

Amaranth - A Functional Food

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Abstract

Amaranthus, collectively known as amaranth or pigweed, is a cosmopolitan genus of herbs. Approximately 60 species are presently recognized, with inflorescences and foliage ranging from purple and red to gold. Because of recent concerns about global food security and malnutrition scientists all over the world are engaged in exploring the plant biodiversity to broaden the crop list. Due to described agricultural advantages, unique nutritional properties and versatile usage, grain amaranth (*Amaranthus spp.*) has gained increased attention. Amaranth seeds have a high content of storage proteins (14-19%) whose amino acid composition is rich in lysine and methionine, two limiting amino acids in cereals and legumes, respectively. Amaranth (*Amaranthuscaudatus*), quinoa (*Chenopodium quinoa*) and ka~niwa (*Chenopodiumpallidicaule*) are originally from the Andes of South America where they have remained a staple since Pre-Hispanic times. Due to its good protein quality which is comparable to casein, high fibre content and bioactive compounds, and these gluten-free grains are formidable food alternatives for celiac patients and/or those suffering from gluten-sensitivity.

Keywords: Grain Amaranth; Nutrition Value; Utilization

Introduction

Amaranthus is recognized as a promising plant genus that may provide high-quality protein, unsaturated oil, and various other valuable constituents. Amaranths are valued as leaf vegetables and cereals. It is noted not only for its environmental hardiness but also for the excellent nutritional quality of its seeds (Bejosano, [1]). Due to its unique nutritional properties and versatile usage, grain amaranth (*Amaranthus spp.*) has gained increased attention. Amaranthus, collectively known as amaranth or pigweed, is a cosmopolitan genus of herbs. Approximately 60 species are presently recognized, with inflorescences and foliage ranging from purple and red to gold. Most species are considered as opportunistic weeds and only three of them, *Amaranthuscaudatus*, *Amaranthuscruentus* and *Amaranthushypochondriacus*, are commonly consumed by humans as a seed or used as a functional ingredient in foods (Gamel). Amaranth is a pseudocereal because of its flavor and cooking similarities to grains. The word "Amaranth" comes from the Greek *amarantos*, the 'one that does not wither' or the never-fading flower. It contains high content of fibre and bioactive compounds Repo-Carrasco [2], these gluten-free grains are formidable food alternatives for celiac

patients and/or those suffering from gluten-sensitivity. It also provides a good source of dietary fiber and dietary minerals such as iron, magnesium, phosphorus, copper, and especially manganese. Amaranth was recognized as gluten-free and is therefore suitable for diets of celiac disease patients (Fasano and Catassi [3]; Thompson [4]). The seeds are eaten as a cereal grain. They are ground into flour, popped like popcorn, cooked into porridge, and made into a confectionery called alegría. The leaves can be cooked like spinach, and the seeds can be germinated into nutritious sprouts. The leaves are variable in size, green or purple, with slender stalks. These are alternate, usually simple, with entire margins and distinct markings, depending on species. Amaranth species are also cultivated and consumed as a leaf vegetable in many parts of the world. In India the leaf is added in preparation of a popular dal called *thotakurappu*. In China the leaves and stems are used as a stir-fry vegetable. In East Africa amaranth leaf is known as *mchicha*- "a vegetable for all". The seeds are used as a source of lipids and a material for the production of flour, flakes, popped seeds, several sorts of bread (Januszewska-Jóźwiak and Synowiecki, [5]) and confectionery Sindhuja [6].

Chemical Composition and Nutrition Value

The small seeds are usually shiny black in colour, in contrast to those of grain types which are cream-coloured. There are up to 3 000 seeds per gram. The tiny, lens shaped seeds are usually pale in colour. A seed of grain amaranth is on average composed of 13.1 to 21.0% of crude protein; 5.6 to 10.9 % of crude fat; 48 to 69% of starch; 3.1 to 5.0% (14.2 %) of dietary fibre and 2.5 to 4.4 % of ash Grobelnik [7]. Enzyme inhibitors and allergens are known to be present in cereals. Protein isolated from wheat, rice, maize and barley may cause allergic reaction, a gliadin fraction isolated from wheat causes celiac disease. But these components are not available in pseudocereals and legumes such as soybean and amaranths Kuhn [8]. Furthermore, amaranths contain dietary fibre in high proportion, which improves lipid metabolism. Its nutritional value is mainly due to its protein fraction (Gorinstein [9] Oleszek [10]). Amaranth, a pseudocereal, is an unconventional and interesting source of proteins. Its seeds contain a large amount (14-17%, w/w) of high nutritional quality proteins (Bolontrade [11]), whose amino acid composition is rich in lysine and methionine, two limiting amino acids in cereals and legumes, respectively [4,5]. Amaranth's balanced amino acid composition is close to the optimum protein reference pattern in the human diet according to FAO/WHO requirements. Protein is high in amino acid lysine but low in leucine. This is the opposite of most other grains. Thus mixing would form an almost perfect protein (Good ratio of unsaturated fat to saturated fat that is beneficial for hypertension and coronary heart disease). The nutritional quality of amaranth seed is high because of its high protein content and balanced essential amino acid composition (Oszvald [12]). Moreover, amaranth grain protein is rich in lysine, which is usually deficient in cereal grains. Proteins have high digestibility (approx. 90%) and are rich with lysine (4.9 to 6.1g/100 g protein) which usually appears in grains as a limiting amino acid. This high lysine concentration is complemented with elevated levels of sulphur amino acid content (2 to 5%), which is higher than that measured in the most important legumes (1.4% on average), such as peas, beans and soybeans (Gorinstein and Moshe,

[13]). Leucine, isoleucine, valine, the limiting amino acids in amaranth, are not considered a serious problem since they are found in excess in most common grains, and therefore, amaranth is well suited for blending with cereals. The main protein fractions present in the amaranth grain are albumins, 11S-globulin, P-globulin, and glutelins .

Amaranth starch is of promising use. The features of starch like high solubility and digestibility are due to its uniquely small size which is about one-tenth the size of cornstarch and therefore offer new possibilities for food processing, pharmacology and cosmetics Resio [14]. The total mineral content has been reported to be generally higher than that observed in cereal grains, especially calcium and magnesium Alvarez-Jubete [15]. On the other hand, it is characterized by higher dietary fibre and lipid content than most cereals and also contains between 50 and 60g of starch per 100 g of grains Alvarez-Jubete [15]. Amaranth has recently become a focus of interest for its high nutritive values and great potential as a functional food given its cholesterol-lowering effect observed in animal models Mendonça [16]; Plate & Arêas [17]. According to Becker [18] seed of grain amaranth is a rich source of iron (72 to 174mg/kg), calcium (1,300 to 2,850mg/kg), sodium (160 to 480mg/kg), magnesium (2,300 to 3,360mg/kg) and zinc (36.2 to 40mg/kg) as well as vitamin riboflavin (0.19 to 0.23mg/100g of flour) ascorbic acid (4.5mg/100g), niacin (1.17 to 1.45mg/100g), and thiamine (0.07 to 0.1mg/100g). Amaranth oil is reported to have high levels of tocotrienols and squalene, which are natural organic compounds that are involved in the metabolism of cholesterol and that could play an important role in lowering LDL-cholesterol in blood. Amaranth lipid is unique with high squalene content ranging from 2.4 to 8.0% of the total oil contents (Rodas and Bressani, [19]). A comparative account of nutritive value of grain amaranths and other cereals is presented in Table 1. On the average pale-seeded amaranths contain 8% of dietary fibre and black coloured 16% with soluble fibre rate of 30 to 40% and 18 %, respectively (Schnetzler and Breene [20], Tosi [21] reported 14.2% of dietary fibre in the *A. cruentus* flour (8.1% soluble, 6.1% insoluble).

Table 1: Comparative account of nutritive value of grain amaranths and other cereals.

Sr. No.	Crops	Protein	Fat	Carbohydrates	Calcium	Iron	Phosphorus	Food energy (Kcal/g)
1	Amaranth	16.0	3.1	60.0	0.49	17.5	0.60	391
2	Rye	12.1	1.7	73.4	0.38	10.5	0.37	334
3	Buckwheat	11.7	2.4	72.9	0.12	15.5	0.28	335
4	Chenopod	12.0	5.0	68.0	0.20	12.6	0.50	342
5	Wheat	13.3	2.0	71.0	0.41	10.5	0.37	333
6	Maize	9.2	3.9	73.7	0.20	3.50	0.25	355
7	Rice	7.0	1.0	78.0	0.20	3.50	0.18	345

Health Benefits

Amaranth leaves are a good source of energy in the body since the crude protein content in the leaves ranges is very high i.e.20

to 32%, on a dry weight basis. Amaranth leaves are a good source of elements like manganese, iron, copper, calcium, magnesium, potassium and phosphorus necessary to maintain adequate electrolyte balance in the body. People suffering from gluten

intolerance or those suffering from celiac diseases can get daily recommended dose of protein from amaranth greens. Compared to other plant sources, such as wheat and rice amaranths are gluten-free and contain 30% more protein with complete set of amino acids. It can improve the digestive system and reduce constipation due to the high content of dietary fibre which is three times that of wheat. The protein in the leaves helps to reduce insulin levels in the blood and also releases a hormone that lessens hunger pangs and prevent over eating. One of the key health benefits of vegetable amaranth leaves is their cholesterol-lowering capacity. Due to the high fibre content, this leafy vegetable is effective in reducing LDL levels in the blood and promotes weight loss. Tocotrienols, a type of vitamin E available in vegetable amaranths, also contributes to its cholesterol lowering ability. Iron-rich (five times that of wheat) red amaranth leaves promote coagulation and increase haemoglobin content and red blood cell counts. It is also an excellent source of folic acid which is necessary to increase the blood haemoglobin level. Amaranth leaves are excellent dietary source of phytosterols that lowers blood pressure and prevents heart ailments including stroke. The presence of lysine (an essential amino acid) along with vitamin E, iron, magnesium, phosphorus, potassium and vitamin C helps to fight against free radicals responsible for ageing and formation of malignant cells which helps in fighting against cancer. The high calcium present in amaranth leaves (two times that of milk) is helpful to reduce risk of osteoporosis and other calcium deficiency-related disorders. Amaranth leaves are excellent source of β -carotene. Inclusion of amaranth leaves in the daily diet can help to prevent vitamin A deficiency. It was reported that the incidence of blindness in children due to malnutrition has been reduced with the consumption of 50-100 g of amaranth leaves per day Das [22].

Bioactive Components and Medicinal Properties

The health benefits of amaranths have always been recognised in homoeopathic and Ayurvedic medicines. Both the seeds and leaves of amaranth are used as herbal remedies and have nutraceutical value. Amaranth protein contains a low proportion of prolamins which makes it a safe ingredient for people with celiac disease and recent studies have shown that amaranth peptides displayed antihypertensive and anti-inflammatory activity. Peptides contained in amaranth seed proteins have shown various biological activities. Some studies using amaranth flour and protein isolates reported the occurrence of peptides with biological activities such as anti-hypertensive, anti-oxidant, anti thrombotic, anti-proliferative among others. Amaranth is ranked as one of the top five vegetables in antioxidant capacities Walter [23]). It contains ample amount of bioactive components, such as L-ascorbic acid, betacarotene, polyphenol, anthocyanins and lutein Walter [23]. It has been used as an antipyretic to reduce labour pain in Indian and Nepalese traditional medicine, as astringent, diuretic, haemorrhage and hepatoprotective agent (Kirtikar and Basu [24]. Amaranths have also been used to treat bladder distress, piles, toothache, blood disorders and dysentery (Madhav [25]. The

health beneficial antioxidant activities are related to their bioactive components. The cholesterol-lowering effects in amaranth may be due to unsaturated fatty acids. Being a good source of magnesium which is effective to relax blood vessels and prevent constriction and rebound dilation, it helps to fight migraines. Cooking had no deleterious effect on total bioactive component except for the reduction of anthocyanins content. Home cooking increases the antioxidant activities and the contents of arytenoids, especially by steaming. Both simmering and blanching increased the betacarotene and lutein in the cooked amaranth (Han and Xu [26].

Food Uses of Amaranth

Vegetable amaranths are widely consumed as leafy vegetables in India and other Asian and Southeast Asian countries, also in African countries where as in North and South America grain amaranths are widely consumed. Amaranth leaves are a good source of high amount of protein, vitamins, minerals and dietary fibre. Chopped plants can also be used as forage for livestock. Amaranth seed oil has been reported to contain large amount (7-8% and 11%) of squalene which is often used in cosmetics and medicine, where olive oil contains only 1% of squalene. Amaranth oil is also a rich source of tocotrienols which is very effective to lower the LDL cholesterol (Becker [27] Plate and Areas [17]. In India A. hypochondriacus is known as the 'king grain' and is often popped to be used in confections. Amaranth grain may be processed in various ways, like grains can be popped, flaked, extruded and ground into flour. Popped amaranth can be enjoyed on its own or can be served with milk or soymilk and fruit for a healthy breakfast. Amaranth can be used as a substitute in porridge, stirred into soups; Amaranth grains can be cooked whole in a pot, rice cooker or pressure cooker to prepare breakfast porridge or savory 'polenta'. The grain flour or flaked grains are combined with wheat or other flours to make cereals, cookies, bread and other baked goods. As per general recommendation, amaranth grain flour should contribute only 10-20% of the mixed flour blended with wheat flour. But it has been shown that amaranth grain flour blended up to 50-75% of the mixed flour, it will still retain functional properties as well as flavour.

Processing

Amaranth is cleaned with screens, by winnowing, with a fan or other blowing device. After harvesting, it is important to further dry the crop to ensure it won't spoil during storage. It can be left on trays in the hot sun or placed near an indoor heat source. Amaranth has no hulls to remove unlike beans or true grains, Amaranth is relatively a small sized grain with average diameter of about 1mm. The embryo part accounts for about 25% of the kernel and situated in the peripheral region. The kernel consists of storage tissue or per sperm and the endosperm part is present as a two layered tissue Coimbra and Salema [28]. The seed coat of the amaranth grain is smooth and thin. Amaranth seed contains 26% of bran and germ components and 74% of flour. The nutrients are not uniformly

distributed throughout the grain like other cereals. Nutrients are concentrated in bran and germ fractions of the grain. The amaranth grain can be toasted, popped, extruded or milled into flour and can therefore be consumed as such or included in other cereal products such as bread, cakes, muffins, pancakes, cookies, dumplings, crepes, noodles and crackers [29-84].

Conclusion

Amaranths especially the grain amaranths are considered as the golden crop of future. Much of the research activities done on amaranths has focussed on its exceptional nutritive value. The health benefits of amaranths have been recognized in homoeopathic and Ayurvedic medicines. Both the seeds and leaves of amaranth are used as herbal remedies and have nutraceutical value.

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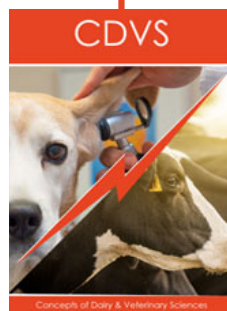
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