RJNMSR
Review Journal of Neurological & Medical Sciences Review

Volume 3, Issue 4, 2025

NUTRITIONAL EXCELLENCE OF AMARANTHUS: FUNCTIONAL FOODS AND PROTECTIVE HEALTH BENEFITS

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DOI: https://doi.org/

Received	Accepted	Published
22 July, 2025	26 Aug, 2025	**29 Aug**, 2025

ABSTRACT

Amaranthus represents a significant medicinal plant with extensive traditional therapeutic applications across various pathological conditions. Extracts derived from this botanical source demonstrate multiple beneficial properties, including anti-diarrheal, gastroprotective, antifungal, and additional therapeutic activities. The foliage of Amaranthus species has been traditionally employed in diabetes management protocols. Ethanol-based preparations from Amaranthus plants exhibit renal protective effects, specifically safeguarding nephron integrity from degenerative processes. Beyond medicinal applications, these plants hold considerable ornamental value and serve as valuable protein sources in nutrition. The therapeutic potential of Amaranthus is attributed to its rich phytochemical profile, containing bioactive compounds such as steroids, flavonoids, saponins, terpenoids, polyphenolic substances, and tannins. These secondary metabolites contribute significantly to the plant's efficacy in treating diverse medical conditions through various pharmacological mechanisms.

Key words: *Amaranthus Plant, Beneficial Effect*

INTRODUCTION

Amaranthus, commonly known as amaranth, is a significant botanical genus within the Amaranthaceae family, encompassing over fifty distinct species. Archaeological evidence indicates that cultivation of these plants began approximately seven millennia ago. The genus exhibits remarkable morphological diversity, with color variations ranging From golden and crimson to deep purple hues. These plants serve as excellent energy sources and are often classified as pseudocereals due to their exceptional nutritional characteristics.

Amaranthus species demonstrate remarkable drought tolerance, thriving in water-scarce environments where conventional crops struggle. Their applications span multiple sectors, including ornamental horticulture, vegetable production, and cereal cultivation. Several species, including A. lividus, A. dubius, A. spinosus, A. blitum, and A. tricolor, are extensively cultivated as leafy vegetables throughout Southeast Asia.

For ornamental purposes, A. caudatus and A. tricolor are predominantly utilized, while A. hypochondriacus and A. cruentus serve as primary sources for pseudocereal production, yielding over three tons of grain. These grain-producing species originated primarily in South and Central America. Wild varieties include *A. paniculatus*, *A. retroflexus*, *A. graecizans*, *A. gangeticus*, and *A. viridis*.The plants can reach heights of up to four meters, featuring oval-shaped leaves that vary in size among different species. Individual plants are capable of producing over 500 seeds. Regional nomenclature varies, with common names including nana, bledo, chochhoh, ganahar, and bliton across different countries.

Amaranthus leaves contain betalains, bioactive compounds with demonstrated anticancer properties, while the seeds provide a concentrated source of carbohydrates, contributing to their nutritional value and pseudocereal classification (Preedy, Watson et al. 2019).

Description of Plant

Amaranthus species exhibit an upright growth habit with annual distribution patterns and display coarse morphological characteristics. The family encompasses over 160 genera, with grain amaranth representing a particularly valuable species that produces cereals while demonstrating color variation across stems, inflorescences, and foliage. A distinctive crimson pigmentation commonly appears throughout these plant structures.

Grain amaranth typically reaches heights between 1.5 to 2.1 meters. Upon reaching physiological maturity, the plants develop broader leaves accompanied by increased stem diameter. The inflorescences contain perfect flowers (possessing both male and female reproductive organs), with floral coloration varying among different species.

Seeds are characteristically small, with weight variations ranging from 1,000 to 3,000 seeds per gram. Seed coat colors span a spectrum from black and pink to cream and golden hues. The genus demonstrates widespread global distribution, particularly thriving in tropical, subtropical, and temperate regions, where it serves as an important nutritional crop for cereal production.

In India, amaranth cultivation predominantly occurs in mountainous regions, while Pakistani production is concentrated in mid-elevation hills and higher Himalayan areas. These plants require elevated temperatures for optimal growth. Photoperiod sensitivity varies among species: A. hypochondriacus experiences reduced flowering under summer conditions, whereas A. caudatus performs optimally under long-day photoperiods.

Grain amaranth species achieve optimal growth at 21°C, with significant damage occurring when temperatures drop to 4°C. While seeds require moist soil conditions for initial germination, established plants demonstrate relatively low water requirements compared to vegetable amaranth varieties, which maintain higher moisture demands throughout their growth cycle (Wrigley, Corke et al. 2015, Perez-Rea and Antezana-Gomez 2018).

Chemical Composition of Amaranthus

The leaves of Amaranthus are a rich source of phytochemicals, vitamins, nutrients, amino acids (AA), and minerals. In leaves, phosphorus, magnesium, zinc, calcium, sodium, potassium, and iron are present. The presence of different vitamins in the leaves includes ascorbic acid, tocopherol, niacin, thiamine, carotene, riboflavin, and pyridoxine. Almost seventeen different amino acids are present in the leaves of Amaranthus, such as glycine, serine, aspartic acid, proline, isoleucine, histidine, lysine, alanine,

cysteine, leucine, arginine, aspartic acid, valine, tyrosine, glutamic acid, threonine, and methionine. Other components like phenols, phytic acid, tannins, alkaloids, hydrocyanic acid, saponins, and flavonoids are also present. (Akubugwo, Obasi et al. 2007). Leaf extracts have demonstrated antimicrobial activity, with fractions obtained using dichloromethane, hexane, methanol, and ethyl acetate showing notable effects (Maiyo, Ngure et al. 2010). Betalains another important component is present in amaranths (Florian and Odile 2014).

Nutritional Value of Amaranths

Constituents	content per 100/gram	
	Grain	green leaves
Crude fiber (g)	2.43	1.30
Energy (k calories)	410	36.o
Calcium (mg)	222	267.o
Protein (g)	15.6o	3.5o
Mineralmatter (gram)	2.93	-
Phosphorus (mg)	548.o	67
Fat (gram)	6.3o	.5o
Iron (mg)	13.9o	3. 90
Carbohydrate (gram)	72.7o	6.5o

Lipids

Amaranth seeds constitute a valuable source of nutritionally significant lipids, with an average lipid content of 8.1%. The lipophilic fraction contains several bioactive compounds, including squalene, tocopherols, triacylglycerols, and fat-soluble vitamins. Additional lipid-associated constituents comprise plant waxes, fatty alcohols, phytosterols, and terpene compounds.

Extraction of the lipophilic components is typically achieved through non-polar organic solvents such as petroleum ether and hexane. Oil extraction from amaranth tissues can also be accomplished through mechanical pressing methods. These lipid constituents contribute to the plant's therapeutic potential and nutritional value, warranting further investigation for clinical applications

Squalene

Squalene represents a significant triterpene compound obtained from Amaranthus species and functions as a beneficial polyunsaturated lipid with essential dermatological properties. This bioactive molecule exhibits multiple therapeutic activities, including antioxidant, antineoplastic, emollient, and moisturizing effects, contributing to optimal cutaneous health and barrier function. (Venskutonis and Kraujalis 2013).

Amaranthus Leaves

Amaranthus leafy vegetables provide significant nutritional value per 100 g of fresh material. Energy content ranges from 27 to 53 kcal, with protein concentrations of 4 to 6 g and minimal lipid content of 0.2 to 0.6 g. Carbohydrate levels measure 4 to 6 g per serving.

Micronutrient analysis reveals substantial mineral content, including iron concentrations of 2.3 to 3.2 mg and calcium levels ranging from 215 to 260 mg. Ascorbic acid content provides 43 to 56 mg per 100 g, representing a significant source of vitamin C for dietary supplementation

Amaranthus Grains

Amaranthus foliage demonstrates sterol concentrations ranging from 0.27 to 0.32 mg per gram of plant material. The extracted oil contains minimal phospholipid content, while tocol concentrations in seed oil vary from 191 mg kg^{-1} to 2000 mg kg^{-1}.

Nutritional analysis of Amaranthus grains reveals substantial macronutrient and micronutrient profiles: crude protein content ranges from 11 to 18 g per 100 g, lipid fraction comprises 7 to 8.5 g, carbohydrate content spans 65 to 75 g, and crude fibre measures 6.5 to 9 g. Mineral composition includes calcium (160-212 mg) and iron (7-15 mg), with total ash content of 2.8 to 3.8 g. Ascorbic acid concentrations range from 4 to 7 mg per 100 g of grain material.

Uses of Amaranthus

Amaranth species have a wide range of applications. Certain varieties are consumed as leafy vegetables, while others are traditionally used for their medicinal properties. The leaves are rich in ascorbic acid and have been reported to possess antifungal activity. Additionally, they are employed in the management of diarrhea, gastric ulcers, and oral inflammations, as well as

in regulating cholesterol levels. It also possesses anti-oxidant activity (Peter and Gandhi 2017). Amaranthus is recognized for its high protein content compared to many other leafy vegetables. It provides essential amino acids that the human body cannot synthesize, thereby supporting metabolic activity and aiding in the conversion of fats into energy. Traditionally, the juice of amaranth leaves has also been applied as a natural shampoo to help reduce hair loss.Nutritionally, amaranth contributes to cardiovascular health by lowering LDL ("bad") cholesterol while increasing HDL ("good") cholesterol. It is an excellent source of calcium, which supports bone strength and helps reduce the risk of osteoporosis. Its vitamin A content promotes healthy vision, while minerals such as iron, phosphorus, magnesium, manganese, and vitamin E contribute to overall well-being. The leaves and seeds are easily digestible and have demonstrated anti-diabetic and anticancer properties.Amaranthus is also valued for women's health. It may help in managing premenstrual syndrome (PMS) by alleviating symptoms such as mood swings, anxiety, restlessness, and pain, particularly when consumed along with calcium. Its folate and vitamin B-complex content supports the production of red blood cells and plays a crucial role in preventing neural tube defects in infants.

Furthermore, the plant contains thiamine, which supports brain function, improves cognition, and strengthens the nervous system, thereby helping to reduce stress. Regular consumption of amaranth may help prevent iron-deficiency anemia due to its high iron content. Emerging evidence also suggests that it could play a protective role in maintaining central nervous system health, with potential benefits in lowering the risk of neurodegenerative disorders such as Parkinson's and Alzheimer's disease (Singh et al., 2024).Squalent antioxidant is highly investigated and numerous potential compounds caused that Olawoye et al. (2024) applied machine learning for selection of most efficient ones (Tang and Tsao 2017).

Amaranths plant is a good diuretic, anti-pyretic, anti-ulcer, laxative, analgesic and used to treat asthma (Pulipati, Babu et al. 2014). The oil of *Amaranthus* exhibits anti-inflammatory activity. The presence of phytonutrients and fiber in Amaranthus improves blood pressure. Additionally, it enhances the immune system (Inglett, Chen et al. 2015).

Anti-Hyperlipidemic Activity of Amaranthus

Multiple *Amaranthus* species demonstrate significant anti-hyperlipidaemic properties through various mechanisms. Clinical investigations have established that squalene, a key bioactive compound, and exhibits pronounced anti-cholesterolaemic effects. Both grain and oil fractions from these plants demonstrate substantial hypocholesterolaemic potential through reduction of serum cholesterol and triglyceride concentrations.

The lipid-lowering mechanisms involve enhanced faecal cholesterol excretion and increased bile acid production, providing hepatoprotective effects against fatty infiltration. The compounds demonstrate mild inhibitory activity against 3-hydroxy-3-methylglutaryl-CoA reductase, the rate-limiting enzyme in cholesterol biosynthesis, thereby contributing to cholesterol reduction.

Amaranthus caudatus contains several bioactive constituents, including proteins, dietary fibre, squalene, anthocyanins, and tocotrienols. Squalene functions as an intermediate in cholesterol biosynthesis and accumulates in subcutaneous adipose tissue. Flavones present in the foliage contribute additional therapeutic benefits.*A. caudatus* extracts effectively reduce serum lipid concentrations and prevent atherosclerotic plaque formation through modulation of cholesterol metabolism. The anti-hyperlipidaemic activity involves flavones and tocotrienols, which demonstrate plaque regression capabilities in hypercholesterolaemic patients by reducing triglycerides, low-density lipoprotein, and apolipoprotein B levels while elevating high-density lipoprotein concentrations (Enayati et al., 2024). These mechanisms normalize cholesterol homeostasis and prevent lipid deposition in serum and aortic tissue, subsequently reducing lipid peroxidation processes. Such effects provide cardiovascular protection by addressing elevated low-density lipoprotein levels, a primary risk factor for coronary artery disease (Kabiri, Asgary et al. 2011).

Amaranthus virid is, commonly known as slender or green amaranth, has been traditionally used for various medicinal purposes. In earlier practices, it was employed in the management of childhood epilepsy, as a blood purifier, for its

anti-inflammatory properties, in the treatment of hemorrhoids, to ease labor pain, and to stimulate appetite (Jin et al., 2025).Recent studies have highlighted the plant's significant antihyperlipidemic potential (Dutta et al., 2025). Ethanolic extracts from its leaves have been shown to reduce oxidative stress and regulate lipid levels, making it effective against dyslipidemia and related metabolic disorders. These effects are attributed to its rich phytochemical profile, which includes alkaloids, tannins, saponins, flavonoids, and glycosides. Among these, saponins and glycosides are particularly associated with antihyperlipidemic activity. Through its hypocholesterolemic and hypotriglyceridemic properties, *A. viridis* plays an important role in controlling oxidative stress and lipid-related disorders, underscoring its therapeutic relevance in hyperlipidemia management (Omodamiro, Jimoh et al. 2016).

A. caudatus, *A. viridis*, and *A. spinosus* demonstrate significant anti-hyperlipidaemic efficacy. Research has established that methanolic extracts from these species effectively reduce low-density lipoprotein cholesterol while increasing high-density lipoprotein concentrations. *A. hypochondriacus* similarly exhibits anti-hyperlipidaemic properties by suppressing plasma cholesterol levels in obese individuals and inhibiting lipogenesis.

Amaranthus-derived proteins demonstrate substantial lipid-lowering potential, offering therapeutic benefits for various metabolic disorders. As pseudocereals, Amaranthus species serve as effective dietary interventions for dyslipidaemia management. The hypocholesterolaemic effects are attributed to bioactive compounds including tocopherols, phytosterols, and tocotrienols, which collectively modulate lipid metabolism through complementary mechanisms.

These findings suggest that Amaranthus species may represent viable nutraceutical approaches for cardiovascular risk reduction, particularly in patients with elevated cholesterol profiles and obesity-related dyslipidaemia (Kumar, Shammy et al. 2014).

CONCLUSION

In conclusion, this review demonstrates the significant therapeutic potential of Amaranthus species across multiple clinical applications. The genus exhibits particular promise for dyslipidaemia management, with bioactive constituents demonstrating measurable efficacy in lipid regulation. The presence of key phytochemicals positions these species as valuable candidates for integrated approaches to disease prevention and management.

Further clinical investigation is warranted to establish standardized therapeutic protocols and define optimal dosing regimens for these promising botanical interventions

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