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Slender Amaranth: A review on botany, chemistry, pharmacological importance and potential benefits

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Abstract

Slender amaranth *(Amaranthus viridis* L.*)* is an annual herb belonging to the family Amaranthaceae. It has been cultivated throughout the world and used for thousands of years for food flavoring, essential oil applications and also in traditional medicine. Mostly slender amaranth contains saponins, tannins and phenols, flavonoids, alkaloids, cardiac glycoside, steroid and triterpenoids. The extent of each of these chemical constituents varies depending on the types of species or cultivars as well as cultivation conditions such as soil type, weather, irrigation, pruning and other horticulture practices. Slender amaranth is an essential component of several industrial applications that range from food to pharmaceutical products. More uses and applications are continuously added. Further research on maximizing yield per hectare and optimum preservation and oil extraction methods are needed, particularly in the developing world and needs much improvement in harvest processing methods.

Key words: Slender amaranth, triterpenoids, flavonoids, Amaranthus

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1. Botany

1.1. Introduction

Slender amaranth (*Amaranthus viridis* L.) is an annual herb belonging to the family Amaranthaceae. It has been used for thousands of years and has become an essential ingredient in many cooking traditions and practices [1]. The genus *Amaranthus* contains nearly 60 species which are native to tropical and subtropical regions of Asia, North America, Europe and Australia [1-2]. The genus *Amaranthus* has a wide range of varieties and cultivars including *Amaranthus albus* (white pigweed), *Amaranthus arenicola* (sand hill amaranth), *Amaranthus australis* (southern amaranth), *Amaranthus bigelovii* (Bigelow's amaranth), *Amaranthus viridis* L. (Slender amaranth) etc. Among them *Amaranthus viridis* L. is most popular. All cultivars vary from each other depending upon source of origin and environmental conditions. Variability is prevalent in morphology, growth, habit, flower, color, leaves, stems and chemical composition [3]. *Amaranthus viridis* is known by different names depending where you are in the world. It is known as slender amaranth/ wild amaranth (English), Jangali chaulai (Urdu), Marrissag (Bengali), Bledo blanco (Spanish), and Amarante verte (French) [4]. Different species of *Amaranthus* are used as ornamental plants in homes and parks, increasing the plants economic value worldwide [5].

1.2. History

Amaranthus viridis (Slender amaranth) is native to the Caribbean (West Indies), Brazil, found in tropical and sub-tropical regions of the world. It has been cultivated for many years [6]. The generic name, *Amaranthus*, comes from the ancient Greek word that means “the never-fading” or “one that does not wither”.

1.3. Demography/Location

Although *Amaranthus viridis* is grown in a variety of climatic and environmental conditions, the optimum conditions are found in countries with a warm climate. Warmth, light and moisture are the key requirements for its cultivation. It commonly grows in the following countries: Afghanistan, Iran, Jordan, Thailand, Cuba, Brazil, Australia, Pakistan, India, Bangladesh, Sri Lanka, Bhutan, Nepal, China, Iraq, Israel, Kenya, South Africa, Zimbabwe, Sudan, Ghana, USA, Nigeria, Egypt, Turkey, Ghana, and Nigeria.

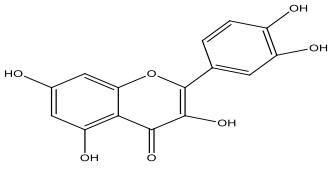
1.4. Botany, Morphology, Ecology

Amaranthus viridis is an annual herb, erect, 10 to 75cm in length; slender, angular and branched. The leaves are glabrous having long petiolate nearly 10 cm. The flowers are green in color and unisexual. They are generally radiating around the stem. The flowers often bear paniculate spikes, 2.5 to 10cm long and 25mm wide. They also possess bracts and bracteoles which are white, pale or reddish. Amaranthus viridis requires warm temperate conditions. The

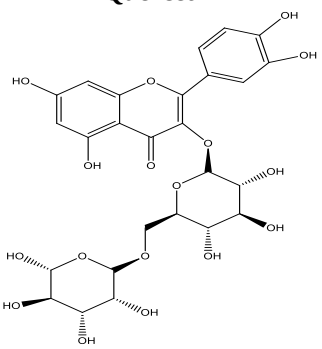
plant can tolerate drought. Optimum temperature for seed germination ranges from 18ºC to 25ºC. The growth stops below 18ºC. The plant develops best in long-day, warm conditions. The plant required well-drained, deeper and fertile soils with a high organic matter content. It grows well in soils with a pH ranging from 4 to 6.

2. Chemistry

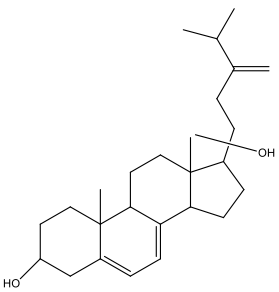
Seeds and leaves of *A. viridis* are highly nutritious. The seeds are rich in protein (14-16%) and fats (4.7- 7%). Leaves contain protein (30-35%), fiber (4-6%). In addition to this, appreciable amounts of vitamin A, riboflavin, vitamin C and niacin are present. The distinctive aroma and fragrance of *A. viridis* is due to the presence of essential oil in leaves and other plant parts. Essential oils are generally characterized by GCMS analysis [7-10]. Major components of essential oil include triterpenoids, saponins, flavonoids, steroid, phenols and tannins. The extent of each of these constituents varies depending on the type of species or cultivators [1-11-13]. Structures of important components are shown in figure 1. Leaf extract (methanolic) showed the presence of quercetin and rutin [14]. Other compounds including spinosterol (24-ethyl-22-dehydrolathosterol), 24-methyl-22-dehydrolathosterol, 24-methyllathosterol, 24-ethyl-22-dehydrocholesterol, and 24-ethyllathosterol were also present. Roots extract showed the presence of amasterol (24- methylene-20-hydroxycholesta- 5,7-dien-3β-ol) [15].



Quercetin



Rutin



Amasterol

Figure 1. Structures of important components of *A. viridis*

3. Postharvest technology

The plants are harvested after 4-8 weeks of sowing. Like other traditional leafy vegetables Amaranthus is highly perishable and likelihood of spoilage increases soon after harvesting. Therefore, it should be transported to shady and cold place within shortest time. Majority of farmers sprinkle chilled water on plants after harvesting for the removal of heat to maintain freshness for the long time. Cleaning is necessary for the removal of dirt particles. Storage temperature should be low. Nutritional value of vegetable is highly affected by postharvest temperatures and very low temperature can cause chilling injury. It has been reported that ascorbic acid content of amaranth declined by 88% when stored at room temperature for four days. However the lowest loss (55%) was observed when stored at 5°C for 23 days. It has been suggested that nutrient loss of vegetable amaranth can be prevented by storing it at 5°C [16].

4. Processing

After harvesting, appropriate processing methods are required to ensure the availability of vegetable throughout the year. Dehydrated plants are subjected to blanching before processing to inhibit the undesirable action of enzymes. Blanched vegetables are then subjected to drying. Warm, dry weather is good for drying purpose. Temperature of vegetables is usually 5 to 15 ˚C during sun drying. The drying time period can be 3-4 days or longer depending upon weather conditions. Drying is economically viable method of preservation, but it leads to loss of water soluble vitamins. However, fat soluble vitamins including β-carotene are well retained in this process. Bioavailability of essential minerals (Zn and Fe) is strongly affected by the presence of anti-nutrients including tannins and phytic acid. Sun drying has been found to significantly lower the contents of these anti-nutrients [16].

5. Value addition

Amaranth is a nutrient rich vegetable, in both cooked and raw forms. Nutrient contents of amaranth are comparable to spinach but much higher than other vegetables including cabbage. Amaranth can tolerate high temperatures and is well adapted to tropical regions but spinach cannot tolerate high temperatures. Saturated fats and sodium contents are low in amaranth while cholesterol is absent. It is a good source of key minerals including P, K, Zn, Mg, Mn, Cu, Ca and Fe. It is also a good source of proteins. Amaranth stems and leaves (raw and cooked) contain high levels of many vitamins including vitamin A (retinol), vitamin B2 (riboflavin), vitamin B3 (niacin), vitamin B9 (folate), and vitamin C (ascorbic acid). Tender stems and leaf are eaten fresh, steamed, fried, boiled and stewed. Seeds are used as flour. Amaranth seeds have high levels of proteins and are very popular in health conscious consumers. Essential oil of amaranth is used in cosmetic industry because of its high antioxidant potential. In India, amaranth grains are mashed with salt, cumin and red chili

after steaming. It can also be used to make curries including Majjigay-hulee and Palya. In Kerala, the amaranth leaves are stir fried and eaten with red chilies and other spices. Amaranth white root (excellent vegetable) is cooked with tamarind or tomato gravy. It is alkaline in nature having milky taste. Leaves of amaranth are stewed with tomatoes, onions or garlic in many regions of the world.

6. Uses

Many herbs and spices contribute significantly to health despite the low amounts of consumption, as they are full of antioxidants and certain mineral compounds. It is not clear that how much quantity of slender amaranth should be used to gain its health benefits. Researchers do not have particular recommendations about the precise amount of use, but it is good source of certain minerals that are beneficial for human health. It adds flavor and taste to the food. Whatsoever is your taste and preference, slender amaranth can be great addition to your kitchen, it adds flavor and personality to different dishes with an added health benefits [17].

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6.1. General uses

Amaranth leaves, stems and whole plant are eaten in raw and cooked form as spinach. Cooking removes harmful compounds including oxalates and nitrates. Amaranth is considered an important nutritious food in regards to cure patients suffering from AIDS, in many regions of the world. On a poor diet, anti-viral medicines do not function properly. Often these drugs become toxic. Amaranth grains in combination with moringa leaves powder provides an excellent nutritious food for the patients of AIDS and makes them able to take anti-viral medicines with no complications. Amaranth ground grains are a common ingredient of noodles, cookies, breads, pan-cakes and other flour based products. The grains can be flaked like oatmeal or popped like popcorns. Essential oil of amaranth contains phytochemicals which prevent various diseases including diabetes, cancer, aging, arteriosclerosis etc. Amaranth can be used: in confections bound with honey or sorghum, in cheese spreads, in salads as a condiment, in breads, and in desserts as topping material. It can also be used as forage, green manure and silage. Fresh leaves of amaranth or their dried powder is used as poultice to cure various infections including inflammations, gonorrhea, haemorrhoids and orchitis. Whole plant infusion is used for blood purification, and roots are used to cure dysentery. In many regions of world, leaf sap of amaranth is used to treat epilepsy and convulsions in children and to cure eye infections. Leaf sap is also effective against heart troubles. Leaves also have febrifugal activities. *Amaranthus viridis* ash is used to make soaps as it is rich in soda [18].

7. Pharmacological Uses

7.1. Antinociceptive and Antipyretic Activities

The alcoholic extract of *Amaranthus viridis* L. was examined for antinociceptive properties using writhing and ethanolic acid induced hot plate test in rats. Yeast induced pyrexia method was used to examine the antipyretic effect of the extract in mice. The extract was administered to both laboratory animals at the doses of 200 and 400 mg/kg body weight, respectively. The statistical analysis showed that alcoholic extract of *Amaranthus viridis* L. had potential ($p<0.01$) antinociceptive and antipyretic activities at 200 and 400 mg/kg [19].

7.2. Antioxidant and antimicrobial Activities

A study was carried out to examine the antioxidant and antimicrobial activities of *A. viridis* L. seed and leaf extracts of *A. viridis* L. Water and pure methanol were used as solvents for the extraction of active components of leaves and seeds. The yield of extracts of active constituents of leaf and seeds using water and methanol solvents ranged from 5.4-6.0% and 2.4-3.7%, respectively. The extracts showed the presence of significant amounts of total phenolics (1.03 to 3.64 GAE, g/100 g) and total flavonoids (18.4 – 5.42 QE, g/100 g) contents and also exhibited potential 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity as revealed by IC_{50} (14.25 - 83.43 µg/ml). In addition to this, the investigated extracts exhibited strong antimicrobial action against selected fungal and bacterial strains. The minimum inhibitory concentration ranged from 179 to 645µg/ml. Antimicrobial and antioxidant potential of seeds extract was greater than leaf extracts [1].

7.3. Hepatoprotective activity

Hepatoprotective potential of methanol extract of *A. viridis* L. was investigated against paracetamol induced hepatotoxicity in wistar rats. Infected animals were treated with methanol extract of *A. viridis* L. at the doses of 0.2 and 0.4 g/kg for 15 days and concentrations of serum glutamate oxaloacetate transaminase, serum glutamate pyruvate transaminase, bilirubin, albumin and total proteins were measured. Methanolic extract of *A. viridis* L. significantly decreased ($P<0.001$) the elevated levels of serum glutamate pyruvate transaminase, serum glutamate oxaloacetate transaminase and bilirubin. In addition to this, albumin and total protein levels were restored [20].

7.4. Antihelminthic activity

In a study, the antihelminthic effects of three plants *Amaranthus spinosus* , *Amaranthus viridis* and *Amaranthus caudatus* were investigated against earthworms. Methanolic extracts of these plants showed dose dependent vermicidal effects at different concentration levels (10, 20, 40, 60, 80, 100 mg/ml) [21].

7.5. Antifungal activity

In a study, antifungal effects of *Amaranthus viridis* extracts (ethanol, ethyl acetate, dichloromethane and hexane) were investigated against various fungal strains. The yields of extracts were 3.6, 3.2, 2.4 and 2.2% (m/m), respectively. Minimum inhibitory concentration (MIC) of all the extracts was determined through dilution method using 96 well microplate. Minimum fungicidal concentration (MFC) was determined using dextrose Sabouraud agar containing plates. All the extracts of *A. viridis* showed potent antifungal activity against *Colletotrichum musae* (causing black spot disease in banana) and *Fusarium solani* (causing fusariosis disease in black pepper. Minimum inhibitory concentration of dichloromethane extract ranged from 15.6-250.0 µg m/l, while that of hexane, ethyl acetate and ethanol extracts ranged from 31.2 to 250.0 µg m/l [22].

7.6. Antihyperlipidimic and antidiabetic activity

Antioxidant, antidiabetic and anti-hyperlipidemic properties of methanol extract of *Amaranthus viridis* were investigated using alloxan induced diabetic rats. Diabetes was induced in albino wistar rats after five days of single intra-peritoneal injection of alloxan (ALX). Methanol extracts of *A. viridis* were administrated orally at the doses of 0.2 and 0.4 g/kg for fifteen days. Blood glucose level was determined on 0, 1, 10 and 15 day, respectively. Low density lipoprotein cholesterol (LDLC), very low density lipoprotein cholesterol (VLDLC), high density lipoprotein cholesterol (HDLC), total proteins, total cholesterol and total glyceraldehydes were determined after 15 days of treatment. Methanol extract of *A. viridis* showed considerable decrease in glucose level of blood and lipid profiles at the doses of 0.2 and 0.4 g/kg. Furthermore, the levels of malondialdehyde, total thiols, catalase and glutathione were enhanced [23].

7.7. Anti-inflammatory activity

An investigation was carried out to study the anti-inflammatory activities of *Amaranthus viridis* L. leaf extracts (aqueous, petroleum ether and alcoholic). Male albino rats were used as animal models for experiment. The anti-inflammatory action of above mentioned extracts was investigated based on their effects on cotton pellet glaucoma and carageenan induced hind paw oedema in animal models. Extracts were orally administrated at concentration levels of 50, 100 and 200mg/kg. Anti-inflammatory activities of extracts were compared with indomethacin (standard drug). Maximum inhibitory action was exhibited by water and ethanol extracts at dose level of 200mg/kg. While, minimum inhibitory action was shown by petroleum ether extract [24].

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