Prospects of using amaranth in the food industry

by Yurii Dmitrievich Belkin.
Cand. Ph.D. (Technical Science). Plekhanov Russian University of Economics, Moscow

Abstract

The article presents research results, considering the biological characteristics of Amaranth, a promising high-yield grain crop that is new to Russia. This crop is rich in high quality protein and can provide humans with food, medicine and feed. The biological values of Amaranth and wheat flour have been compared. The content of amino acids in Amaranth has been analyzed compared to other more common cereal crops (wheat, corn, rice). It is necessary to emphasize that pulse plants lack amino acids such as lysine and methionine. Its content in Amaranth seeds is double.

INTRODUCTION.

Humans use only about 20 out of all crops known in the world to obtain a sufficient amount of calories and protein. Wheat, corn, millet, sorghum, potatoes, sweet potatoes, cassava, beans, soybeans, peanuts, sugarcane, sugar beets, and bananas make the greatest contribution to the human nutrition. However, these are only a few of the known edible crops. It is necessary to include them in the diet to vary and enrich the food. The amaranth is one of such crops. Sixty species of the Amaranthus genus (the Amaranthacea family) are known. Most of them are considered weeds, 12 species are cultivated and used as vegetables, cereals, feed and ornamental plants.

DEVELOPMENT.

Methods.

The amaranth is an annual purple or yellow-green herb, the height of which can reach 2.5 – 4 m. The mature panicle is as long as 30 cm, and its diameter is 15 cm. The weight of one panicle reaches 1kg. Amaranth seeds are very small, like grains of sand, and their number is huge (up to 500 thousand in one panicle). The cereal amaranth produces seeds that, according to their characteristics and properties, are similar to cereals. However, since it does not belong to the family of cereals, it is called a pseudo cereal. Among the cereal species, A.

Cruentus L., A. hypochondriacus L., A. Caudatus L. are the most well studied, because they are mainly used in food.

Amaranth seeds contain on average 15 – 17 % of protein, 5 – 8 % of oil and 3.7 – 5.7 % of fiber, which is more than most cereals contain (to compare, the corn contains 10 – 12.6 % of protein, 4.6 –

6.7 % of fats, rice contains 8 % of protein and 1.1 % of fats, and wheat contains 9 – 14 % of protein and 1.1 – 3.4 % of fats).

The quality of the amaranth protein is considered to be very high because it contains a considerable amount of the lysine amino acid. Its content in the amaranth is twice higher than in wheat and three times higher than in corn and sorghum, and its quantity can be even compared to that in soy and cow's milk.

The lysine is known to be a valuable essential amino acid, because it cannot be synthesized in animal tissues, and both humans and animals obtain it only from plants. If the ideal protein (close to the egg protein) is taken as 100 points, the content of protein in milk will be 72 points, in soybean – 68 points, in wheat – 58 points, in corn – 44 points, and in amaranth – 75 points.

Results.

An important biological feature of the amaranth is its ecological plasticity demonstrated by good adaptability to various soil and climatic conditions (Chirkova, 1999). Over the recent years, the geography of the amaranth research has considerably expanded in Russia, but this crop is still considered exotic because of the lack of the cultivars adapted to the Russian conditions, a system of seed production and storage based on the awareness about physiological features (Zelenkov et al., 2011).

The accumulation of biologically active substances is known to depend on the growing conditions. Since the amaranth originated in warm zones of the Earth, it has a high adaptive potential, and it is of undoubted interest how the harsh Northern conditions can affect the development biology, content and component composition of the biologically active compounds of these unique plants.

The amaranth seeds are also a source for the production of oil and squalene. Squalene is a hydrocarbon derived from isoprene, a precursor of triterpenes and steroid compounds. Its content in amaranth oil is 8 %. It can be used to produce steroid hormonal drugs, to prevent cancer and cardiac diseases, and for cosmetic purposes. The amaranth oil contains many unsaturated fatty acids as compared to saturated ones, which makes its quality similar to the sea buckthorn oil. In addition, the seeds contain a lot of tocopherol (vitamin E that has an antioxidant effect). Tocopherols can be used, in particular, as a medicine to lower cholesterol in the blood.

The amaranth grain, unlike other cereals, contains very few glutelins. This is important for the nutrition of those people who are hypersensitive to cereals due to their lack of enzymes that hydrolyze glutelin, and therefore need an agluteline diet. The carbohydrate component of seeds' starch causes interest because its granules are very small and convenient for using in aerosols as filler in food products or as a talcum substitute for the production of cosmetics.

Discussion.

The flour made of amaranth seeds that smells like a nut, or cereals can be used as food additives (5 – 20 %) for the production of many dietary products: cereals, bakery, pasta and confectionery products. These products are useful for the patients who suffer from cardiovascular diseases and cancer, for those who work in harmful environmental conditions, as well as for all who want to stay healthy.

The amaranth grain contains four main groups of proteins. Albumins and globulins are dominant. In total, they are up to 75 % of all proteins, and the total ratio of gluten-forming ones (prolamin, glutelin) does not exceed 20 % (3). Low content of glutenin is very important for the nutrition of those who follow a gluten-free diet due to their lack of glutelin hydrolyzing enzymes.

Table 1 shows the content of amino acid in amaranth seeds as compared to other cereals. Table 1. Amino Acids (mg/100 g) in Amaranth Seeds as Compared to Other Cereal Crops (1).

Amino acid	Amaranth	Wheat	Corn	Rice
Isoleucine	4.8 – 6.2	4.0 – 5.7	3.3 – 4.6	3.0 – 3.5
Leucine	7.5 – 9.2	7.6 – 8.9	11.9 – 13.0	5.7 – 6.5
Lysine	7.0 – 9.1	2.9 – 3.7	1.9 – 2.7	2.7 – 3.0
Methionine	5.9 – 7.5	4.2 – 5.3	2.9 – 3.3	2.1 – 2.7
Phenylalanine	9.6 – 12.5	9.0 – 11.5	8.3 – 10.6	6.4 – 7.2
Treanin	4.5 – 5.8	3.2 – 3.8	3.4 – 4.0	2.6 – 3.1
Tryptophan	1.4 – 2.2	1.4 – 1.6	0.5 – 0.7	0.7 – 1.0
Valin	5.7 – 7.2	5.2 – 6.2	4.6 – 5.1	4.3 – 5.2

According to the table, the amaranth protein consists of 28.0 – 35.0 % of essential amino acids, the high content of which is mainly due to phenylalanine, lysine and isoleucine found in it. The amount of lysine in the amaranth is three times higher than in other major cereal crops. It is necessary to emphasize that pulse plants lack such amino acids as lysine and methionine. Their content in amaranth seeds is twice as much.

Lysine is a valuable essential amino acid. Since it cannot be synthesized in animal tissues, a human obtains it only from plants. Lysine is required for the normal growth and development of the body. It is a part of the proteins involved in the synthesis of antibodies, hormones and enzymes, and improves the hair structure.

Threonine is involved in the protein and fat metabolism, the synthesis of collagen and elastin, and is found in the heart, the central nervous system, and skeletal muscles. Valin restores damaged tissues, it is a source of energy, and is involved in the metabolism of nitrogen in the body. Methionine contributes to the digestion process, and protects the body from the radiation.

Leucine stimulates the synthesis of growth hormone, lowers sugar in blood, and restores bones, skin and muscles. Isoleucine is required for the synthesis of hemoglobin, and increases endurance. Phenylalanine helps to improve memory, and has impact on the mood.

Tryptophan has a positive effect on the cardiovascular system, and contributes to the weight normalization. This makes it possible to state that the amaranth seed protein is the most balanced, and therefore more nutritious than the protein of other crops, which allows using the amaranth in the food that has high biological value.

It has also been found that there is no monosaccharide in the amaranth seeds, and the main polysaccharide is sucrose, the amount of which exceeds its content in rye, wheat and millet grains almost twice (Volkova et al., 2017).

Starch is the most common carbohydrate of the amaranth seed. It has been found that its content is from 4.8 % to 6.9 % depending on the type of the amaranth (Volkova et al., 2017). The amaranth starch is referred to as a waxy type of starch. The high content of amylopectin and extremely small sizes of starch granules give it such useful and unique properties as high gelatinization temperature (62 – 76 C), high amylographic viscosity, increased water retention capacity, and stability of gels when freezing and unfreezing. Due to this, the amaranth starch is more preferable as filler in the production of sausages to be frozen and later unfrozen (Shmalko et al., 2009).

The amaranth seeds are rich in vitamins B1, B2, PP, E, and carotenoids, the amount of which is 20 – 60 % higher than that in the grain of traditional cereals. Besides, the amaranth seeds are rich in calcium, iron, phosphorus, magnesium, zinc, copper, sodium and potassium. The proportion of calcium and phosphorus is 1:2, which is physiologically beneficial for the human body (Volkova et al., 2017).

It is promising to use raw materials for bread making – the amaranth protein semi-skimmed flour obtained from the amaranth semi-skimmed grain, a secondary product in the production of the amaranth oil (Kliuchkin, 1997, Shmalko et al., 2009).

The amaranth flour has a valuable chemical composition. Thus, the content of proteins in the amaranth flour is 3.8 times higher than that in the wheat flour, of lipids – 9.4 times, of fiber – 17 times, of ash – 8.8 times, of mineral substances: sodium – 24 times, potassium – 4.2 times, calcium

– 19 times, magnesium – 6 times, phosphorus – 6 times, iron – 36 times, of vitamins: thiamine – 33 times, riboflavin – 74 times, and niacin – 1.2 times.

The energy value of the amaranth flour is somehow higher than that of the wheat flour due to the higher content of proteins and lipids. The biological value of the amaranth flour has been studied by experimentally determining the amino acid composition of the protein and calculating the amino acid score of essential amino acids (Shmalko et al., 2009). Table 2 shows the results of the study.

Table 2. Biological Value of Amaranth Flour.

Amino acids	Wheat flour, first quality		Amaranth flour, protein semi-skimmed	
	g/100 g of protein	% as to protein	g/100 g of protein	% as to protein
Isoleucine	0.530	5.08	1.659	4.4
Leucine	0.813	7.79	2.279	6.05
Lysine	0.265	2.54	3.692	9.8
Methionine + cystine	0.400	3.87	1.522	4.04
Phenylalanine + Tyrosine	0.880	8.42	3.319	8.81
Alanine	0.359	3.44	0.641	1.7
Arginine	0.500	4.79	3.767	10.00
Histidine	0.220	2.10	0.712	1.89
Glycine	0.384	3.68	3.386	9.00
Serine	0.454	4.35	2.615	6.94
Amino acids, total	10.434	100	37.668	100

The amino acid score for protein of the amaranth flour by valine is 112.8 %, by leucine – 86.4 %, by isoleucine – 110.0 %, by lysine – 178.2 % (such indicator for the wheat flour does not exceed 57 %), by methionine+cystine – 115.5 %, by threonine – 127.2 %, by phenyl-lanine+tyrosine – 146.9 %, and by tryptophan – 287.2 %.

The use of the amaranth flour is promising to improve the quality of the bread flour, activate (biologically adapt) yeast cake, intensify the dough preparation, and improve the quality, nutritional and biological value of the wheat bread.

CONCLUSIONS.

Now it is vitally important to cultivate amaranth and use its products in food as feed and medicine. It is necessary to pay serious attention to the ecological importance of this crop not only as a source of dietary and environmentally friendly products, but also due to its possibility to clean and refine the soil.

The amaranth has a high adaptation potential, and is of particular importance now when the ecological situation on Earth has considerably deteriorated due to the anthropogenic human activity.

References.

1. Chirkova, T.V. (1999). Amarant – kultura XXI veka [Amaranth – the culture of the 21st century].
Sorov Educational Journal, 10, 22-27.
2. Kliuchkin, V.V. (1997). Osnovnye napravleniya pererabotki i ispolzovaniya pishchevyh produktov iz semyan lyupina i amaranta [Main areas of processing and using food made of lupine and amaranth seeds]. Storage and Processing of Agricultural Raw Materials, 9, 30-33.
3. Shmalko, N.A., Drozdovskaya, N.A., Chalova, I.A., & Romashko, N.L. (2009). Perspektivy ispolzovaniya amarantovoy belkovoy muki v khlebopechenii [Prospects of using amaranth protein flour in breadmaking]. Methods and Technology of Food Production, 1. Retrieved from: http://fptt.ru/stories/archive/12/1.pdf
4. Volkova, G.A., Shirshov, T.I., Beshley, I.V., Matistov, N.V., & Ufimtsev, K.G. (2017). Amarant: khimicheskiy sostavi perspektivy introduktsii na Severe [Amaranth: chemical composition of the prospects of introduction in the North]. News of the Komi Scientific Center, Ural Branch of the Russian Academy of Sciences, 3(31), 15-23.
5. Zelenkov, V.N., Gulshina, V.A., & Lapin, A.A. (2011). Amarant. Biohimicheskiy i khimicheskiy portret v ontogeneze [Amaranth. Biochemical and chemical portrait in ontogenesis]. Russian Academic Sciences. Department of Physical and Chemical Biology and Innovation, Moscow.