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AMARANTH: PROBLEMS AND PERSPECTIVES OF PROCESSING

Abstract

Amaranth is one of the ancient, so-called pseudo-cereal crops, the first mentions of it date back more than 8,000 years. Despite the sufficiently high study of amaranth and its wide distribution, according to the volume of its cultivation, it can be classified either as a niche crop or as a special purpose crop. Amaranth can be attributed to small-seeded grain crops, the grain has a rounded lenticular, oval-rounded shape with a diameter of 0.9 to 1.7 mm, the weight of 1000 grains is in the range of 0.6 to 1.1 g. Amaranth grains can be white, red, golden, black, or brown in color, with the white grain having the highest manufacturability. In Ukraine, up to 50 enterprises are engaged in the processing of amaranth, while receiving oil, cereals, flakes and flour, but at the moment, despite the high usefulness of these products, a permanent circle of its consumers has not yet been formed in our country, which in turn affects the volume of amaranth cultivation and volumes of its processing into food products. 15 varieties of amaranth are included in the register of plant varieties suitable for distribution on the territory of Ukraine, among which seven varieties are intended for grain. Sterkh, the forage amaranth variety, was the first to enter the Register... in 1994. In the following year, 1998, three amaranth varieties Atstek and Ul'tra and Kremovyi rannii were registered. It should be noted that the first two varieties are grain requirements according to the recommendations of the Register..., and the Kremovyi rannii variety is a fodder variety. In 1999, two more grain varieties of amaranth, Orkhideia and Polischuk, were registered. In 2000, the grain requirements variety Zhaivir was registered. In 2003, the Liera and Sem grain requirements varieties were registered, and in 2009, the Students'kyi variety. Indirectly, amaranth can be characterized by a mass fraction of protein up to 19%, fat up to 9%, carbohydrates up to 60 %, fiber up to 4 %, ash up to 3 %. An impeding factor in increasing the volume of amaranth grain processing is the lack of approved regulations and the lack of enterprises with the appropriate understanding of how to effectively clean amaranth grain from impurities, carry out dehulling, sorting of dehulling products and, most importantly, what kind of product range to produce. All this stops the wide spread of this crop in our country and, accordingly, amaranth products are not widely distributed compared to other traditional crops and are not well known to the domestic consumer.

Key words: amaranth, chemical composition of grain, cultivation volume, grain, grain production, amaranth oil, grain processing, amaranth grain, amaranth flour.

Introduction

In the modern world conditions, the development and implementation of new technological solutions is which are replacing the old and the less efficient, energy-intensive, extended technological processes that took place in the second half of the 20th century. The existing technologies of the Ukrainian grain industry have been virtually unchanged since their first widespread publication and use, and the varieties of cereals that have served as a guide in their development cannot be compared with the modern ones in their yield and basic properties.

Since the early 21st century, there has been an increase in the proportion of small businesses in the groats industry, which are increasing today. The majority of such enterprises do not allow the use of existing extended full grain processing technologies, there is a reduction in the number of basic technological operations, often not sufficiently substantiated, which affects the quality of the obtained products, which does not always responds all the basic rules of the regulations on the finished products.

High efficiency of cereals processing, expanding the range of products and improving its quality properties is traditionally achieved due to new, breeding varieties of traditional grain that have better properties - higher yields, lower hoodness, better chemical composition (more protein, β-glucan vitamins), which allows for a gradual reorientation of the processing plant to higher quality standards, with economic costs being minimal as a rule and technological schemes and equipment for their implementation remain virtually unchanged, the main adjustment occurs with the modes of operation of the most energy-intensive stages that are available available during processing and are considered irrational for the processing of new grain.

Amaranth is one of the ancient, so-called pseudo-cereal crops, the first mentions of it date back more than 8,000 years. This culture was most widespread in the countries of Central America and South Asia, where it was widely used to meet food and fodder needs.

When using amaranth as a food crop, it was processed into flour, which was a raw material for bread production [1,2]. In South America, amaranth was widespread among the Aztecs and Incas, who used it approximately 6,000 years ago for food and various rituals.

The amaranth seed entered Europe in the 17th century and immediately gained wide popularity, but later it began to be forgotten as a valuable culture. In fact, interest in amaranth was revived only in the 20th century,

when the search for new types of grain raw materials began to meet the needs of a growing population. At the beginning of the 20s of the 20th century, American scientists rediscovered this culture, and at the end of the second half of the 20th century, amaranth entered the category of valuable grain crops [3].

Amaranth came to Ukraine from South America around the beginning of the 20th century, but at the first stages it was recommended as a fodder crop and only in the 70s its more in-depth study began, later research centers were formed in Kyiv, Odessa, Kharkiv, Lviv, Vinnytsia, etc. [1].

Literary review

In Ukraine and the World, a large number of studies of amaranth grain have been carried out and its significant usefulness, first of all, for the needs of the human body, has been proven. Despite the sufficiently high study of amaranth and its wide distribution, according to the volume of its cultivation, it can be classified either as a niche crop or as a special purpose crop.

Thus, increasing the efficiency of amaranth use in the food and grain processing industry of Ukraine and providing the population with its processing products with high nutritional and biological value is an urgent direction.

Amaranth is grown in small quantities in South America, Southeast Asia, Africa and Western Europe [4]. The largest cultivated areas are concentrated in China (about 100 thousand ha) and India (40-50 thousand ha) [5-7]. In Poland, the sown area for amaranth is only 100 hectares [8]. In Ukraine, amaranth is also not widely distributed, the estimated cultivated area in our country does not exceed 20 thousand ha, while it should be noted that amaranth is partly grown as an organic grain, the area of which is cultivated up to 800 ha. Amaranth cultivation in our country is mainly done by small agricultural holdings or households and farms [6-8].

Several types of amaranth can be distinguished according to their value, potential and purpose, among which the greatest economic value is the fodder-type grain *A. Cruentus*, and the fodder and grain-type grains - *A. hybridus* and *A. Hypochondriacus* [11,12]. Amaranth can be attributed to small-seeded grain crops, the grain has a rounded lenticular, oval-rounded shape with a diameter of 0.9 to 1.7 mm, the 1000 grains weight is in the range of 0.6 to 1.1 g. Amaranth grains can be white, red, golden, black, or brown in color, with the white grain having the highest manufacturability [13].

Despite the fact that amaranth production volumes are small, the range of products from it is quite wide. On the African continent, amaranth is a vegetable crop that is widely used in cooking when preparing various dishes. On the European continent, amaranth is a raw material for the preparation of flour, which is then included in the recipes of various desserts, pasta, bread, functional and dietary products, a common product is amaranth oil. The total number of enterprises in the world engaged in amaranth processing does not exceed 700 [9,10].

In Ukraine, up to 50 enterprises are engaged in the processing of amaranth, while receiving oil, cereals, flakes and flour, but at the moment, despite the high usefulness of these products, a permanent circle of its consumers has not yet been formed in our country, which in turn affects the volume of amaranth cultivation and volumes of its processing into food products [9,10].

15 varieties of amaranth are included in the register of plant varieties suitable for distribution on the territory of Ukraine, among which seven varieties are intended for grain. Sterkh, the forage amaranth variety, was the first to enter the Register... in 1994. In the following year, 1998, three amaranth varieties Atstek and Ul'tra and Kremovyi rannii were registered. It should be noted that the first two varieties are grain according to the recommendations of the registry, and the Kremovyi rannii variety is a fodder variety. In 1999, two more grain varieties of amaranth, Orkhideia and Polischuk, were registered. In 2000, the grain variety Zhaivir was registered. In 2003, the Liera and Sem grain varieties were registered, and in 2009, the Students'kyi variety. The recommended areas for amaranth cultivation in Ukraine are the Forest-Steppe, Polissia and Steppe zones.

Formulation of the problem

Despite the sufficiently large number of varieties recommended for growing on the territory of Ukraine, there is no official regulation on the processing of this grain. The processing of this crop is carried out according to technical and technological instructions, which are based on the processing of amaranth-like traditional grain crops and on international experience, which does not always take into account the peculiarities of grain grown in Ukraine. Accordingly, this leads to the production of a scientifically unfounded assortment of products using scientifically unfounded modes of operation of technological equipment. This reduces the potential of this crop and can potentially reduce the nutritional value of its products.

Materials and methods

The purpose of the work: substantiation of the expediency and prospects of expanding the range of food products obtained from amaranth and improving the technology of its processing.

Objective:

- to analyze the volume of amaranth cultivation in the world and in Ukraine, to determine current trends, problems of cultivation and processing;
- determine the nutritional and biological value of amaranth, justify the feasibility of using it in the human diet;
- to analyze the existing ways of using amaranth and to justify promising methods of processing to expand the assortment of the obtained products.

Results of the study and their discussion

In 2011, DSTU 7213:2011 "Amaranth Grain Technical Conditions" was adopted. This standard regulates directions of use of amaranth grain. According to it, it is recommended to use amaranth grain of all light colors for food and pharmacological needs, and all other colors are recommended for use for fodder or technical needs. Also, in this standard, for grain intended for food or pharmacological needs, there is a division of grain into two classes depending on the mass fraction of fat and protein. In terms of color, food grain according to the

standard can be light yellow, yellow or cream, while the shape for the first and second class can be lenticular, oval-rounded or rounded. The size of the grain is small from 0.5 to 0.8 mm with floury or waxy endosperm. For grain for food use, the standard regulates such indicators as the test weight of grain (not less than 750 g/l), moisture (not more than 9%), the share of grain impurities (not more than 9%), waste impurities (not more than 2%). These indicators are integral to both classes of amaranth food grain.

For grain of the 1st class, the mass fraction of protein must be at least 16.0% in terms of dry matter, for the second class at least 12%. The mass fraction of fat for first class grain should not be more than 7.0% based on dry matter, for second class - no more than 4.0%. According to the standard, amaranth grain intended for food or pharmacological needs is classified as type I, fodder and technical grain as type II. At the same time, fodder grain is not divided into classes in accordance with the standard. Having considered DSTU 7213:2011 "Amaranth grain Technical conditions", it can be noted that its presence in our country significantly improves the classification of grain by direction and, accordingly, simplifies the choice of the right raw material for processing enterprises, which corresponds to the direction of the enterprise's work. An important shortcoming in the standard is the absence of the names of amaranth varieties most suitable for food purposes, especially considering that the standard was adopted in 2011 and at that time 8 varieties of amaranth for grain use were already registered in the register (Aztek, Zhaivir, Liera, Orchid, Polishchuk , Sam, Students'kyi, Ul'tra), which in turn allows us to talk about the insufficient study of amaranth grain as a food crop in our country.

Important for any grain raw material intended for the production of food products is its chemical composition. Amaranth grain has a valuable chemical composition, thanks to which there was a kind of return to this culture. Amaranth exceeds soy in terms of essential fatty acids, and in terms of content and composition of amino acids, some products of animal origin prev ail [14]. Indirectly, amaranth can be characterized by a mass fraction of protein up to 19%, fat up to 9%, carbohydrates up to 60 %, fiber up to 4 %, ash up to 3 % [16].

The chemical composition of amaranth seeds according to [16] is shown in the diagram (Fig. 1).

In the production of any food product, the mass fraction of protein, the content of amino acids indispensable for the human body in the protein complex, and the fractional composition of proteins are of the greatest importance. The return of interest in amaranth as a valuable grain crop is primarily due to its high protein content and balanced amino acid composition [16].

The mass fraction of protein in amaranth varies depending on varietal characteristics and ranges from 12 to 23%, while the amaranth grain contains a sufficiently high amount of lysine and tryptophan, the limiting amino acid is leucine, the content of which is lower compared to other cereal crops. Using this feature, it is possible to use amaranth processing products to improve other products, for example, corn products that have an insufficient amount of lysine and tryptophan and a sufficient content of leucine [17-19]. The fractional composition of

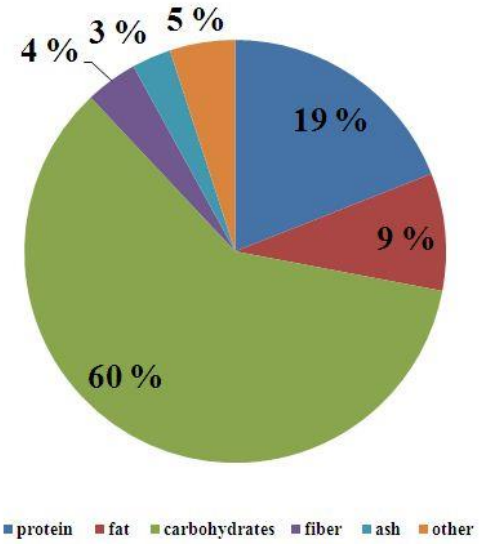

Fig. 1. The chemical composition of amaranth seeds

the protein complex mainly consists of water-soluble albumins, the mass fraction of which can reach 56%, and globulins (up to 18%), alkali-soluble glutelins (up to 42%), and alcohol-soluble prolamins (up to 4%) [19].

The mass fraction of fat in amaranth is higher compared to other traditional cereal crops and due to which it is a raw material for the production of valuable amaranth oil. The mass fraction of fat, depending on the varietal characteristics of amaranth, ranges from 6 to 9%, while it should be noted that it is dominated by polyunsaturated fatty acids, which are useful for the human body, and the proportion of which can reach 75%. In addition, the fat complex of amaranth contains 6-8% squalene in its composition, a substance that allows the creation of medicinal and functional products from this grain, as well as in pharmacology during the production of medicines. Among the fatty acid composition of amaranth, linoleic acid has the largest mass fraction (up to 40%), fatty acids such as palmitic and stearic acids, which are present in small amounts, are limited. Amaranth also contains a large proportion of vitamin E compared to other cereal crops [20-24].

The carbohydrate complex, as in most crops, occupies a dominant place in the chemical composition of the grain, the main component of which is traditionally starch, the mass fraction of which is up to 60%, the carbohydrate complex of amaranth also includes sucrose (up to 2%) and a small amount of maltose (up to 0.5 %). Starch is located in the carbohydrate complex in the form of granules ranging in size from 1.05 to 1.78 μm [25-27].

Amaranth grain is a valuable source of micro- and macroelements. Compared to other traditional cereals, amaranth is characterized by a higher mass fraction of vitamins of group *B*, especially riboflavin and folic acid, as well as vitamin *C* [28]. Similarly, in terms of the content of mineral substances, amaranth grain is superior to cereal crops, among other microelements, sodium, calcium, phosphorus, potassium and magnesium are the most abundant in it [29].

The analysis of data on the chemical composition of amaranth grain fully confirms its special usefulness as a raw material for the domestic grain industry. Amaranth can be used both to expand the raw material base and to

expand the range of existing products. In addition, the processing of this grain, due to its improved chemical composition compared to other traditional crops, makes it possible to create medicinal, dietary and functional products based on it, especially considering that in our country there is at least one variety of amaranth that is not the grain requirements, but a medicinal purpose - variety Kharkivskyi-1, which was registered in the Register of plant varieties suitable for distribution on the territory of Ukraine back in 2001.

Today, the main hindering factor in increasing amaranth grain processing volumes is the lack of approved regulations and the lack of appropriate understanding among processing enterprises on how to effectively clean amaranth grain from impurities, carry out peeling, sorting of peeling products and, most importantly, what kind of assortment of products to produce. All this stops the wide spread of this crop in our country and, accordingly, ready-made amaranth products are not widely distributed compared to other traditional crops and are not well known to the domestic consumer.

The analysis of literary sources shows that in our country a method of production of polished amaranth groats has been developed and patented, which involves cleaning the grain from impurities, its preparation and processing. According to the proposed method, cleaning is carried out on sieves with round holes with a diameter of 1.0-2.5 mm. Control of grain color is recommended to be carried out on a photoseparator. After that, the amaranth is moistened to a moisture content of 15-16% and tempered for 1-2 hours. Amaranth grain prepared in this way is dehulled and polished. The yield of the entire polished core, depending on the mode of moistening, is from 50 to 70% [30].

The Swiss company Buhler offers an option for the production of ground amaranth groats using highly efficient and productive equipment of this company. The process involves preliminary cleaning of grain before the main technological process, cleaning of grain from characteristic impurities, peeling and polishing, and sorting, for which it is suggested to use SORTEX J SpectraVision optical separators (Fig. 2).

Photoelectronic separators SORTEX J SpectraVision are the latest development of this company and

Fig. 2. SORTEX J SpectraVision

allow to work more efficiently on grain sorting thanks to new installed full-color cameras for analysis and specially developed software with artificial intelligence.

Conclusions

1. Amaranth is a promising raw material for the production of food products with therapeutic and preventive and functional properties.

2. The availability of only one option for processing amaranth grain into groats for its widespread introduction into domestic production is insufficient, given the high biological potential of the raw material, it is possible to significantly increase the profitability of production.

3. An in-depth study of the technological properties of amaranth grain of various varieties intended for grain requirements, research into the modes of their cleaning and preparation of grain for processing, the features of its dehulling, polishing, fat release, flaking and, accordingly, justification on the basis of this recommended assortment of products is necessary. All this will make it possible to develop science-based technologies for its processing into a traditional or specially developed assortment of products, as well as to develop projects of standards for finished products.

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АМАРАНТ: ПРОБЛЕМИ І ПЕРСПЕКТИВИ ПЕРЕРОБКИ

Анотація

Амарант є однією з давніх, так званих псевдозлакових культур, перші згадки про нього датуються понад 8000 років тому. Незважаючи на достатньо високу вивченість амаранту і широке розповсюдження, за обсягами вирощування його можна віднести або до нішевих або до культур спеціального призначення. Амарант можна віднести до дрібнонассінєвих зернових культур, зерно має округлу лінзоподібну, овально-округлу форму з діаметром від 0,9 до 1,7 мм, маса 1000 зерен знаходиться у межах від 0,6 до 1,1 г. За кольором оболонок зерно амаранту може бути білого, червоного, золотистого, чорного та коричневого кольору, при цьому найбільшу технологічність має зерно білого кольору. В Україні переробкою амаранту займається до 50 підприємств, при цьому отримують олію, крупи, пластівці та борошно, але на даний час незважаючи на високу корисність цих продуктів в нашій країні ще не сформовано постійне коло її споживачів, що в свою чергу впливає на обсяги вирощування амаранту та обсяги його переробки в харчові продукти. В реєстр сортів рослин придатних для поширення на території України внесено 15 сортів амаранту, серед яких сім сортів мають зернове призначення. Першим в Реєстр у 1994 році потрапив сорт амаранту кормового призначення Стерх. У наступному 1998 році було зареєстровано три сорти амаранту Ацтек та Ультра та Кремовий ранній. Слід відмітити що перші два сорти є зерновими за рекомендаціями реєстру а сорт Кремовий ранній є кормовим сортом. У 1999 році було зареє-

стровано ще два зернових сорти амаранту Орхідея та Поліщук. У 2000 році зареєстровано зерновий сорт Жайвір. У 2003 році зареєстровано зернові сорти Лєра та Сем, у 2009 році сорт Студентський. Опосередковано, амарант може характеризуватися масовою часткою білку до 19 %, жиру до 9 %, вуглеводів до 60 %, клітковини до 4 %, золи до 3 % Перешкоджаючим фактором збільшення обсягів переробки зерна амаранту є відсутність затвердженого регламенту і відсутність у переробних підприємств відповідного розуміння яким чином проводити ефективне очищення зерна амаранту від домішок, здійснювати лущення, сортування продуктів лущення і, найголовніше, який саме асортимент продуктів виробляти. Все це зупиняє широке поширення даної культури на території нашої країни і відповідно готова продукція з амаранту не має широкого розповсюдження в порівнянні з іншими традиційними культурами і не є добре знайомою вітчизняному споживачу.

Ключові слова: амарант, хімічний склад зерна, обсяги вирощування, крупа, круп'яне виробництво, амарантова олія, переробка зерна, амарантова крупа, борошно з амаранту.

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