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RESEARCH OF GROATS FROM AMARANTH GROWN IN THE CONDITIONS OF CENTRAL KAZAKHSTAN

Abstract. Amaranth is a crop of interest to scientists and researchers due to its unique nutritional properties and resistance to climatic conditions. The aim of this research was to investigate the groats from amaranth grown in Central Kazakhstan for further use in the production of bakery and confectionery products. Amaranth groats were evaluated for its chemical composition, vitamin and mineral content, amino acid profile, food safety, and organoleptic assessment. The results showed that amaranth groats are rich in protein (17.97%), fiber (5.15%), and carbohydrates (67.68%). A high content of minerals (magnesium 190.96 mg per 100 g, calcium 173.41 mg, potassium 301.78 mg) was found in the amaranth groats, as well as vitamins B_1, B_2, B_6, B_5, B_{12}, and C. The amino acid profile of amaranth groats showed the presence of all amino acids necessary for human health. Based on the results obtained, the amaranth groats we produced is a rich source of biologically active compounds and, due to its nutritional properties, can be used in the development and improvement of functional food products.

Keywords: amaranth groats, chemical composition, amino acid profile, vitamins, minerals, food safety.

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Introduction. Globally, amaranth has long been recognized as a highly efficient agricultural crop, widely used in various fields. Interestingly, in southern Kazakhstan, amaranth, which includes more than fifty species, was until recently considered a persistent weed by farmers. In southern Kazakhstan, there are now plans to produce groats, oil, and even popcorn from amaranth [1].

The growing interest in using pseudo cereals in food technologies is linked to their high-quality amino acid, mineral, and vitamin composition [2]. Amaranth is valued for its key functional components, namely dietary fibers (11.10%) [3], proteins (10.18-29.35%) [4], polyunsaturated fatty acids (3.23%) [5], vitamins: riboflavin (0.23%), ascorbic acid (4.50%), folic acid, and vitamin E [6], minerals (calcium: 178 mg/100 g; magnesium: 248 mg/100 g; phosphorus: 557 mg/100 g; potassium: 508 mg/100 g) [5], and various biologically active compounds [7]. The biggest limitation of its functional properties is that amaranth does not contain

gluten and, therefore, lacks dough-forming and baking properties. However, it is a potential raw material for people with gluten intolerance.

Russian scientists recommend using amaranth oilcake in dairy, plant-based, meat, and cereal products, as well as in sweet and groats confectionery, and food concentrates [8].

Studies by other scientists confirm that using amaranth cake as a dry component can increase biological value due to its high content of easily digestible protein (18-20%), which includes all essential amino acids in sufficient quantities [9].

As a functional ingredient, gluten-free amaranth groats (containing fiber) can act as a prebiotic, while its proteins (with a unique amino acid profile) support muscle recovery [10].

Amaranth is a new crop for the northern regions of Kazakhstan, attracting researchers' and practitioners' attention due to its rich and balanced protein, high vitamin content, and mineral salts. We have conducted trial work observing the survival of the "Giant" variety of amaranth in Northern Kazakhstan. With the harvested amaranth, studies were conducted to produce oil from the seeds, use the dry mass of stems and leaves as animal feed, and examine the impact of the plant's growth on the soil [11].

Materials and methods. The research utilized seeds of the "Voronezh" grade of amaranth, cultivated by the farming enterprise "Nuray 2013" LLP in the Akmola region. The seeds were pre-defatted using a press method at the vegetable oil production workshop of S. Seifullin Kazakh Agrotechnical Research University. The resulting cake was ground in a crusher to obtain amaranth groats.

The organoleptic characteristics of the amaranth groats were determined according to GOST 27558-2022.

The mass fraction of protein was determined according to GOST 10846-91. This method involves the mineralization of organic matter with sulfuric acid in the presence of a catalyst to form ammonium sulfate, the decomposition of ammonium sulfate with an alkali to release ammonia, the distillation of ammonia with steam into a solution of sulfuric or boric acid, followed by titration.

The mass fraction of fat was determined according to GOST 29033-91 by extracting crude fat from amaranth groats using a solvent mixture of hexane and diethyl ether in a Soxhlet apparatus, followed by the removal of the solvent, drying, and weighing the extracted crude fat.

The mass fraction of carbohydrates was determined by the permanganometric method.

The mass fraction of fiber was determined according to GOST 31675-2012 with intermediate filtration.

Analyses to determine the organic substances, amino acid, mineral, and vitamin composition of amaranth groats samples were conducted in the Research Laboratory for the Assessment of Quality and Safety of Food Products at JSC "Almaty Technological University" (Protocol No. 342 dated April 22, 2024).

Research on the food safety of amaranth groats samples were carried out in the accredited laboratory of RSE "Center for Sanitary and Epidemiological Expertise" of the Medical Center of the Administrative Department of the President of the Republic of Kazakhstan (Protocol No. 157 dated January 11, 2024).

Research results. The results of the organoleptic characteristics of amaranth groats are presented in Table 1.

Table 1

Organoleptic Indicators of Amaranth Groats

Indicator	Standard document for research methods	Standard values of indicators	Research results
Color	Visually	Yellow and white shades with noticeable particles of groats husks	Corresponds
Taste and smell	GOST 27558-2022	Characteristic of amaranth groats without any off-odors or flavors	Corresponds

The Table 2 provides data on the mass fraction of protein, fat, carbohydrates, fiber, organic substances, energy value, as well as the content of key minerals and vitamins in amaranth groats.

Table 2

Analysis results of amaranth groats for physic-chemical parameters

Indicators	Standard document for research methods	Research results
Physic-chemical parameters, %:		
– protein content by mass	GOST 10846-91	17.97±0.27
– fat content by mass	GOST 29033-91	8.30±0.12
– carbohydrate content by mass	Perganometric method	67.68±1.01
– fiber content by mass	GOST 31675-2012	5.15±0.07
– organic substances	Thermogravimetric method	9.59±1.49
Energy value, kcal		417,3
Mineral elements:		
– magnesium, mg per 100 g	GOST 32343-2013	190.96±2.86
– calcium, mg per 100 g	GOST 32343-2013	173.41±2.60
– potassium, mg per 100 g	GOST 32343-2013	301.78±4.53
– iodine, μg per kg	MUK 4.1.1106-02	Not detected
Vitamins, mg per 100 g:		
– B_1	GOST 31483-2012	0.098±0.017
– B_2		0.147±0.043
– B_6		0.035±0.007
– B_5		0.961±0.22
– B_{12}		0.75±0.15
– C		3.14±0.04

An important indicator of raw materials is the amino acid composition. The content of essential and non-essential amino acids in amaranth groats is presented in Table 3 and chromatogram (Fig. 1).

Table 3

Amino acid composition of amaranth groats, %

Amino acids names	Standard document for research methods	Research results
1	2	3
Arginine	M-04-41-2005	1.404±0.562
Lysine		2.533±0.868
Tyrosine		0.915±0.274
Phenylalanine		1.085±0.326

Table 3 (continued)

1	2	3
Histidine	M-04-41-2005	1.255±0.628
Leucine-isoleucine		1.830±0.476
Methionine		0.745±0.253
Valine		1.468±0.57
Proline		1.043±0.271
Threonine		1.149±0.460
Serine		0.915±0.238
Alanine		1.936±0.503
Glycine		1.021±0.347

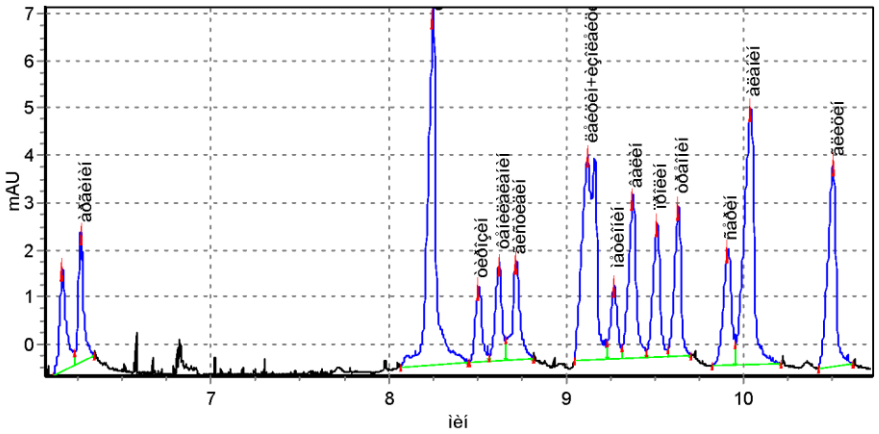

Fig. 1. Chromatogram of the amino acid composition of amaranth groats

Food safety is one of the main priorities for both producers and consumers. Food safety is one of the important issues facing humanity, as it determines the health of the nation, its development, and well-being. The term “safety” in accordance with the Technical Regulations of the Customs Union “On Food Safety” refers to the state of food products indicating the absence of unacceptable risk associated with harmful effects on humans and future generations. At all stages from storage, transportation, production, and storage, it is necessary to follow rules and ensure the food safety of raw materials and finished products. The results of food safety research are presented in Table 4.

Table 4

Analysis results of amaranth groats for food safety

Indicator	Standard document for research methods	Standard values of indicators	Research results
1	2	3	4
Mycotoxins, mg/kg: – aflatoxin B_1	GOST 30711-2001	Not more than 0,005	Not detected
Toxic elements, mg/kg – cadmium – lead – arsenic – mercury	 GOST 30178 GOST 30178 GOST 31266 GOST 26927	 Not more than 0,1 Not more than 0,5 Not more than 0,3 Not more than 0,02	 Not detected Not detected Not detected Not detected
Pesticides, mg/kg: – α-HCH	ST RK 2011-10	Not more than 0,5	0.00

Table 4 (continued)

1	2	3	4
– β-HCH	ST RK 2011-10	Not more than 0,5	0.00
– γ-HCH	ST RK 2011-10	Not more than 0,5	0.00
4,4'-DDT and its metabolites:			
– DDT	ST RK 2011-10	Not more than 0,02	0.00
– DDE	ST RK 2011-10	Not more than 0,02	0.00
– DDD	ST RK 2011-10	Not more than 0,02	0.00

Discussion. The organoleptic characteristics of the studied amaranth groats meet the requirements of GOST 27558-2022. The obtained results of the physic-chemical parameters of amaranth groats (Table 2) are almost in agreement with the results obtained by other researchers [12,13], which reported 15.38% and 15.05% crude protein, 3.55% and 3.00% crude fiber, and 65.69% carbohydrates in amaranth groats, respectively. The chemical composition results of our amaranth groats are superior, with protein content at 17.97%, crude fiber at 5.15%, and carbohydrates at 67.68%. The fat content (8.3%) and nutritional value (417 kcal) of the studied amaranth groats match the data of other researchers [14], which reported 8.2% fat and 417.2 kcal. However, the content of minerals such as magnesium and calcium in amaranth groats grown in the central region of Kazakhstan was significantly higher compared to data from Nigerian researchers: magnesium 190.96 mg/100 g (8.23 mg/100 g) and calcium 173.41 mg/100 g (33.29 mg/100 g). The mineral content is approximately twice as high as in regular cereals [15].

Overall, amaranth is not a significant source of vitamins. However, analysis of Table 2 shows the presence of B group vitamins and a high content of vitamin C. Some studies claim that amaranth contains more riboflavin (vitamin B_2), folic acid (vitamin B_9), and ascorbic acid (vitamin C) compared to regular cereals [15].

The amino acid composition of amaranth protein is considered close to that of an ideal protein. Since the quality of its protein is similar to that of animal sources [16,17], amaranth groats can be considered an alternative to meat in the human diet [18], not only due to its favorable amino acid composition but also because protein is the second most abundant nutrient [16,17,19].

Data from Table 3 and the chromatogram show an ideal balance and quality of amino acids. Eight essential amino acids were found: histidine (1.255%), isoleucine with leucine (1.830%), lysine (2.533%), methionine (0.745%), phenylalanine (1.085%), threonine (1.149%), and valine (1.468%), which play an important role in the human body by promoting protein synthesis, influencing human metabolism, regulating numerous biological processes, and affecting body mass and energy balance. In comparison, the article [20] reports much lower contents of these amino acids at 0.23%; 0.95%; 0.54%; 0.28%; 0.43%; 0.38%, and 0.42%, respectively.

Conclusion. The conducted research has confirmed the nutritional value of amaranth groats. The properties of amaranth groats combine characteristics of a safe and health-beneficial product and raw material. Thus, amaranth groats can be used as a natural substance in the food industry. The research results confirm that the protein content in amaranth groats (17.97%) is comparable to meat, making it an alternative high-protein product. The nutritional value of amaranth groats is further highlighted by its high content of essential minerals such as magnesium (190.96%), calcium (173.41%), and potassium (301.7%). The amino acid profile of

amaranth groats shows significant levels of almost all essential and non-essential amino acids. The safety of amaranth groats was demonstrated by the absence of mycotoxins, toxic elements, and pesticides including 4,4-DDT and its metabolites.

The superior nutritional value and health-promoting properties of amaranth should encourage food producers to develop new technologically innovative functional food products. We will continue research on cultivating other varieties of amaranth, developing new beneficial products based on amaranth groats, and conducting detailed studies of their qualitative indicators to determine the balanced use of this raw material.

Amaranth should be recognized as one of the promising nutrient-rich and health-beneficial crops with great potential to expand the range of food products and enhance the country's economy.

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ОРТАЛЫҚ ҚАЗАҚСТАНДА ӨСІРІЛГЕН АМАРАНТТАН АЛЫНҒАН ЖАРМАНЫ ЗЕРТТЕУ

Аңдатпа. Амарант өзінің ерекше тағамдық қасиеттеріне және климаттық жағдайларға төзімділігіне байланысты ғалымдар мен зерттеушілердің қызығушылығын тудыратын дақыл. Бұл зерттеудің мақсаты нан-тоқаш және кондитерлік өнімдер өндірісінде одан әрі пайдалану үшін Орталық Қазақстанда өсірілген амаранттан алынған жармаларын зерттеу болды. Амарант жармалары химиялық құрамы, дәрумендер мен минералдардың мөлшері, аминқышқылдарының құрамы, тағамдық өнімдердің қауіпсіздігі және органолептикалық крсеткіштері бойынша бағаланды. Нәтижелер амарант жармаларының ақуызға (17,97%), талшықтарға (5,15%) және көмірсуларға (67,68%) бай екенін көрсетті. Амарант жармаларында минералдардың көп мөлшері (100 г-ға магний 190,96 мг, кальций 173,41 мг, калий 301,78 мг), сонымен қатар B_1, B_2, B_6, B_5, B_{12} және С дәрумендері бар. Амарант жармаларының аминқышқылдық профилі адам денсаулығына қажетті барлық аминқышқылдарының мөлшерін көрсетті. Осы жерден алынған нәтижелерге сүйенсек, біз алған амарант дәні биоактивті қосылыстардың бай көзі болып табылады және оның қоректік қасиеттеріне байланысты функционалдық азық-түліктерді әзірлеуде және жақсартуда қолдануға болады.

Тірек сөздер: амарант жармасы, химиялық құрамы, аминқышқылдарының құрамы, дәрумендер, минералдар, азық-түлік қауіпсіздігі.

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ИССЛЕДОВАНИЕ КРУПЫ ИЗ АМАРАНТЫ, ВЫРАЩЕННОЙ В УСЛОВИЯХ ЦЕНТРАЛЬНОГО КАЗАХСТАНА

Аннотация. Амарант представляет собой культуру, интересную для ученых и исследователей благодаря своим уникальным питательным свойствам и устойчивостью к климатическим условиям. Целью данной работы было исследование крупы из амарантов, выращенной в Центральном Казахстане для дальнейшего использования в производстве хлебобулочных и кондитерских изделий. Амарантовую крупу оценивали по химическому составу, содержанию витаминов и минеральных веществ, аминокислотному составу, пищевой безопасности и органолептической оценке. Результаты показали, что амарантовая крупа богата по содержанию белка (17,97%), клетчатки (5,15%), углеводов (67,68%). В амарантовой крупе обнаружено высокое количество минералов (магния 190,96 мг на 100 г, кальция 173,41 мг, калия 301,78 мг), а также витамины B_1, B_2, B_6, B_5, B_{12} и С. Аминокислотный профиль амарантовой муки показал содержание всех аминокислот, необходимых для здоровья человека. Судя по полученным здесь результатам, полученная нами амарантовая крупа является богатым источником биологически активных соединений и благодаря своим питательным свойствам может использоваться при разработке и совершенствовании функциональных продуктов питания.

Ключевые слова: амарантовая крупа, химический состав, аминокислотный состав, витамины, минералы, пищевая безопасность.