Identification, adaptability, phytochemical and nutritional potential of Slender amaranth: A review

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Abstract- Slender amaranth (*Amaranthus viridis*) has an excellent geographic adaptability to a wide range of environmental conditions such as rapid growth, increased drought tolerance and environmental adaptation, enhanced nutritional value, pleasant taste, a low risk of crop failure, there is adequate opportunity for its widespread cultivation on a broad scale. It is an excellent source of proximate carotenoids, dietary fibre, and beneficial compounds that have a significant role as natural antioxidants, minerals such as calcium, iron, zinc, and magnesium and phytopigments. *A. viridis* has high concentrations of phytochemicals, protein, carbohydrate, ash, fibre, vitamins, minerals with well-documented health and industrial benefits. Essential oils, which include high concentrations of triterpenoids, saponins, flavonoids, steroids, phenols, and tannins have been a presence in antioxidants which prevent from various diseases, have antiallergic, anticancer and antihypertensive. Slender amaranth is used as a wild vegetable. The present article may be useful for further research of interest due to its nutritional values, medicinal properties, rapid growth, adaptability to unfavourable climate and soil conditions, resistance to drought.

Key Words: Adaptability, Essential oils, Nutritional values, Slender amaranth,

I. INTRODUCTION/ BACKGROUND

Slender amaranth *(Amaranthus viridis)* is an annual herb with an upright, light green stem that grows to about 1.5 m in height belong to the family *Amaranthaceae*. *A. viridis* leaves and succulent stems are good sources of protein, dietary fiber, ascorbic acid, methionine, carotenoids, and essential minerals like magnesium, calcium, phosphorus, potassium, iron, copper, zinc, and manganese (Chakrabarty et al., 2018). To determine which components of the extract are biologically active in terms of activity, more research is needed in more detail about in vitro and in vivo investigations. It might be highly economical to isolate components from this easily available plant resource and use them as natural agents. It has various names depending on where you are in the world (Adegbola et al., 2020). Slender amaranth or green amaranth (English), Chowlai (Pakistan), Bledo blanco (Spanish), Marrissag (Bengali), Amarant (Germany), Colites (Philippines), Caruru-de-mancha (Brazil), Aobiyu (Japan), are some of the popular names for Amaranthus viridis (Sogbohossou et al., 2014; Ashraf & Jaffer, 2021). *Amaranthus viridis* is well-known as grain and leaves for food in many parts of the world, including Southeast Asia, Africa, North America, South America and Central America, as well as China and other parts of Central and Eastern Europe (Grundy et al., 2020; Adegbola et al., 2020; Roy et al., 2009). *A. viridis* can be found in nearly any disturbed environment. It can grow in soils ranging from heavy organic to very sandy, as well as mucky soils that have dried out for the season (Khan et al., 2021). The chemical composition of *A. viridis* leaves is excellent, and it has a mild spinach-like flavour, so it belongs in the category of a true leafy vegetable (Obi., 2011). It can either be eaten raw in a salad or cooked with other vegetables, especially potatoes, to make a delicious dish. After dehydrating, they can be used as spices, sauces and also as a major ingredient in soups with other greens and cereals (Mügge et al., 2021; Azi et al., 2018). The purpose of this review is to investigate farmer income, describe A. viridis, and investigate their ultimate nutritional security in order to increase population potential.

II. DEMOGRAPHY ECOLOGICAL SURVIVE

Thomas et al. (2006) examined the effects of environmental factors on the germination of slender amaranth (*Amaranthus viridis*). Under controlled environmental conditions, the germination response of Slender amaranth was evaluated with respect to temperature, solution pH, moisture stress, and depth of emergence. They concluded that the ideal constant temperature for germination was found to be 30 °C. It grows well in soils with a pH ranging from 5 to 8.5. Slender amaranth can be grown in a variety of climatic and environmental conditions, with warm climates providing the best results with respect to growth and yield (Kumar *et* al., 2021). It is commonly found in Afghanistan, Pakistan, Bangladesh, Iran, Jordan, Thailand, Sri Lanka, Bhutan, and Nepal, China, Iraq, Israel, Zimbabwe, Sudan, Ghana, Kenya, South Africa, Cuba, Brazil, Australia, India, the United States of America, and Nigeria. The best growth and yield were noted in all the warm regions of the above countries (Khan et al., 2021). The plant is resistant to drought (Qiu & Liu et al., 2021). The ideal temperature for seed germination is between 18 and 25 °C. The growth of this plant is stopped, when the temperature falls below 18 ^{0C}. (Idris et al., 2020; Mandal & Mondal et al., 2020). The plant grows best in long-day, warm temperatures (Ribeiro et al., 2017). A pH range of 4 to 6 is ideal for its growth (Towolawi et al., 2020; Grandjean et al., 2021).

III. DISTRIBUTION

Amaranthus genus is comprised of both cultivated and wild species. Grain amaranths have been cultivated in Central and South America for more than 8,000 years, even before the Pre-Colombian civilization of Central and South America (Thapa and Blair, 2018). *A. viridiis*, sometimes known as green amaranth, was a popular food in Australia during the nineteenth century (Mofunanya and Owolabi, 2017). Although the introduction of amaranth as human food has been delayed, it is now grown and consumed as a grain or leafy vegetable across FV India, China, Southeast Mexico, Asia, the Andean highlands of South America, and the United States, among other places (Rugeley., 2020; Toader *et al*., 2020). The Nebraska panhandle has become the primary source of grain amaranth production in the United States (Toader *et al*., 2020; de Sanctis *et al*., 2021). *Amaranthus viridis* is grown as a vegetable and grain in many regions across the world, including Africa, Southeast Asia, South and Central America, and China (Grundy *et al.,* 2020; Roy *et al.,*2021). In the early 1980′s, its cultivation and production increased significantly, especially in the developing countries, due to its tolerance to drought and other adverse climatic conditions (Jain., 2021; Kaur *et al*., 2021). *Amaranthus viridis*, popularly known as "tete" among the Yoruba people, is the most widely cultivated of the grain amaranth species and is most widely cultivated in Nigeria (Olawoye and Gbadamosi; 2020). *Amaranthus viridis* is a popular vegetable grown in Nigeria. It is the most consumed specie of weedy amaranths in Nigeria (Ogwu *et al*., 2020). When compared with other cereal plants *Amaranthus viridis* leaves and grains have a high nutritional value, which is one major reason for its increased cultivation in different parts of the world (Aderibigbe *et al*., 2020; Fairbanks., 2021; Ogwu *et al*., 2020). Because of the high concentration of vitamins, proteins, and minerals present in the leaves and stems of *Amaranthus viridis* plants, it is a widely consumed vegetable in Africa and Asia (Noah and Alaba., 2020; Park *et al*., 2020). People in Mexico, Central and South America, and other parts of the world began cultivation and harvesting grain amaranth for at least 50 years after the Spanish arrival (Joshi et al. 2018; Torra et al., 2020). Amaranthus spread throughout Europe, Africa, and Asia during the arrival of the Spanish. In Central and Latin America, the use of amaranth seed also had a long history (Aswal et al., 2016; Vandebroek and Voeks., 2018; Krause-Sakate et al., 2020). According to some reports, the amaranth plant is one of the most widely consumed vegetables in Africa and Asia (Qumbisa *et al* 2020; Emmanuel and Babalola., 2021). *Amaranthus viridis L.* is largely cultivated in Jamaica, Caribbean islands, and parts of Africa on small plots of less than two hectares in size (Atkins., 2020). The local market is highly profitable because vegetable amaranth is traditionally part of the Jamaican diet, where it is known as callaloo, and it is a potential non-traditional export crop with key markets in the United States and Canada. The crop's value to the Jamaican economy increased from $2.3 million to $8.7 million between 1991 and 1995, the amount offered to growers increased 2.5-fold, and the area of land increased 1.6-fold (Aderibigbe *et al*., 2020). Even though *Amaranthus viridis* is a common plant throughout Asia, particularly in Pakistan, where it is consumed as a wild leafy plant but morphological, nutritional and pharmacognostic characteristics, however, are not as well documented (Abbas *et al*., 2020).

IV. TAXONOMY

Despite several research, the taxonomy of the Amaranthus genus is still considered "complex." Many hybrid species, a broad geographic range, and difficult-to-detect diagnostic components confuse the classification (Wolosik & Markowska, 2019). Slender amaranth is classified into the following taxonomic groups by the Centre for Agriculture and Bioscience International (Maruthadurai & Ramesh, 2020; Mureithi et al., 2017):

- Domain (Eukaryota)
- Kingdom (Plantae)
- Phylum (Spermatophyta)
- Subphylum (Angiospermae)
- Class (Dicotyledonae)
- Order (Caryophyllales)
- Family (Amaranthaceae)
- Genus (Amaranthus)
- Species (Amaranthus viridis)

V. MORPHOLOGY AND PHYSIOLOGY

Amaranthus viridis exhibits C4 photosynthesis, allowing it to use CO_2 more efficiently throughout a larger temperature range (25°C to 40°C), at higher light intensities, and under more moisture-stressed conditions (Lara *et al*., 2008; Gill *et al*., 2011). *Amaranthus viridis* has an excellent geographic adaptability to a wide range of environmental conditions (Joshi *et al*., 2018). Slender Amaranth is one of the few crops that may be utilized as grains, as a green vegetables and for fodder (Gupta *et al*., 2013; Dubey *et al*., 2019). As a relatively short-lived annual with rapid growth, increased drought tolerance and environmental adaptation, enhanced nutritional value, pleasant taste, and a low risk of crop failure, and a variety of biotic and abiotic factors, there is adequate opportunity for its widespread cultivation on a broad scale (Rani., 2022; Rana *et al*., 2015). *Amaranthus viridis* has strong leaf venation and long petioles, similar to other Amaranthus species. It is an annual herb that grows to a height of 15-100 cm and has an upright or ascending habit. On the upper portion of the stem (especially in the flowers), there are short or longer multicellular hairs that are either glabrous or hairier upwards (Mohammed *et al*., 2004). Long-petiolate (petioles up to 10 cm long, the longest commonly longer than the lamina), lamina deltoid-ovate to rhomboid-oblong, 2-7 x 1.5-5.5 cm, the margins occasionally clearly sinuate, shortly cuneate to sub-truncate below, obtuse and narrowly to clearly emarginated at the tip, minutely mucronate (Hussain *et al*., 2018). Amaranthus male and female flowers overlap, but the latter are more frequent, in slender, axillary or terminal paniculate spikes 2.5-12 cm long and 2-5 mm broad, or in dense axillary clusters to 7 mm in diameter in the lower section of the stem. Bracts and bracteoles are deltoid-ovate to lanceolate-ovate in shape, whitish-membranous in colour, and have a very short, pale or reddish awn created by the excurrent green midrib; bracteoles are shorter than the perianth (1 mm) (Das., 2016). In male flowers, the three perianth segments are oblong-oval, acute and concave; in female flowers, the three perianth segments are narrowly oblong to narrowly spathulate, finally 1.25-1.75 mm, minutely mucronate or not, the borders white-membranous, the midrib green, and usually thickened above. Indehiscent or rupturing irregularly, the capsule is subglobose, 1.25-1.5 mm, not reaching the perianth, very strongly rugose throughout. Spherical, only slightly compressed seed that is 1-1.25mm in diameter, dark brown to black in colour with a paler thick border and shiny surface. Reticulate and covered in shallow scurfy verrucae on the reticulum, the verrucae that look like areolas (Zhigila et al., 2014). Amaranthus viridis is found in different environmental conditions. It grows in a wide variety of soil types, from heavy organic to very sandy, including marginal soils, but grows well in fertile, well-drained soils and deeper soils (Khan et al., 2021). *Amaranth viridis* grows on soils with a pH range of 5.5 to 7.5, but it may survive pH levels as high as 8.5. Because the crop is sown directly and the seed size is small (Sahoo and Tripathy 2017). Amaranth requires strong seed-soil contact for quick germination and emergence, and sufficient soil moisture at the sowing depth must be maintained throughout initial establishment (Steckel *et al*., 2017; Bora., 2018). The majority of Amaranthus cultivars germinate at temperatures of 20 degrees Celsius or higher (Ye and Wen., 2017). According to Chauhan and Johnson (2009), for good seed germination of *Amaranthus viridis* requires a soil temperature of 25°C or higher and an air temperature of 28°C to 30°C. It is mainly grown during the summer and rainy seasons. Bangladesh, India, tropical and subtropical Asia, Africa, and Central America are among the countries where it is widely grown (Srivastava *et al*., 2021).

VI. NUTRITIONAL VALUE

Table1. Proximate composition of *Amaranthus viridis*

It is an excellent source of proximate carotenoids, dietary fibre, and beneficial compounds that have a significant role as natural antioxidants, ROS scavenger minerals such as calcium, iron, zinc, and magnesium, and Phytopigments (Sarker *et al*., 2014; Chakrabarty *et al*., 2018). Amaranth species is one of the ancient plant groupings that has considerable potential for treating the under and malnutrition problems facing the world (Aderibigbe *et al*., 2020). It's also known as poor man's spinach, and it is a most popular leafy vegetable growing in various countries throughout the summer and rainy seasons (Sulaiman and Andini; 2020). Amaranth viridis assumes greater nutritional significance as a fancy food crop. The toasted seed flour combined with wheat in 10:90 ratio gave bread of excellent texture. Amaranth meal or flour should be blended with wheat meal or wheat flour because it lacks useful gluten (Mlakar *et al*., 2009). *Amaranthus viridis* is one of the plants in the Amaranthaceae family, which produces grains as well as leafy edible vegetables. The seeds of these plants can be found all over the world, growing in a variety of soil types and from tropical to temperate regions (Mawufe., 2019). Amaranth grain has a nutritional value that is 2-3 times that of other cereal grains, including much more protein and important amino acids such as lysine and methionine e (Maurya and Arya., 2018; Miranda-Ramos., 2019). Interest in Amaranth grain is currently high in the food and pharmaceutical industries because of its well-known nutritional benefits, but also because of its potential therapeutic use in the diets of hypercholesteraemic patients (Martínez *et al*., 2020).

VII. PROXIMATE COMPOSITION

Protein is required for muscle growth, neurological function, digestion, naturally balancing hormones, and maintaining a positive mood, suggesting that this protein is beneficial for the immune system and muscle recovery for athletic performance (Zhang *et al*., 2017; Fedewa *et al*., 2019; Holeček, 2020). About 12.5 to 17% of the protein in *Amaranthus viridis* seeds is made up of amino acids, including lysine (0.73% to 0.84% of the total protein) and methionine and cysteine (0.73% to 0.84% of the total protein) (Assad *et al*., 2017; Sahoo, 2018). Whereas Dry matter ensures highest protein content 17.5–38.3% in *A. viridis* leaves (Dada., 2017). Because of its excellent balance and high amount of essential amino acids like lysine, arginine, histidine, cystine, phenylalanine, leucine, isoleucine, valine, threonine, methionine, and tyrosine, as well as a few non-essential amino acids, amaranth protein is continuously high in quality (Caselato-Sousa and Amaya-Farfán, 2012; Soriano-García and Aguirre-Díaz, 2019). The essential amino acids included in *Amaranthus viridis* are excellent sources for human consumption, according to the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) (Fasuan *et al*., 2021; Paz *et al*., 2021).

Proximate composition	Leaves	References
Water content (%)	80.73 to 91.56	(Muhammad et al., 2020; Olawoye and Gbadamosi, 2020)
Protein	3.91 to 4.53	
Carbohydrates (g/100g^{-1})	6.31 to 9.03	
Ash (g/100g^{-1})	5.43 to 6.86	
Dietary fiber (g/100g^{-1})	8.81 to 9.38	

VIII. VITAMINS

Vitamins and minerals are micronutrients that the body needs to perform a variety of activities. These micronutrients, on the other hand, are not created by our bodies and must be obtained from the plants we consume (Godswill *et al* 2020). Vitamins are a collection of substances that are required for normal cell function, growth, and development (Mahmood., 2014; Aslam *et al*., 2017). *Amaranthus viridis* leaves (both 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 (Jiménez-Aguilar, and Grusak, 2017; Sarker and Oba, 2019; Sarker *et al*., 2020; Jahan *et al*., 2021). While the leaves of *Amaranthus viridis* have a similar flavour to spinach, they are more nutritious due to the fact it contains three times the vitamin C, calcium, and niacin found in spinach (Verma *et al*., 2017). *Amaranthus viridis* leaves have 18 times more vitamin A than lettuce leaves (carotenoid concentration is highest in leaves, followed by seeds, stems, and roots), 20 times more calcium, 13 times more vitamin C, and 7 times more iron than found in leaves of lettuce leaves (Guillet, 2004; Ogedengbe *et al*., 2019; Sarker and Oba, 2020).

IX. MINERALS

Minerals, which are inorganic compounds that are required in minute amounts by the body, enable the body to perform a number of functions. Minerals play a role in the formation of bones and teeth, as well as in the formation of body fluids and tissues, as components for normal nerve function and enzyme systems (SH *et al*., 2018; Zohoori, 2020). Calcium, iron, magnesium, potassium, zinc, and other minerals like these are found in *Amaranthus viridis* in large amounts (Fasuan *et al*., 2021). Calcium helps in the formation and maintenance of healthy bones by promoting mineralization. *Amaranthus viridis* also contains more Macro-micro elements than other plants, making it an important part of a balanced diet that helps in the development of healthy bones and the prevention of osteoporosis (Ghugre *et al*., 2021).

Table 2. Minerals composition of *Amaranthus viridis* in leaves

Macroelements (mg g^{-1})	Leaves	References
K	4.82 to 7.22	(Sarker and Oba, 2019; Ahmed et al., 2013)
Ca	2.16 to 2.84	
Mg	3.51 to 3.78	
P	0.71 to 0.94	
S	1.25 to 1.66	
Microelements (µg g^{-1})		
Fe	20.12 to 22.18	
Mn	8.83 to 8.99	
Cu	2.28 to 3.51	
Zn	11.54 to 15.1	
Na	27.62 to 31. 25	
B	10.83 to 12.63	
Mo	0.29 to 0.47	

X. MEDICINAL PROPERTIES

Leafy vegetables are traditionally cooked and consumed in several Asian countries, and are eaten as a relish with starchy staple food (Sowunmi *et al*., 2015). *Amaranthus viridis* has high concentrations of phytochemicals, protein, carbohydrate, ash, fibre, fat, amino acids, vitamins, minerals with well-documented health and industrial benefits (Mofunanya *et al*., 2021). Traditionally, *Amaranthus viridis* is used as a medicinal plant by Indian and Nepalese to reduce labor pains (Faiz *et* *al*., 2019). The crushed leaves of *Amaranthus viridis* are used directly by the Negritos of the Philippines to treat eczema, psoriasis, and rashes (Sharma *et al*., 2012). Because of its antipyretic and analgesic characteristics, *Amaranthus viridis* is commonly used in traditional medicine to treat pain and fever (Kumar *et al*., 2010). *Amaranthus viridis* also possesses antihyperglycemic, anthelmintic, antioxidant, antimicrobial, anti-inflammatory, hypolipidemic, hepatoprotective, anti-nociceptive, anti-phytopathogenic, and antidiabetic activity (Reyad-ul-Ferdous *et al*., 2015). Amaranthus species had several medicinal applications like Astringent, diaphoretic, diuretic, emollient, febrifuge, galactagogue, gonorrhoea, eczema, burns, wounds, boils, earache, hemorrhoids, and bronchitis, Menorrhagia, sudorific, snake poison antidote, diarrhea, stomach pains, ulcerated mouths, nosebleeds, ulcers, and dysentery are all examples of internal bleeding symptoms (Sarker and Oba, 2019).

PHYTOCHEMICAL

The medicinal value of the plants lies in some chemical substances that produce a definite physiological action on the human body. The most important of these bioactive constituents of plants are alkaloids, tannins, triterpenoids, saponins, flavonoids, steroids, and phenolic compounds and commonly regarded as phytochemicals. Phytochemicals are primary and secondary metabolites commonly present in plant parts. Chlorophyll, proteins and common sugars are included in primary compounds and secondary compounds consist of terpenoids, alkaloids, flavonoids, saponins, phenolic compounds and so on (Swarnakumari *et al*., 2021). Preliminary qualitative phytochemical screening of plants is the need of the hour to discover and develop novel therapeutic agents with improved efficacy (Lodh and Swamy, 2019). *Amaranthus viridis* is rich in antioxidants, that decrease the effect of free radicals and are crucial in the prevention of cancer and degenerative diseases (Arora and Ramawat, 2018). Essential oils, which include high concentrations of triterpenoids, saponins, flavonoids, steroids, phenols, and tannins have been a presence in antioxidants which prevent from various diseases, have antiallergic, anticancer and antihypertensive properties (Lodh and Swamy, 2019). *Amaranthus viridis* is helpful in the prevention of hemorrhagic strokes and haemorrhoids, as well as bleeding disorders such as celiac disease and functional infertility. Additionally, it protects against a variety of other diseases, such as bleeding disorders and other blood diseases, as well as premature aging, recurrent colds and respiratory infections, tuberculosis, and wound healing (Assad *et al*., 2017; Faiz *et al*., 20119; Ahamad *et al*., 2020).

Table 3. Phytochemical composition of *Amaranthus viridis* in leaves

PHYTOCHEMICAL	Leaves	References
Alkaloids (%)	10.34 to 13.14	(Muhammad et al., 2012; Reyad-ul-Ferdous et al., 2015; Silva et al., 2021; Swarnakumari 2021)
TPC (GAE $\mu g g^{-1}$)	30.56 to 46.72	
TFC (RE $\mu g g^{-1}$)	14.45 to 182.46	
Tannins (%)	4.98 to 6.07	
Saponins (%)	52.87 to 53	
Glycosides (%)	61.34 to 64.02	

CONCLUSION

As evidence from the above discussion, *A. viridis* leaves and succulent stems are good sources of protein, dietary fiber, ascorbic acid, carotenoids, and essential minerals. It is also possessing antihyperglycemic, anthelmintic, antioxidant, antimicrobial, anti-inflammatory, hypolipidemic, hepatoprotective, anti-nociceptive, anti-phytopathogenic, and antidiabetic activity. Additionally, it protects against a variety of other diseases, such as bleeding disorders and other blood diseases, as well as premature aging, recurrent colds and respiratory infections, tuberculosis, and wound healing, rapid growth, adaptability to unfavourable climate and soil conditions, resistance to drought.

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