain crops.

Table 4 shows that the content of carbohydrates in the studied samples varies in the range of 70–76 %. The highest content of carbohydrates was found in the grain of the "Marzhan" variety. It is known that the quantitative content of carbohydrates in a grain of rice depends not only on genetic traits, but also on many external factors and growing conditions (the chemical composition of the soil, its acidity and humidity). Dietary fiber, poorly absorbed by the human body, accelerates intestinal peristalsis, normalizes lipid and carbohydrate metabolism in the body, and promotes the elimination of heavy metals [25]. The high nutritional value of rice is provided by the protein composition of rice varieties. The analysis of protein in the grain of breeding rice varieties showed higher rates for the ““Syr Suluy” variety (7.96 %), and for the “Aykerim” variety, the mass fraction of protein was 6.62 %.

The data obtained indicate that the rice variety “Syr Suluy”, which has a high protein content, will have the best technological properties in the future in the production of vegetable milk beverages.

Table 1

Qualitative characteristics of rice grain in accordance with the requirements of the Standard of the Republic of Kazakhstan (ST RK) 1019—2000

Name of indicator	Requirements according to ST RK 1019–2000	Rice varieties		
		“Syr Suluy”	“Aykerim”	“Marzhan”
Harvested and supplied rice must be in a healthy unheated condition, have the characteristics of a healthy grain		complies	complies	complies
normal color and smell (no musty, malty, moldy, foreign)		complies	complies	complies
Humidity, %	14	complies	complies	complies
Weed impurity, %, no more	1.0	0.06	0.08	0.08
Mineral admixture	0.5	–	–	–
Spoiled rice grains	not allowed	not detected	not detected	not detected
Dead pests (beetles), pcs. in 1 kg, no more	not allowed	not detected	not detected	not detected
Grain admixture, %, not more than:	2.0	0.2	0.2	0.2
Yellowed grains, %, no more	0.3	–	–	–
Red grains, %, no more	3.0	–	–	–
Pest infestation	not allowed	not detected	not detected	not detected

Table 2

Quality characteristics of oat grain in accordance with the requirements of GOST 28673-2019

Name of indicator	The norm for the 1st class according to GOST 28673-2019 “Oats. Specifications»	Oat varieties		
		“Duman”	“Arman”	“Bitik”
in a healthy, unheated condition. inherent in healthy oat grain		complies	complies	complies
characteristic of healthy oat grain, without moldy, malty, musty and other foreign odors		complies	complies	complies
Humidity, %	13.5	12	13	12.5
Weed impurity, %, not more than:	2.0	0.06	0.07	0.05
including:				
mineral admixture	0.2	–	–	–
including:				
pebble	0.1	–	–	–
spoiled grains of oats and other cultivated plants	not allowed	not allowed	not allowed	not allowed
Grain admixture, %, not more than:	4.0	0.1	0.2	0.1
including:				
oat grains classified as grain impurities	3.0	0.1	0.1	0.2
including sprouted	not allowed	not allowed	not allowed	not allowed
grains and seeds of other cultivated plants classified as grain impurities	1.5	–	–	–
including grains of barley, rye	1.0	–	–	–
Small grains, %, no more	3.0	0.2	0.3	0.2

Table 3

Qualitative characteristics of buckwheat grain in accordance with the basic requirements of GOST 19092-92

Name of indicator	Basic norm according to GOST 19092-92 “Buckwheat. Procurement and supply requirements”	Buckwheat varieties		
		“Shortandin”	«Batyr»	«Saulyk»
Harvested and supplied buckwheat must be in a healthy, unheated condition, have a normal color and smell characteristic of healthy grain (without musty, malty, moldy, foreign odors)		complies	complies	complies
Humidity, %	14.5	11	12	12.5
Weed impurity, %	1.0	0.06	0.07	0.07
Grain admixture, %	1.0	0.005	0.008	0.01
Pest infestation	not allowed	not detected	not detected	not detected

Table 4

The chemical composition of breeding varieties of grain crops

Name of indicator	Varieties								
	rice			oat			buckwheat		
	"Syr Suluy"	"Aykerim"	"Marzhan"	"Duman"	"Arman"	"Bitik"	"Shortan-din"	«Batyr»	«Saulyk»
Mass fraction of carbohy-drates, %	74.66±1.08	70.09±1.54	76.18±0.93	57.03±0.58	55.49±0.58	54.23±0.58	54.43±0.41	54.55±0.41	52.63±0.41
Mass fraction of pro-tein, %	7.96±0.09	6.62±0.09	7.40±0.04	12.77±0.16	12.5±0.16	11.30±0.16	13.04±0.18	11.67±0.18	12.45±0.18
Mass fraction of fat, %	1.20±0.01	1.79±0.02	1.93±0.01	1.80±0.02	3.2±0.02	3.6±0.02	3.55±0.04	3.21±0.04	3.10±0.04
Nutritional value, kcal	341.28	322.95	361.49	295.4	300.76	294.52	303.27	293.77	446.11

Analysis of the Table 4 allows to state that in the studied samples of oat grains of the "Duman" variety, the mass fraction of carbohydrates is 2.8 %; 1.54 % higher than the varieties "Bitik" and "Arman". It is known that carbohydrates are the main source of energy for physical and mental activity. In addition, carbohydrates are necessary for uninterrupted cell division, muscle strengthening and normalization of growth dynamics [26]. In terms of protein content, the "Duman" variety also leads, in comparison with other studied varieties, the mass fraction of protein is higher by 1.47 %; 0.27 % respectively. In terms of fat content, the "Bitik" variety is the leader.

In the studied samples of buckwheat, the maximum carbohydrate content belongs to the "Batyr" and "Shortandin" varieties, which is 54.55 % and 54.43 %. Analysis of protein in the grain of breeding varieties of buckwheat showed higher rates for the variety "Shortandin" (13.04 %), and for the variety "Batyr" the mass fraction of protein was 11.67 %.

Further, the safety indicators of the quality of rice, oats and buckwheat were studied according to the requirements of the technical regulation of the Customs Union "On the safety of grain" 015/2011. Table 5 shows the results of the content of toxic elements in breeding varietal samples of rice, oats and buckwheat.

As can be seen from Table 5, all the studied samples of rice in terms of the content of toxic elements meet the requirements of regulatory documents. In the studied samples, the content of cadmium and arsenic was not found, and the content of lead did not exceed the permissible limits of 0.001–0.11 mg/kg.

No arsenic content was found in the analyzed samples of oat grains. The content of lead cadmium is within the permissible limits of 0.007–0.008 mg/kg and 0.0002–0.0003 mg/kg, respectively.

All studied samples of buckwheat meet the requirements of regulatory documents in terms of the content of toxic elements.

The acid number of the studied samples was determined according to the method provided for by GOST 10858-77.

As a result of the research, the samples did not deviate from the regulatory requirements. The acid number of the selected samples was determined by titration of the oil extracted from the crushed seeds according to GOST 10858-77. As a result of the determination of acidity, the arithmetic mean of the results of two determinations was taken, the difference between which does not exceed 0.1 mg. If this limit is exceeded, the determination is repeated. According to the requirements of the regulatory document, the acid number should not exceed 0.8–25 KOH/mg.

The results of the study on the acid number are given in Table 6.

The results of the study showed that the acid number in the studied samples was the highest in the rice variety "Syr Suluy " – 0.18±0.002 KOH/g, and the lowest was the variety "Aykerim" at 0.08±0.001 KOH/g.

Table 5

Determination of toxic elements in test samples

Indicators	Permissible levels according to TR TS mg/kg, not more than	Varieties								
		rice			oat			buckwheat		
		"Syr Suluy"	"Aykerim"	"Marzhan"	"Duman"	"Arman"	"Bitik"	"Shortan-din"	«Batyr»	«Saulyk»
Cadmium	0.1	not de-tected	not detect-ed	not detect-ed	0.0002± ±0.0001	not de-tected	0.0003 ±0.0001	not de-tected	not de-tected	not de-tected
Lead	0.5	0.011± ±0.0002	0.001+ +0.0001	0.001± ±0.0001	0.008± ±0.0001	not de-tected	0.007± ±0.0001	not de-tected	not de-tected	not de-tected
Arsen	0.2	not de-tected	not de-tected	not detect-ed	not de-tected	not de-tected	not de-tected	not de-tected	not de-tected	not de-tected

Table 6

Acid number in the studied samples

Indicators	Varieties								
	rice			oat			buckwheat		
	"Syr Suluy"	"Aykerim"	"Marzhan"	"Duman"	"Arman"	"Bitik"	"Shortan-din"	«Batyr»	«Saulyk»
Acid number, KOH/g	0.18± ±0.002	0.08± ±0.001	0.11± ±0.001	0.44± ±0.006	0.24± ±0.006	0.30± ±0.006	0.23± ±0.003	0.13± ±0.001	0.18± ±0.003

As can be seen from Table 6, all studied oat samples meet the requirements of the ND. According to the content of acid number, the oat variety "Duman" is in the lead, which amounted to 0.44±0.006 KOH/g.

All indicators for the acid number of the studied samples of buckwheat were within the normal range and varied from 0.18±0.003 to 0.23±0.003 KOH/g. The maximum value was shown by the buckwheat variety "Shortandin".

Knowledge of the total content of natural antioxidants in basic foods and beverages will allow them to be used in a new technology for the production of grain beverages. A high level of antioxidants has a positive effect on the body. The antioxidant content in rice helps rejuvenate the body and protect it from oxidative stress. In general, rice grain fractions are a rich source of antioxidant compounds.

Epidemiological studies have shown that the low rates of some chronic diseases in rice-consuming regions of the world may be related to the content of antioxidant compounds in rice. The results of the study of the amount of antioxidants in cereals are presented in Table 7.

As a result of the study, when comparing the identified indicators, it was found that among the breeding varieties in the rice variety "Syr Suluy" contains more antioxidant compounds compared to the varieties of rice "Aykerim" and "Marzhan". It was 0.268±0.004 mg/g for the variety "Syr Suluy". According to the study, it can be seen that the oat variety "Duman" is the leader in the content of antioxidants, which is 0.327±0.005 mg/g.

The content of antioxidants in buckwheat of the variety "Shortandin" is 0.430±0.006 mg/g, in the varieties "Saulyk" and "Batyr" it was 0.412±0.005 and 0.325±0.006, respectively.

Table 7

The content of antioxidants in the studied samples

Indicators	Varieties								
	rice			oat			buckwheat		
	"Syr Suluy"	"Aykerim"	"Marzhan"	"Duman"	"Arman"	"Bitik"	"Shortandin"	«Batyr»	«Saulyk»
Content of antioxidants, mg/g	0.268± ±0.004	0.252± ±0.003	0.260± ±0.003	0.327± ±0.005	0.217± ±0.002	0.305± ±0.005	0.430± ±0.006	0.325± ±0.006	0.412± ±0.005

5. 3. The results of the study of the vitamin composition and indicators of the biological value of grain crops

The results of the content of vitamins in the selected varieties of grains are presented in Table 8.

The analysis of experimental data showed that among the samples taken for testing, in terms of the amount of vitamins of group B and vitamin C in the composition of raw materials, rice of the variety "Syr Suluy" took the leading position. And also according to the content of vitamins of group B and ascorbic acid, the variety of oats "Duman" and the variety of buckwheat "Shortandin" stood out, which are the most desirable in terms of nutritional value for the production of grain beverage.

Among the vitamins of group B for the human body, riboflavin B2 is important, which is in the range of 0.054±0.021 in the rice variety "Syr Suluy". Further comparison of vitamin B2 shows that its content in the variety "Aykerim" 0.048±0.019 and in the variety "Marzhan" 0.042±0.015 is low. In the studied samples of oats, the variety "Duman" has the maximum content of vitamin B2 in comparison with other varieties, which amounted to 0.085±0.035. Also, according to the content of vitamin B2, the buckwheat variety "Shortandin" is in the lead with an indicator of 0.084±0.036.

The whole complex of B vitamins provides the human body with the normal functioning of the nervous system and is responsible for energy metabolism. Riboflavin is a biologically active substance that plays an important role in maintaining human health.

Table 8

The content of vitamins in experimental samples

Indicators	Concentration, mg/l								
	rice			oat			buckwheat		
	"Syr Suluy"	"Aykerim"	"Marzhan"	"Duman"	"Arman"	"Bitik"	"Shortandin"	«Batyr»	«Saulyk»
-B1 (thiamine chloride)	0.345± 066.0±	0.341± 050.0±	0.331± 061.0±	0.368± ±0.073	0.258± ±0.054	0.351± ±0.033	0.476± ±0.092	0.458± ±0.085	0.578± ±0.075
-B2 riboflavin	0.054± 021.0±	0.048± 019.0±	0.042± 015.0±	0.085± ±0.035	0.080± ±0.031	0.068± ±0.023	0.084± ±0.036	0.075± ±0.027	0.081± ±0.034
-B6 pyridoxine	0.702± 078.0±	0.652± 068.0±	0.051± 013.0±	0.487± ±0.097	0.457± ±0.087	0.398± ±0.085	0.58± ±0.116	0.44± ±0.058	0.51± ±0.114
-C ascorbic acid	0.309± 105.0±	0.288± 98.0±	0.307± ±0.101	0.565± ±0.19	0.489± ±0.20	0.521± ±0.17	0.628± ±0.212	0.556± ±0.214	0.634± ±0.125
-B3 pantothenic acid	0.366± 072.0±	0.322± 065.0±	0.315± 082.0±	0.473± ±0094	0.456± ±0087	0.396± ±0085	0.52± ±0.104	0.51± ±0.027	0.65± ±0.214
-B5 nicotinic acid	0.114± 021.0±	0.105± 012.0±	0.121± 020.0±	0.078± ±0.014	0.067± ±0.017	0.074± ±0.024	0.060± ±0.008	0.068± ±0.007	0.054± ±0.006
Bc folic acid	0.048± 009.0±	0.041± 005.0±	0.038± 009.0±	0.073± ±0.014	0.070± ±0.015	0.068± ±0.012	0.052± ±0.008	0.045± ±0.005	0.065± ±0.009

Vitamin C is an organic compound that is an essential element of the human body. The highest value in the studied samples was within 0.309±0.105 in the rice variety "Syr Suluy". In oats, in terms of vitamin C, the leader is the variety "Duman" 0.565±0.19, in buckwheat the variety "Saulyk" 0.634±0.125. The recommended dose of vitamin C should not exceed 0.25 ml per kilogram of body weight. Vitamin C helps the body fight various infections and viruses, improves skin condition, promotes the formation of lipids, proteins and the release of fats.

The next experiment was the study of polyunsaturated fatty acids of the studied samples.

Omega-3 fatty acids are essential and must be ingested through food. Omega-3 is also found in large quantities in flax seeds, rapeseed oil, soybeans, etc.

In functional nutrition, polyunsaturated fatty acids are necessary for the proper development of young organisms, as well as maintaining a person in good health. These acids belong to the ω-6 and ω-3 family. Among the general effects of essential acids, the main place is occupied by its antioxidant activity. Omega 3 and 6 protect cell membranes from damage by free radicals. They protect cellular contents from the action of lipid peroxidation products.

Table 9 shows the results of a study on the content of fatty acids in test samples.

Table 9

Content of fatty acids in test samples

No.	Fatty Acids	Concentration, %		
		rice	oat	buck-wheat
1	Methyl Butyrate	2.3252	2.3021	2.2848
2	Methyl Hexanoate	97.65	97.44	97.334
3	Methyl Octanoate	–	–	0.0093
4	Methyl Decanoate	–	–	0.0045
5	all Cis–4.7.10.13.16.19-Docosa-hexaenoate	–	–	0.0032
6	Methyl Undecanoate	0.0017	0.0074	0.0046
7	Methyl Lignocerate	0.00102	–	–
8	Methyl Laurate	–	0.0068	0.0356
9	Myristoleic acid methyl	0.00848	0.023	–
10	Methyl Myristate	0.0074	0.034	0.099
11	Cis-10-Pentadecenoic acid methyl ester	–	0.0073	0.0406
12	Methyl Pentadecanoate	0.00265	0.0465	–
13	Methyl Palmitoleate	–	0.0028	0.0071
14	Methyl Palmitate	–	0.0159	0.0504
15	Cis-10-Heptadecenoic acid methyl ester	0.0019	0.0059	0.0035
16	Gamma–Linolenic acid Methyl	–	0.0198	0.004
17	Cis-11,14,17-Eicosatrienoic acid methyl ester	–	0.033	–
18	Methyl cis-11 Eicosenoate	–	0.0504	–
19	Methyl Linolenate	–	–	0.0274
20	Methyl Linoleate	–	–	0.0014
21	Linolelaidic acid methyl ester	–	–	0.0008
22	Methyl Arachidate	–	–	0.0917

According to the data in Table 9, the amount of methyl ester of linolenic acid/Omega-3 (Linolelaidic acid methyl ester) in buckwheat was 0.0008 % of the total amount of fatty acids of the studied sample.

The content of gamma-linolenic acid in 100 grams of oats was 0.0198 % and in buckwheat 0.004 % of the total fatty acids. As it is known, Gamma-Linolenic acid Methyl (GLA) is a polyunsaturated fatty acid that belongs to the Omega-6 series. GLA is an essential fatty acid and enters the human body from the outside: either with food or as a supplement to it. Moreover, Omega-6 is converted into GLA already in the human body under the influence of certain enzymes. In its pure form, GLA is found in mother's milk, which in the first year of life makes up to 100 % of a child's nutrition.

The value of lipid compounds of PUSF is great, but there is an important nuance – fatty acids must be supplied in a certain ratio in order to be beneficial, not harmful.

The proportions are just as important as the origin (animal, vegetable) or the quality of the fats (cold-pressed oil instead of refined, fresh fish instead of frozen or smoked, soaked nuts instead of roasted).

The food that most people are used to (sunflower and butter, meat, nuts, seeds) is high in Omega-6. The ratio of Omega-6 to Omega-3 is required to be 4:1 or 5:1. However, the modern Western diet implies a very different ratio, from 16:1 to 30:1.

With an imbalance, that is, an excessive intake of Omega-6, substances begin to compete for desaturase enzymes. Desaturase is a substance that enters all cell membranes, including the membranes of muscle cells, skin, mucous membranes, and meninges. It is human desaturases that are involved in the synthesis of some essential acids from others – arachidonic from linoleic, eicosapentaenoic from alpha-linolenic, docosahexaenoic from eicosapentaenoic, etc.

The biological value of the developed products, characterized by the content of free amino acids, was studied.

Essential amino acids of food proteins are used in the body for the synthesis of tissue proteins and enzymes, for the synthesis of active non-protein compounds that are intermediate products of the metabolism of individual amino acids, and as energy sources. According to modern concepts, the biological value of food proteins is understood as the degree of nitrogen retention or the efficiency of its utilization to maintain nitrogen balance in humans, depending on the amino acid composition and other structural features. In other words, this criterion allows one to establish the place of certain food proteins according to the degree of comparative benefit for the human body. Supplying the human body with the necessary amount of essential amino acids is the main function of dietary protein.

The results of studies of the amino acid composition showed that amino acids are found in all plant tissues. The composition of amino acids affects the biological value of food products. In physiological terms, amino acids play an important role in metabolism, many of them serve as activators of enzymes and vitamins. Their deficiency causes serious diseases in humans. Amino acids are the end product of protein breakdown in the alimentary canal. They serve as structural material for the formation of proteins in the human body. Studies show that the absence or lack of essential amino acids in food leads to metabolic disorders (negative nitrogen balance). This also leads to the cessation of protein regeneration in the body, loss of appetite, pathological changes in the nervous system, internal secretion organs, blood composition, enzyme systems, etc. The daily human need for essential amino acids is (in g): lysine – 3–5.2, valine – 3.8–4, leucine – 4–9, isoleucine – 3–4, methionine – 2–4, threonine – 2–3.5, tryptophan – 1–1.1, phenylalanine – 2–4.4. Eight amino acids – valine, isoleucine, leucine, lysine, methionine, threonine, tryptophan and phenylalanine are essential and in the absence of at least one of them, protein synthesis, as well as protein substances, is impossible [27]. Of these, amino acids – lysine, methionine, and tryptophan – are basic or critical, since they limit the use of other amino acids for the synthesis of a protein molecule [28]. The results of the study on the amino acid composition of grain crops are presented in Table 10.

Table 10

Amino acid composition of grain crops

Name of amino acids	Concentration, %		
	rice	oat	buckwheat
Essential amino acids			
Lysine	0.18±0.06	0.40±0.14	0.15±0.05
Phenylalanine	0.67±0.20	0.85±0.26	0.55±0.17
Leucine+Isoleucine	0.85±0.22	1.31±0.34	1.29±0.34
Methionine	0.36±0.12	0.23±0.08	1.50±0.51
Valine	0.79±0.32	0.63±0.25	1.54±0.61
Threonine	0.52±0.21	0.68±0.27	0.63±0.25
Non-essential amino acids			
Arginine	1.15±0.46	0.57±0.23	0.72±0.29
Tyrosine	0.37±0.11	0.57±0.17	1.69±0.51
Histidine	0.39±0.20	0.52±0.26	0.17±0.08
Proline	0.79±0.20	2.05±0.53	1.47±0.38
Serene	0.59±0.15	0.97±0.25	0.60±0.16
Alanine	0.67±0.17	1.25±0.33	0.68±0.18
Glycine	0.67±0.23	0.57±0.19	1.40±0.48

As can be seen from Table 10, all studied samples are rich in various amino acids. By the number of valuable amino acids, the grains are close to proteins of animal origin, which determines the nutritional value of the grains.

The data obtained indicate that the content of amino acids varies greatly depending on the type of crops. Buckwheat turned out to be the most balanced in terms of amino acid composition, but the highest content of the most deficient amino acid, lysine, belongs to oats, which amounted to 0.40±0.14.

6. Discussion of the research results of quality and biological value indicators of grain crops

To justify the expediency of using local grain crops for the production of grain beverages, crops growing in the Republic of Kazakhstan, such as rice, buckwheat and oats were considered. According to the analysis of statistical data on the gross harvest of grain crops (Fig. 1–3), it was found that the leading region for growing oats is the North-Kazakhstan, Akmola and Pavlodar regions (Fig. 1). The leading region in terms of gross harvest of buckwheat is Pavlodar region (Fig. 2), in terms of rice, Kyzylorda region (Fig. 3). As evidenced by the data given in Tables 1–3 quality characteristics of crops in comparison with a standard sample, crops are in a healthy, not basking condition. The maximum moisture content in grains of oats of the "Arman" variety was 13 %, in rice grains no more than 10 %, for buckwheat no more than 12 %. The aim of the study was to study the physicochemical composition and biological value of grain crops. The conducted studies have shown that the analyzed samples of grains meet the requirements of regulatory documents, have high technological properties, which in the future can ensure the maximum yield of products in the production of grain beverages. The above studies (Table 4) of the chemical composition of grain crops are characterized by a high content of carbohydrates from 70 to 76 %. A high protein content was observed in the rice variety "Syr Suluy" (7.96 %), and in the variety "Aykerim" – 6.62 %. The content of the mass fraction of protein in oats of the variety "Duman" is 1.47 % higher than in the "Bitik" variety, however, in the variety "Bitik", the mass fraction of fat is 2 times higher compared to the variety "Duman". In buckwheat samples, there is a high content of carbohydrates in the variety "Batyr" – 54.55 %, and the protein content in the variety "Shortandin" is 13.04 %. On the basis of the data obtained, it can be concluded that in terms of the quantitative content of carbohydrates and the mass fraction of protein, the indicators of the rice variety "Syr Suluy", the oat variety "Duman", and the buckwheat variety "Shortandin" are in the lead.

As a result of the study of grain crops, the content of toxic elements (Table 5), such as cadmium, lead and arsenic, was not found, and the lead content did not exceed the permissible limits of 0.001–0.11 mg/kg.

The obtained data on the vitamin composition of grain crops (Table 8) indicate that, in terms of the amount of vitamins of group B and vitamin C in the composition of raw materials, rice of the variety "Syr Suluy", oats of the variety "Duman", and buckwheat of the variety "Shortandin" took the leading position. These varieties are desirable in terms of nutritional value for the production of cereal beverages. According to the content of fatty acids in the studied samples (Table 9), the amount of methyl ester of linolenic acid/Omega-3 in buckwheat was 0.0008 %, while in rice and oats it was not found. The content of Gamma-linolenic acid in 100 grams of oats was 0.0198 %, in buckwheat 0.004 %, and not found in rice. The data obtained (Table 10) indicate that the content of amino acids varies greatly depending on the type of crops. Buckwheat turned out to be the most balanced in terms of amino acid composition, but the highest content of the most deficient amino acid, lysine, belongs to oats, which amounted to 0.40±0.14.

All selected crops are a massive source of vegetable protein and, importantly, the possibility of their production in almost the entire region of the Republic of Kazakhstan, i.e., the presence of a significant local raw material base.

The main disadvantage of this study is the insufficient coverage of breeding varieties of grains of rice, oats and buckwheat. In this study, let's limit ourselves to only 3 varieties for each type of grain. The results of the study of scientists indicate the variability of quality indicators of different varieties of grains of rice, oats and buckwheat. Therefore, the technical performance of other varieties of grains of rice, oats and buckwheat may differ.

The limitation of this study is that in this study only the preparation for processing into cereal beverages was considered, in the future it is planned to determine the risks for each type of product, taking into account the storage process. Therefore, the prospect of further research is the development of technology for grain beverages from selected varieties of grain crops, the study of the nutritional biological value of the developed products, and the establishment of the shelf life of beverages.

7. Conclusions

1. Statistical studies were carried out on the gross harvest of three main grain crops over the past 5 years. The analysis of statistical data showed that, in the Republic of Kazakhstan, the volume of rice cultivation is quite high, but additional cultivation volumes are needed for the production of oats and buckwheat.

2. As a result of the research, the following breeding varieties were selected: oats varieties "Duman", "Arman", "Bitik"; rice varieties "Syr Suluy", "Aykerim", "Marzhan"; buckwheat varieties "Shortandin", "Batyr", "Saulyk". The conducted studies have shown that the selected varieties of grain meet the requirements of regulatory documents, have high technological properties, which in the future can ensure the maximum yield of products during their processing. According to the quantitative content of carbohydrates and the mass fraction of protein from the selected three varieties of rice, the leader is the variety "Syr Suluy"; from oats, the leader is the variety "Duman" and from the 3 three studied varieties of buckwheat "Shortandin". The safety quality indicators in the test samples are within the norm according to the requirements of TR CU 015/2011.

3. By determining the biological value of grain crops, it can be concluded that, in terms of the content of essential amino acids, the studied grain crops are characterized by a high content of essential amino acids. The content of essential amino acids is within the FAO/WHO norm, and does not have a limiting acid, which allows to conclude that the studied crops have a high biological value.

Conflict of interests

The authors declare that they have no conflict of interest in relation to this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

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