The revival of Amaranth as a third-millennium food

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Abstract

The article deals with the importance and advantages of the amaranth plant – a genus of herbs of the family Amarantaceae. Amaranth, highly nutritional pseudocereal and traditional american crop has good food potential value. Amaranth grain doesn´t contain gluten. The high content of quality protein and unsaturated fatty acids is one of its advantages. It is also a carrier of a very valuable fibre and good source of squalene.

REVIEW ARTICLE

PLANT CHARACTERISTICS

Amaranth is one of the oldest cultivated plants. In the past the Aztecs and the Incas grew cultivated forms of some varieties and called these plants the "holy grain" or "immortal". They grew it as their basic food, and it was also a sacred plant used in ritual ceremonies. Nowadays amaranth is called the third-milennium plant because of its high nutritional value and undemanding cultivation.

The high nutritional value of the seeds, the great variability of the genus and the adaptibility to the cultivation conditions contributed to the revival and spread of this plant (Nepal, Tibet, China, India, the U.S.A., Russia and Europe). About 100 genera of the Amaranth genus have spread from the tropics to mild zones all around the world. Amaranth is considered to be one of the false grain crops. It is a one year broad-leafed plant with a panicle inflorescence. It contains a lot of small seeds. The white seed varieties of amaranth (the seeds are white or yellow-beige, their size is about 1–1.5 mm) are used for food purposes.

NUTRITIONAL PARAMETERS OF AMARANTH

The protein is of an unusually high quality when compared to true cereals. The quality of protein in food is connected with its biological value determined by the amount and ratio of essential amino acids (Table 5). Biologically complete proteins contain all essential amino acids in the required amount and reciprocal ratio. Biologically incomplete proteins either don´t contain all the essential amino acids, or they contain them, but in the nutritionally unfavorable ratio. The amino acid missing in protein is called "limitative" amino acid, and its absence makes the utilization of appropriate protein impossible. The seeds of Amaranth are a good source of protein and contain in one grain 16% of the quality protein with all the essential amino acids (leucine, isoleucine, valine, methionine, phenylalanine,lysine, threonine, tryptophane). The content of protein in amaranth is higher in comparison with common grain crops and the composition of these proteins is more bal-

anced as concerns the essential amino acids (Correa *et al.* 1986; Morales *et al.* 2005). Most fruits and vegetables do not contain a complete set of amino acids, and thus different sources of protein must be used.

A big advantage of amaranth is the high content of lysine which is indispensable for the human organism and which the organism cannot create itself. Compared to other grains, amaranth is unusually rich in this essential amino acid, an amino acid that is low or limited in other grains or plant sources. So, because of its lysine and tryptophane content, amaranth is comparable with other animal proteins (Correa *et al.* 1986).

Another important advantage of amaranth is the fact that its proteins do not contain gluten, which is otherwise a part of grain crop proteins – wheat, rye, oats and barley. Some patients have to be on a gluten-free diet for their whole lives and the amaranth products are especially good for them. Amaranth may be a promising source of protein to those who are gluten sensitive. Gluten-free amaranth flour can fully substitute the normal flour when baking. A gluten-free diet is also suitable for patients with food allergies because amaranth comes from a far-off geographical region. Therefore there is only a small risk that the patients will react negatively to it (Alvarez *et al.* 2009; Saturni *et al.* 2010).

The content of sacharides in amaranth is comparable with other cereals, and at the same time it is completely created by polysaccharides, especially by starch (Table 1). Simple saccharides are found only in small amount. The structure of amaranth starch is special because of the small size of starch elements and the low content of amylase (the linear chain of glucose elements). The main part is the ramified amylopectin, from which the glucose elements are gradually released. Glucose is gradually absorbed from the intestine, and so the postprandial fluctuation of the blood sugar level and the elimination of a great amount of the insuline are limited.

A great advantage of amaranth is the presence of valuable fibre (Mustafa *et al.* 2012). A beneficial role of dietary fiber in human nutrition is known and the amaranth grain contains about 7% of fibre, which is more than in wheat, barley, rye, rice and corn (Punna *et al.* 2004).

Fats are concentrated in amaranth grain sprouts. In light seed varieties the grain contains approximately 7% fat, in dark seeds the fat content is greater. High quality amaranth oil with a large volume of unsaturated fatty acids is made by extraction from the amaranth grains.

Tab. 1. Amaranth grain, basic nutrient values.

Nutrient	Unit	Value per 100 g
Water	g	11.29
Energy	kcal	371
Energy	kJ	1554
Protein	g	13.56
Total lipid	g	7.02
Ash	g	2.88
Carbohydrate	g	65.25
Fiber, total dietary	g	6.7
Starch	g	57.27

USDA National Nutrient Database for Standard Reference.
http://ndb.nal.usda.gov/ndb/foods/list

Tab. 2. Amaranth grain, minerals.

Minerals	Unit	Value per 100g
Calcium	mg	159
Iron	mg	7.61
Magnesium	mg	248
Phosphorus	mg	557
Potassium	mg	508
Sodium	mg	4
Zinc	mg	2.87
Copper	mg	0.525
Manganese	mg	3.333
Selenium	µg	18.7

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Tab. 3. Amaranth grain, vitamins.

Vitamins	Unit	Value per 100 g
Vtamin C	mg	4.2
Thiamin	mg	0.116
Riboflavin	mg	0.2
Niacin	mg	0.923
Pantothenic Acid	mg	1.457
Vitamin B-6	mg	0.591
Folate, total	µg	82
Folic acid	µg	0
Choline, total	mg	69.8
Vitamin B-12	µg	0
Vitamin A	µg	0
Lycopene	µg	0
Vitamin E, alpha-tocopherol	mg	1.19
Vitamin D	µg	0
Vitamin K	µg	0

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The main element is linoleic acid which the human organism is not able to produce and which is necessary for its existence. Amaranth grain contains tocotrienols and squalene compounds, which are known to affect cholesterol biosynthesis (Rodas & Bressani 2009).

Squalene is a substance of the isoprenoid type which is a precursor in the synthesis of steroids and important anti-oxidizing substances such as vitamin Q 10 (ubiquinone). Squalene itself has (similarly to vitamin Q 10) favourable anti-oxidizing properties – thus it protects a number of body structures against oxidative damage (Reddy & Couvreur 2009; Waterman & Lockwood 2007; Temple 2000). The chemical synthesis of squalene is complicated. The largest source of squalene is shark liver and, as far as plants are concerned, amaranth (He *et al.* 2002; Caselato & Amaya 2012; Escudero *et al.* 1999).

Tab. 4. Amaranth grain, lipids.

Lipids	Unit	Value per 100 g
Fatty acids, total saturated	g	1.459
Fatty acids, total monounsatureated	g	1.685
Fatty acids, total polyunsaturated	g	2.778
Cholesterol	mg	0
Phytosterols	mg	24

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Tab. 5. Amaranth grain, amino acids (essential amino acids*).

Amino Acids|	Unit	Value per 100 g
Tryptophan*	g	0.181
Threonin*	g	0.558
Isole ucine*	g	0.582
Leucine*	g	0.879
Lysine*	g	0.747
Methionine*	g	0.226
Cysti ne	g	0.191
Phenylalanine*	g	0.542
Tyrosine	g	0.329
Valine*	g	0.679
Arginine	g	1.06
Histidine	g	0.389
Alanine	g	0.799
Glycine	g	1.636
Proline	g	0.698
Serine	g	1.148

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Amaranth has a relatively large content of mineral substances (Dyner *et al.* 2007; Table 2). In comparison with wheat, oats, rice, corn and soya, amaranth seeds are a better source of calcium, iron and sodium whereas the content of magnesium, phosphorus and zinc is similar (Table 6). It also contains a number of other microelements such as manganese, copper and selenium. Amaranth seeds contain a lot of vitamins (Table 3). In grains the vitamins are mainly concentrated in the sprouts. The content of vitamin B2 (riboflavin), niacin and anti-oxidizing vitamin E (alpha-tocopherol) is important for nutrition, the content of vitamin B1 (thiamine) and vitamin C is lower (Gajewska *et al.* 2002; Negi *et al.* 2003).

THE CLINICAL SIGNIFICANCE OF AMARANTH

The excellent nutritional properties of amaranth offer a large scale of usage both in healthy people, and in patients with a number of various diseases (Chaturvedi *et al.* 1993; Weickert & Pfeiffer 2008; Gnagnarella *et al.* 2008; Van Horn *et al.* 2008).

Amaranth protein application is possible as a component of enteral nutrition, or as an addition to liquid nutrition for improving the protein balance of seriously ill patients. As gluten free, the amaranth bars are also an alternative product for celiacs, also contributing to the enhancement of calcium absorption, a problem frequently observed in these patients.

It can be applied in people suffering from food allergies, in children as well as adults suffering from gluten

Tab. 6. Comparison between Amaranth and other crops, basic nutrients and minerals.

Composition	Amaranth	Wheat	Rice	Potato
Component (per 100g portionn)	Amount	Amount	Amount	Amount
Water (g)	11	11	12 1	82
Energy (kJ)	1554	1506	1527	288
Protein (g)	14	23	7	1.7
Total lipid (g)	7	10	1	0.1
Carbohydrate (g)	65	52	79	16
Fiber (total dietary)	7	13	1	2.4
Iron (mg)	7.6	6.3	0.8	0.5
Magnesium (mg)	248	239	25	21
Calcium (mg)	159	39	28	9
Phosphorus (mg)	557	842	115	62
Potassium (mg)	508	892	115	407
Zinc (mg)	2.9	12.3	1.1	0.3

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enteropathy. Because of the complete structure of essence amino-acids, it is advantageous to apply amaranth protein in vegetarians who otherwise refuse protein with an animal origin for various reasons (Young & Borgonha 1999). In general, amaranth protein is useful in convalescence after serious infectious diseases, after operations, or for making up protein in patients with malnutrition caused for various reasons. In healthy people with increased physical activity (sportsmen or physically demanding work), amaranth is an important source of biologically valuable protein with simultaneous limitation of fat reception from food (Pasko *et al.* 2011).

The advantageous structure of saccharides in amaranth grain, where simple saccharides represent only about 1–2% of the total pool, enables us to use a wide range of treatment in metabolic disorders. Because of the gradual absorption of glucose from the intestine, amaranth starch is suitable for patients with diabetes mellitus type II (Kim *et al.* 2006; Miroshnichenko *et al.* 2009).

Amaranth starch binds water, and thus helps to prevent constipation. The large content of fibre in amaranth grain is of great advantage (King *et al.* 2012). Fibre is an important part of human nutrition. In developed industrial countries, to which the Czech Republic belongs, there is a lack of dietary fibre in food and the content of fibre corresponds to the figures recommended by the WHO (World Health Organisation) (WHO 2004). The putting the population on an amaranth dietary fibre program increases the consumption of dietary fibre and positively affects the health of the individuals (Weickert & Pfeiffer 2008). Fibre is good for preventing constipation, haemorrhoids and colon diverticula development with the possibility of inflammation and perforation. A sufficient fibre intake also preventively affects the development of colon cancer. The fibre decreases cholesterol absorption from the intestine and thus the blood cholesterol level. In this way it preventively affects the development of atherosclerosis and its complications. Cardiovascular disease is the Nation's leading killer for both men and women among all racial and ethnic groups (Graham *et al.* 2007; Wilkins *et al.* 2012). Development and progression of cardiovascular disease is linked to the presence of risk factors such as hyperlipidemia, hypertension, obesity, and diabetes mellitus (Gonor *et al.* 2006). The satiety from the full digestive tube decreases the food intake and thus the energy intake. In this way it prevents redundant energy deposition, obesity development and pathological conditions connected with obesity, e.g. metabolic X-syndrome, ischemic heart disease, diabetes mellitus type II, stroke, hypertension, gout, locomotor apparatus defects, etc.

A high content of unsaturated fatty acids (Table 4) and squalene is characteristic for amaranth fats. The unsaturated fatty acids decrease the cholesterol level, and so they prevent atherosclerosis and its complications ([2]Kim et al 2006). It is known that cholesterol is an indicator of increased risk of heart attack and stroke. The amaranth oil could be of significant benefit for patients with CVD (Cardiovascular disease) (Shin *et al.* 2004).

The hypocholesterolemic effect of amaranth seeds has been described – namely the reduction of serum lipids and triglycerides and the increase of HDL cholesterol levels (Chaturvedi *et al.* 1993; Andrea *et al.* 2002; Punita & Chaturvedi 2000). Squalene is represents in amaranth oil about 5% of the total fat content. It removes the symptoms of chronic fatigue in people living in polluted areas. Squalene also reduces the toxic effects of exhaust fumes in places with heavy traffic. It belongs to important antioxidants – it increases the resistance against radioactivity and X-rays. 0.25–0.50 mg of squalene a day lowers the blood cholesterol level, and thus reduces the risk of atherosclerosis and heart attack (Reddy & Couvreur 2009; Ortega 2006).

SUMMARY

From scientific knowledge and experience it is obvious that amaranth seeds surpass traditional cereals in a number of nutritional values, and in food they can provide a good supplement to them. It is a reasonably well-balanced food with functional properties that have been shown to provide medicinal benefits. Thanks to its properties, amaranth gives us a wide range of possibilities for using it in human nutrition, including active health support. It can be applied when we need more easily digestible quality proteins, e.g. in children, sportsmen and elderly people.

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