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A review on nutrition value of Amaranth (*Amaranthus caudatus* L.): The crop of future

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Abstract
From the past 20 years, little progress has been achieved in reducing child malnutrition food insecurity and hunger. To address these problems, increased consumption of leafy vegetables is promoted as sources of both bio-active compounds and micronutrients. Amranthus is one of the crop, which has been rediscovered as a promising food crop in form of leaf and seed, mainly due to its resistance to drought, heat, diseases and pests, and the high nutritional value of both seeds and leaves. The seeds are small and lent cellular or oval in shape. The grain is high in fibre and low in saturated fats, factors which contribute to its use by the health food market. The oils obtained from amaranth are important because they contain oleic, linoleic and linolenic fatty acids. The lipid fraction of amaranth also contains compounds with antioxidant potentials, such as tocopherols, which act as scavengers of lipid peroxyl radicals. It also contains several classes of flavonoids and anthocyanins, as well as other phenolic constituents. It is high in protein content which contains essential amino acids that are good for human nutrition. It contains a high level of lysine and sulphur-containing amino acids like cysteine. Amaranth has become popular among patients with celiac disease because it does not cause allergic reactions in the intestinal mucosa. Quantification of bio-active compounds of Amaranthus seed oils like squalene, β-sitosterol and α-tocopherol will help enhance its use for human consumption as a nutraceutical. Leaves and succulent stem are good sources of iron, calcium, vitamin A and vitamin C. In view of the enormous nutritional benefits of the crop, there is a definite need for its genetic improvement to develop high yielding varieties with high content of desired quality traits.

Keywords: Amaranth, quality traits, lysine, squalene, bio-active, phenolic

Introduction
In the world child malnutrition, food insecurity and hunger is a big problem. Lack of essential nutrients is spread mainly among children and women and due to which global disease burden of children increases by limiting proper cognitive development, impairing physical development, and increasing susceptibility to infectious diseases. So, In order to overcome these problems increased consumption of seeds and leafy vegetables is very good, as these are considered sources of many vital micronutrients, macronutrients and bio-active compounds. Farming communities and other peoples living in Uttarakhand hills depends heavily on available resources, climate and geographic conditions for food and nutritional security. The climate of Himalayan region having a wide ranges and hence suitable for cultivation of economical and nutritive crops like Grain Amaranthus, Foxtail Millet, Finger Millet, Buck-Wheat, Rice Bran, Barnyard Millet etc. These crops are underutilized but are commercially important. One can get food products with enhanced nutritional value by using them [1]. It is mainly due to its resistance to drought, heat, diseases and pests. As Amaranthus exhibit C4 photosynthesis pathway it can tolerate a large variety of unfavourable conditions, including high salinity, alkalinity, or acidity, making it suited for subsistence agriculture. Amaranthus have high nutritional value in both seeds and leaves [2]. The genus Amaranthus is a valuable food source of nutrients containing high quality proteins, minerals, vitamins and bioactive compounds such as phenolics. It can be consumed as a staple food, additionally both the grain and leaves of vegetable Amaranthus have also been commercially used for natural dyes, skin lubricants and pharmaceuticals. The grains of Amaranthus are gluten-free, and also contain a balanced essential amino acid profile. Both the grain and leafy vegetable portion of Amaranthus plants have many beneficial health effects. The Amaranthus leaves also show anticancer potential by inhibiting the proliferation of liver, breast and colon cancer cell lines [3]. Amranthus is considered as a native of tropical America and its meaning is immortal in Greek. In the Aztec, Mayan, Incan civilizationsit was a staple crop. Now a days, it is cultivated throughout India, China, Nepal, Indonesia, Malaysia, Phillipines; whole of Central America, Mexico; Southern and Eastern Africa. Genus Amaranthus belongs to order Caryophyllales, family Amaranthaceae, sub-family Amaranthoideae.

It have 70 species, out of which 40 are native to the Americas, 17 Amaranthus species are of vegetative types, and 3 are grain types (*A. caudatus, A.cruentus*and and *A. hypochondriacus)* [4].

Plant morphology

Amaranthus is an annual herbaceous plant which is having height of 1-6 feet, leaves are petioled and alternate having a length of 3-6 inches, vary in colours and rough, ovate, hairy or rhombic with wavy margins. The flowers are small, with greenish or red terminal panicles. Taproot is long, fleshy red or pink. The seeds are small and lent cellular or oval in shape. The colour of seeds may vary from white, red to black [5]. Amaranthus is a non-grass cereal-like (pseudo cereal) dicotyledonous plant. The leaves and grains both of Amaranthus are used as staple food in major/minor form [6]. Pollination in Amaranthus is either by wind or by insects, many of the species are monoecious, some are dioecious. The inflorescence can be drooping erect, rope-like, or inconspicuous in the leaf axil. Amaranthus has numerous utilities, and based on them it is also known as super grain, miracle grain, and grain of future [7]. Amaranthus leaf and stalk have a wide variety of colours that varies from red to green, and the colour of seed ranges from black to white. Highly pigmented vegetables like Amaranthus usually have higher nutritional value as compared to other species of the same plant. The colour of most Amaranthus plants is bright red-violet, and battalions are generally considered to be responsible for the maroon pigment [3].

Nutritional value

In hills, the leaves of Amaranthus are used in form of vegetable or saag, and ripen seeds are used in form of very nutritious pseudo cereal with very high amount of protein as compared to the true cereals. High fibre and low saturated fat makes grain Amaranthus popular in the health food market. As per the information of national research project, in India, grain Amaranthus is recognized as a major crop to produce highly nutritive food and feed. Amaranthus is considered to be new millennium crops of nutraceutical value [8]. The seeds have high protein content having essential amino acids mainly methionine and lysine; it also contain significant levels of squalene, which is an important precursor for all steroids [9].

Element analysis of Amaranthus in mg/100 g (DW) reported that the leaves contained potassium (54.20), sodium (7.43), calcium (44.15), Iron (13.58), Magnesium (231.22), Zinc (3.80) and phosphorus (34.91). The Amaranthus leaves having high amount of bio-available iron [10]. The vitamin content of the leaves in mg/100 g (DW) was -carotene (3.29), thiamine (2.75), pyridoxine (2.33), riboflavin (4.24), niacin (1.54), ascorbic acids (25.40) and tocopherol (0.50). Amaranthus contain 17.5 – 38.3 % protein, which consists of 5 % lysine and sulphur-containing amino acids (lacking in cereals and tubers) and many other amino acids are also present in considerable amount [11]. Seventeen amino acids (isoleucine, leucine, lysine, cysteine, phenylalmine, tyrosine, threonine, methionine, valine, alanine, arginine, glutamic acid, aspartic acid, glycine, histidine, proline and serine) were detected in Amaranthus. Lysine content is much higher than maize (3-3.5 times) and wheat (2-2.5 times) [12]. Biological value of Amaranthus protein is 75 and blending of Amaranthus with corn flour almost reaches the biological value 100 [13]. Amaranthus protein is highly digestive (approx. 90 %). Amaranthus protein is gluten free and is therefore suitable for celiac disease patients [14].

Average oil content of Amaranthus varies between 11 to 14%. The oils obtained from Amaranthus have a high saponification value (130-190) and the iodine value (100-113). The unsaponifiable matter present is (5-7%) that is of great importance. The major 5 fatty acids present in Amaranthus were: Oleic acid (26.5-31%), palmitic acid (14-20%), stearic acid (2-3.5%); linoleic acid (32-41%) and docosahexaenoic acid (DHA) (7-21%) [15].

Polyphenols and antioxidant properties

Three polyphenols viz. rutin, isoquercitrin, and nicotiflorin were isolated in Amaranthus. Rutin was present in higher concentration (10.1 mg/g flour) in seed flour. Eleven phenolic compounds (gallic acid, protocatechuic acid, chlorogenic acid, gentistic acid, 2,4-dihydroxybenzoic acid, ferulic acid, salicylic acid, rutin, ellagic acid, kaempferol-3-rutinoside and quercetin) were recognized in the extracts of different parts of Amaranthus. The total phenolic content (TPC) fluctuated from 1.04 to 14.94 mg GAE/g DW; the total flavonoid content (TFC) fluctuated from 0.27 to 11.40 mg CAE/g DW; while the total betalain content (TBC) fluctuated from 0.07 to 20.93 mg/100 g DW. The Total Phenolics content of 8.45 GAE equivalents (µg GAE/mg sample) was estimated to be 0.85 mg GAE \100 mg extract [16]. Antioxidant activityFree phytochemicals content in crude seeds was 2.32±0.12 while after optimization it increased to 11.26±0.20. Bound phytochemicals content in crude seeds was 3.08±0.12 while after optimization it increased to 10.30±0.21. Total phytochemicals content in crude seeds was 5.40±0.13 while after optimization it increased to 21.56±0.30. Antioxidant activity free phytochemicals content in crude seeds was 0.90±0.06 while after optimization it increased to 7.71±0.13. Bound phytochemicals content in crude seeds was 1.23±0.09 while after optimization it increased to 4.44±0.11 Total phytochemicals content in crude seeds was 2.13±0.12 while after optimization it increased to 12.16±0.23. Total phenolics content in crude seeds was 26.65±1.10, while after optimization it increased to 247.63±2.20. Total flavonoids content in crude seeds was 26.01±0.14 while after optimization it increased to 81.39±1.17 [17].

Medicinal uses

Amaranthus has astringent, appetizing and diuretic properties and is used in the treatment of diarrhoea spelling, dysentery [18], inflammation, gonorrhoea spelling and piles [19]. Whole plant of Amaranthus is used as laxative and the root are regarded as highly specific for colic. Amaranthus leaves and roots are traditionally boiled and given to children as laxative. Amaranthus is also used traditionally as diuretic, anti-snake venom, antipyretic, antidiabetic, antigonorrhea, and antileprotic. The plant sap is used as an eye-wash to treat ophthalmia and convulsions in children. The seeds of Amaranthus or oil are beneficial for those with hypertension and cardiovascular diseases; it also reduces high blood pressure and cholesterol levels, and also helps in subsiding antioxidant level in body and immune system. The leaves of Amaranthus are recommended well for young children, lactating mothers and for patients with constipation, haemorrhage, fever, anemia or kidney complaints. The water of softened plants is used as to treat pains in the limbs. The ash of the stems is used in wound dressing. Heated leaves can be used in tumours. Amaranthus can be used externally to treat inflammations, and internally to treat diuretic problems. The seed of Amaranthus is used as a poultice for broken bones. It is used internally in the treatment of internal

bleeding and excessive menstruation. Root can be used in treatment of gonorrhoea and is also applied as an emmenagogue and antipyretic. Crushed leaves are also considered a good emollient. It is also used for the treatment of snake-bites [2].

Conclusion

Amaranthus is a source of various phytochemicals (rutin, isoquercitrin, nicotiflorins etc.). It having tremendous used in our daily food and industries. These phytochemicals also having various uses in medical field. Amaranthus has therefore a great potential, because it is a sustainable crop that could help in improving household food security and income of farmers. In arid regions where commercial crops such as maize, beans or rice cannot be grown, Amaranthus cultivation could contribute to the first Millennium Development Goal of reducing hunger and poverty. To improve breeding of Amaranthus the research should be strengthened and that requires collection and diffusion of knowledge of many local communities on the value of neglected Amaranthus species. Identification and preservation of germplasm is very important for maintaining genetic diversity and studying genetic material to improve the nutritional quality. Inter-specific and intra-specific hybridisation should be done to improve seed yield, macro and micro-nutrients of cultivated Amaranthus including vitamin A, iron and zinc contents. There should be an effective collaboration between farmers and scientists for proper utilization of Amaranthus crop.

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