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"AMARANTH SPECIES: A PHARMACOLOGICAL OVERVIEW AND APPLICATIONS"

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Abstract

Amaranth is a cereal that has existed since prehistoric times. Its past is firmly ingrained in the cultures of the pre-Columbian New World. It is a "pseudocereal" crop. In India it is also known as "chaulai" in Hindi, which may have been imported to India in ancient times by trade routes connecting South America, Africa, and Asia. Over time, the plant adapted to the Indian climate and became widely farmed, especially in hilly and semi-arid areas. This review focuses on the pharmacological properties, applications, and botanical description of these species. Amaranthus is distinguished by broad leaves, vivid inflorescences, and small, nutrient-dense seeds, which make it useful in both traditional and modern settings. The plant's pharmacological potential includes antioxidant, anti-inflammatory, and antibacterial properties, linked to bioactive components such as flavonoids, saponins, and phenolic acids. These chemicals are increasingly being investigated for their involvement in the treatment of inflammation, oxidative stress, and microbial infections. Amaranthus is viewed as a promising option for the development of nutraceuticals and herbal medications due to its diverse medicinal applications. Further investigation into its pharmacological properties could improve its application in modern medicine." This abstract highlights the key characteristics of pharmacological activity, application, and plant description.

IndexTerms: amaranth, pseudocereal, proteins, pharmacological actions, applications, global hunger.

1. INTRODUCTION

Over the past few years, there has been a noticeable increase in interest in plant raw materials with properties that make them suitable for use in food and medicine. Numerous cereal grains are found to be extensively used in the food and pharmaceutical sectors. The term "pseudocereal" refers to a rather wide category of plants. These are processed non-grass plant seeds that are utilized similarly to cereal grains. They taste and have nutritional qualities similar to cereals. These are not typical traditional cereals, but they can be a decent substitute because of their similar makeup and the nutritional benefits discussed earlier. For millennia, pseudo-cereals have been a staple diet consumed by our forefathers throughout history. In many parts of the world, distinct different pseudocereals predominate. Even today, pseudo-cereals still form the basis of nutrition in the poorest parts of the world.

Amaranth is the most well-known pseudocereal among the other varieties. Because of its remarkable qualities in a variety of areas, amaranth is regarded as one of the "superfoods" of the twenty-first century. The crop is not a recent discovery, though, and it has had to overcome several challenges to reach its current nutritional status and level of popularity among consumers as a nutrient-dense food. Despite the obstacles and lack of use, Amaranth has merited the title of "superfood."

Commonly referred to as the "Amaranth family," the Amaranthaceae family. It's also referred to be a third-millennium crop plant these days. Just 15 species are native to Europe, Asia, Africa, and Australia, whereas the majority of the 70 species of the genus Amaranth are found in North America, according to the FAO. Species are categorized according to how they are utilized. The variety includes decorative, weedy, grain, and veggie amaranth. The four species of grain amaranth are *A. hypochondriacs*, related to three weedy species *A. cruentus, A. caudatus, and A. edulis.* Except for certain dioecious forms, the genus Amaranthus typically contains monoecious annual plants. The many species of plants range in height from 0.3 m to 5 m.

The genus's leaves are oblong to elliptic in shape, and they range in color from light to dark green, with some displaying red pigment. There is one male flower per glomerule of roughly 100-250 blossoms in the colorful, terminal inflorescence. The tiny, lenticular seeds have an average diameter of 1-3 mm and a weight range of 0.6-1.2 g per 1000. Seed color varies from species to species, ranging from light ivory to black. The nutritive layer surrounds the seed embryo, perisperm cells with thin walls are packed with starch grains, and the protein bodies are embedded in a lipid matrix. Among the pseudocereals, amaranths are a major group of plants with a significant potential to reduce malnutrition, particularly in low-income nations with inadequate access to food. Pseudocereals are defined as fruits or seeds of non-grass species that are consumed in a very similar way as cereals and are effective supplements to them. These days, amaranth is regarded as one of the few crops that can be grown for a variety of purposes. Its large seed supply can be utilized to make pseudocereals, pleasant, higher-quality green vegetables, animal feed, and food.

The genus Amaranthus is thought to have sixty native species in the New World and roughly fifteen in Australia and the Old World. These are small crops, grown sporadically, in the Asia-Pacific region, which includes China, India, Nepal, Bhutan, Afghanistan, Indonesia, Japan, Thailand, and Israel. These are grown throughout India's plains and hills, in the states of Jharkhand, Chhattisgarh, Maharashtra, Gujarat, Odisha, Karnataka, Kerala, Tamil Nadu, Himachal Pradesh, Uttarakhand, Sikkim, Assam, Meghalaya, Arunachal Pradesh, Nagaland, and Tripura.

The crop is mostly grown as a pure or mixed crop in the Himalayan region's mid- and high-hill regions. Amaranth is a herbaceous plant with a brief life cycle of 4-6 weeks, and it can only be propagated by seeds. The kind and growing conditions determine the precise dimensions. Plant height ranges from 3 to 8 feet on average (the leafier cultivars tend to be lower). Breadth: one to three feet.

2. AMARANTH BOTANICAL DESCRIPTION

A. Roots

Amaranth has a fast-growing tap root system, which helps in the easy uptake of water and nutrition from soil. After days of sowing roots can reach up to 2.4 m in soil and spread around 1.8 m. This type of root system is found in both vegetable and grain amaranth, which makes it competitive with other crops.

Fig.1

B. Stem

The stem is robust, erect, cylindrical, fibrous, 0.5 to 3.5 m in height, simple or branched, relying on species, genotype, and developing conditions, but usually on plant population. After maturation, the stem becomes hollow inside. It has thick stripes on the outside, and shades of green, red, pink, brown, or purple, depending on variety. At the base of the stem or mid-height of the plant, some ramifications arise from the axils of the leaves. The number of branches of the plant depends directly on the density of crop plants.

Fig.2

C. Leaves

Amaranth leaves are stalked and compound, alternate, rhomboid-shaped, elliptical, lanceolate, or oval with acute, obtuse, or acuminate leaf tips, of green, purple, or silver color Leaves may be from green-yellow to deep red. Because of anthocyanin (amaranthine) coloration, purple plant life and flowers with reddish or silver spots on the leaves additionally exist. Its size ranges between

Fig.3

D. Inflorescence

The inflorescences of amaranth are large, in the form of panicles. The inflorescence can be terminal or axillary. They can offer different colors depending on the variety: yellow, orange, brown, red, pink to purple. Amaranth is a monoecious, flora that is unisexual with a pentamerous organization.

Fig.4

E. Fruit and seed

Amaranth fruits are botanically capsules called unilocular pixidio. At maturity the grain opens transversely, dropping the top (operculum) to release the "urn", which is the part where the seed is. The seeds are small, spherical, lenticular, shiny, white, yellow, gold, red, pink, or black, depending on the variety of plants. Seed size is very small, between 1 and 1.5 millimeters in diameter, and color ranges from creamish yellow to reddish and the weight of 1000 seeds varies from 0.7 to 0.9 grams. The seed coat is smooth and thin.

Fig.5

3. CHEMICAL COMPOSITIONS

With a distinct chemical composition that includes a healthy ratio of vital amino acids, minerals, and vitamins, amaranth is a nutrient-rich grain. A list of its principal elements is provided below:

Table 1: Macronutrient's content of Amaranth species

Parameter	Amaranth
Water (g)	11.3
Ash(g)	2.88
Energy(kcal)	371
Protein(g)	13.6
Carbohydrates by difference(g)	65.2
Today lipids/fats (g)	7.02
Fibers, total dietary(g)	6.7
Fatty Acid, total saturated(g)	1.46
Fatty acids, total monounsaturated(g)	1.68
Fatty acids, total polyunsaturated(g)	2.78

Table 2: Mineral's content of Amaranth species

Parameters	Amaranth
Calcium, Ca(mg)	159
Iron, Fe(mg)	7.61
Magnesium, Mg(mg)	248
Potassium, K(mg)	508
Phosphorus, P(mg)	557
Sodium, Na(mg)	4
Zinc, Zn(mg)	2.87
Copper, Cu(mg)	0.525
Manganese, Mn(mg)	3.33
Selenium, Se (µg)	18.7

Table 3: Vitamin content of Amaranth species

Parameters	Amaranth
Vitamin A (IU)	0
Vitamin B1, Thiamine(mg)	0.116
Vitamin B2, Riboflavin(mg)	0.2
Vitamin B3, Niacin(mg)	0.923
Vitamin B5, Pantothenic acid(mg)	1.46
Vitamin B6, Pyridoxine (mg)	0.591
Folate, total (µg)	82
Vitamin B12 (µg)	0
Vitamin C (mg)	4.2
Vitamin D (IU)	0
Vitamin E (mg)	1.19
Vitamin K (µg)	0

4. PHARMACOLOGICAL ACTIONS

A. Antioxidant Effect

The ability of a material to counteract excess oxygen free radicals created by environmental conditions is known as antioxidant potential. Many amaranth species, including *Amaranthus gangeticus L., Amaranthus spinosus*, and *Amaranthus tricolor* have antioxidant properties. Twenty-five distinct phenolic compounds that demonstrated effective radical scavenging—a material that shields cells from harm caused by free radicals were found in *A. gangticus* and *A.spinosus*. A study looked at *A. spinosus's* capability for antioxidants.

The DPPH experiment demonstrated the potent antioxidant activity of betalain, a pigment found in plants. The betalain content of the *A.spinosus* extract may be the cause of its antioxidant effect. *A. tricolor's* biological components, including as proteins and peptides, give rise to their antioxidant effect. Certain proteins and their hydrolyzates have demonstrated antioxidant action.

B. Antimicrobial activity

Broad-spectrum antibacterial activity has been documented for several Amaranthus species, including *Amaranthus viridis, Amaranthus hybridus, Amaranthus spinosus, and Amaranthus caudatus*. Certain antimicrobial chemicals found in *Amaranthus tricolor* include alkaloids (betacyanins and betaxanthin), terpenoids (cerasinone and norecasantalic acid), polyphenols (flavonoids, steroids, catechuic acid, and tannins), and saponins. The crude extract of *Amaranthus tricolor* (ATCE) exhibits strong antibacterial properties. It has been noted that the amaranth alcoholic extract exhibited greater antibacterial activity than the fluid extract.

Amaranthus tricolor, a medicinal plant, contains a novel antimicrobial peptide with potent anti-E. coli action. This peptide was identified after analyzing the protein fraction of *A. tricolor* and was found to be highly antibacterial.

Combining amaranth oil with the antifungal medication terbinafine has synergistic fungistatic and fungicidal effects, making it a potentially significant component of antifungal formulations. Additionally, amaranth's antiviral properties have been reported recently. Betacyanin fractions from red spinach *(Amaranthus dubius)* leaves have been shown to have antiviral qualities. In vitro, DENV-2 was suppressed by *A. dubius* betacyanin fractions. After the virus had attached itself to the host cells, betalazin fractions showed dose-dependent antiviral efficacy against DENV-2.

C. Hepatoprotective activity

Amaranth oil and plant extracts are known to provide hepatoprotective effects. The addition of amaranth oil to the diet regulates lipid metabolism and protects the liver. Amaranth oil dramatically alters the physical-chemical properties of lipids and cell membranes in hepatic cells. As a result, it acts as a hepatoprotective agent and stabilizes cell membranes. Squalene is well known for its anti-inflammatory, hepatoprotective, and cholesterol-regulating properties, as well as its ability to help the human body eliminate toxins. This liver-protective action is most likely induced by amaranth oil, which has been shown to contain a high concentration of squalene. Aqueous extracts of *A. tricolor Linn*. showed hepatoprotective efficacy against paracetamol (PCM)-induced hepatotoxicity.

D. Gluten-free

Eating gluten, a protein included in wheat, barley, and rye, can cause an immunological reaction in the body that damages the lining of the small intestine and causes inflammation. This condition is known as celiac disease. Among other symptoms, damage to the lining of the small intestine results in poor nutrient absorption, diarrhea, exhaustion, weight loss, impaired memory, joint stiffness, bloating, and anemia.
The amaranth grain has been more popular recently due to its status as a gluten-free pseudocereal. It serves as a substitute when allergens prevent the consumption of gluten-containing cereals like wheat, barley, and rye. For people who are vegan, vegetarian, or have developed allergies, amaranth is also a great source of protein that can help them live a healthy lifestyle and perform better.

E. Neuroprotective activity

The study examined the neuroprotective potential of extracts from *A. lividus L.* and *A. tricolor L.* against oxidative stress and cytotoxicity caused by AGEs.Advanced glycation end products (AGEs) cause oxidative stress and damage in neural cells. It was found that the extracts under study protected human neuroblastoma SH-SY5Y cells from the AGEs' cytotoxicity. In human neural immortalized SH-SY5Y cells, it was discovered that the alcohol concentrations of *A. lividus and A. tricolor* leave reduced cell cytotoxicity and reactive oxygen species generation.

F. Hypolipidemic and antihyperglycemic actions

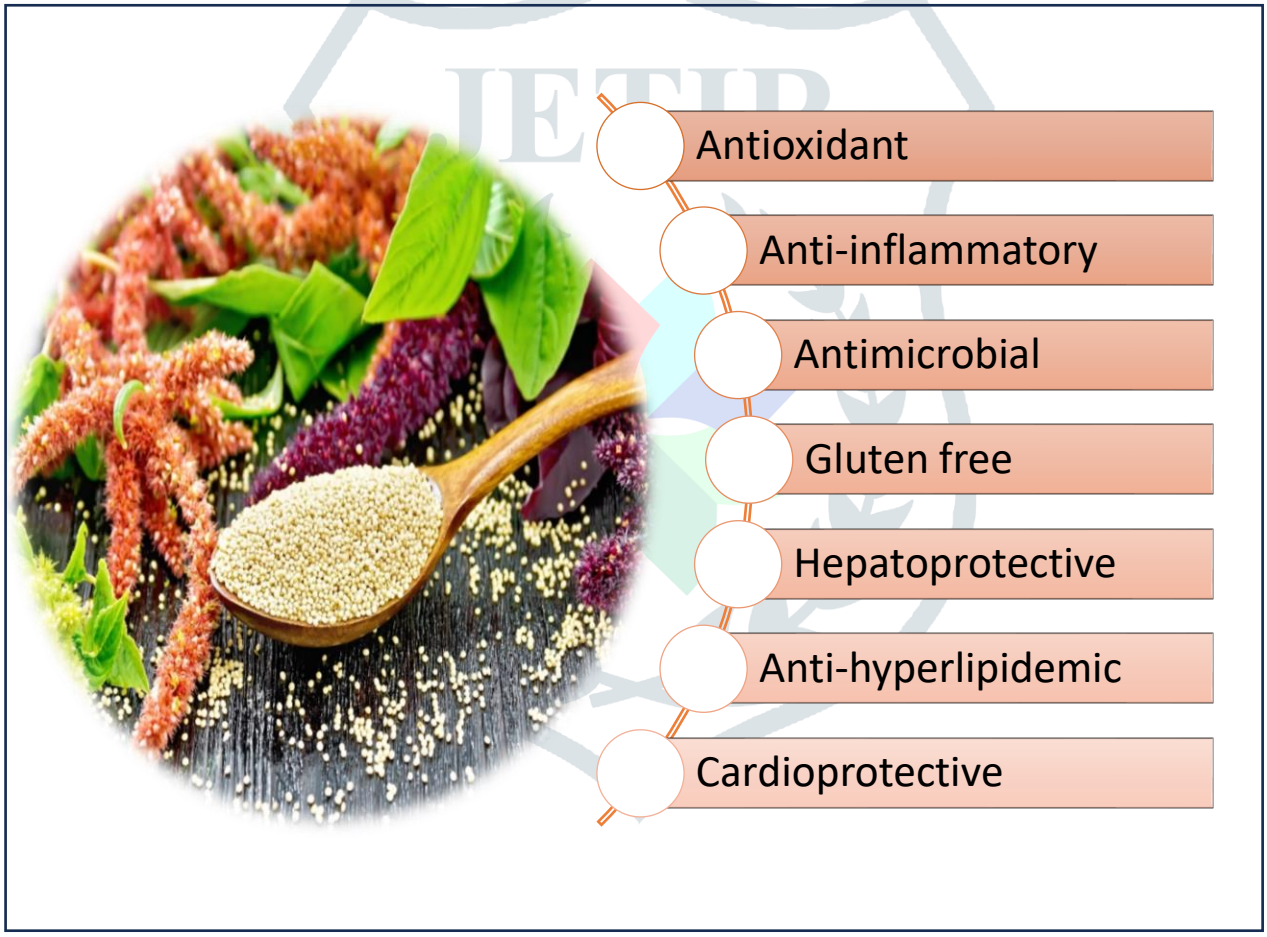
Studies on the role of particular proteins in amaranth *(Amaranthus cruentus*) suggest that this plant has low cholesterol. The substantial squalene concentration of amaranth oil is linked to its hypolipidemic action. Studies indicate that an effective dietary supplement to ward against diabetic retinopathy may be made from the fluid extract of heated red amaranth foliage. In a human lens, an epithelial cell line known as HLE-B3, the antiglycation and anti-oxidative effect of extracts against high glucose-induced damage was investigated.

G. Anti-inflammatory action

Research has also clarified that eating amaranth lowers inflammation brought on by illness. This is because bioactive peptides activated by extruded amaranth protein hydrolysates inhibit inflammation by lowering the expression of many pro-inflammatory markers.

The anti-inflammatory properties of A. lividus and A. tricolor extracts can lower the expression of pro-inflammatory cytokine genes. There was a noticeable rise in proinflammatory cytokines such as TNF, IL-1, and IL-6.

Fig.6: Pharmacological Actions of Amaranth.



5. APPLICATIONS OF AMARANTH

A. FOOD SOURCE

Traditional leafy green

Amaranth leaves have multiple uses. Its leaves are used as the traditional green leafy vegetable.
It is also used in culinary preparations.
Here are some popular uses like Saag (leafy green curry), Dal (lentil soup), Stir fries, Roti and parathas, Smoothies and juices, porridges and stews, etc.

Fig.7: Leafy vegetables.

Sweets

Amaranth (also called "Rajgira" in India) it's a grains, which are mostly used in sweet dishes and preferred during fasting time, like Rajgira ladoo (Amaranth sweet balls), Rajgira Kheer (Amaranth pudding), Amaranth and coconut fudge etc.

Fig.8: Amaranth porridge and Laddoos.

B. CATTLE FEED

Amaranth whole plant like its leaves, stems and seeds can be used as green forage for cattle. It is high in proteins, fibers, and minerals.

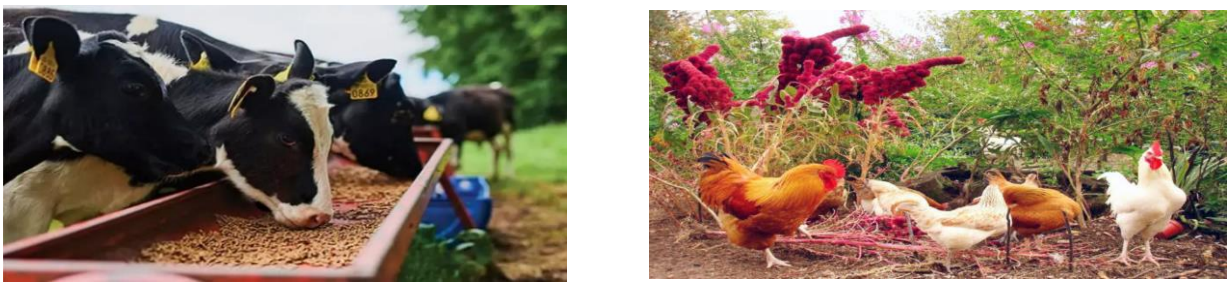


Fig.9: Cattle feed.

C. NUTRITIONAL SNACKS

Amaranth Popcorn:

Amaranth seeds can be puffed into popcorn by heating them in a hot pan. It provides nutritional benefits like high protein, fiber, minerals, etc.

Amaranth Energy Bars:

Amaranth energy bars are prepared by combining puffed amaranth with nuts, seeds, dry fruits, honey, etc. It provides nutritional benefits like healthy fats, carbohydrates, iron, calcium, etc.


Fig.10: Amaranth popcorn and Energy Bars.

D. COSMETICS

Amaranth oil:

Amaranth oil is used to provide skin hydration. Its seed oil is rich in natural compounds that help to provide high moisture to the skin and prevent dehydration, reduce dryness, protect skin from excess oil, etc.

Serums and Creams:

Amaranth oil is used for the preparation of anti-aging products. It helps to reduce fine lines and wrinkles from the face, helps to improve the elasticity of skin, and provides firmness.

Hair care Products:

Amaranth is used in various haircare products like shampoos, conditioners, hair masks, etc, and provides strength, hydration, smoothness, and shine to the hair.


Fig.11: Amaranth oil and Shampoo.

E. TRADITIONAL MEDICINES

Digestive Health:

Amaranth seeds and leaves help to improve digestion because they are rich in dietary fiber. Helps to prevent constipation, and treat diarrhea and IBS (Irritable Bowel Syndrome).

Anemia:
Amaranth leaves are used to treat anemia because they have high iron content. Helps to increase hemoglobin levels, and enhance iron absorption through Vitamin C.

Wound Healing:
Amaranth leaves are used to treat wounds, cuts, and skin irritation because they have anti-inflammatory and antibacterial properties that promote quick healing.

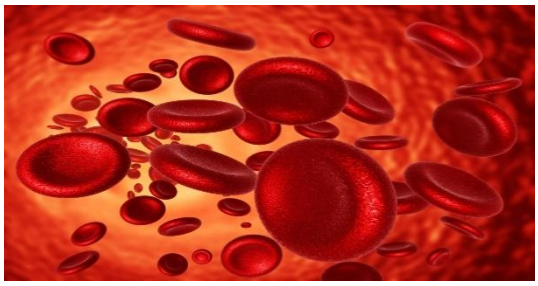



Fig.12

F. ENVIRONMENTAL APPLICATIONS:

Soil improvement:
Amaranth is used for soil improvement in the following ways:
1.Amaranth extensive roots help to hold soil and prevent soil erosion.
2.Its deep taproots help to stabilize soil structure.
3.It also helps to support the beneficial microorganism.

Environmental detoxification:
1.Amaranth helps to absorb heavy metals and reduces soil pollution.
2.It helps in water purification (amaranth roots help to filter the water) and wastewater treatment by removing water pollutants.
3.Amaranth leaves and stems absorb the sound waves and help to reduce noise pollution.

Bio fuel:
Amaranth can be used as the Bio fuel.
Benefits:
1.Waste reduction
2.Renewable energy source
3.Energy independence

6. AMARANTH FUTURE PERSPECTIVE

Due to the demanding needs of the twenty-first century's population and their need for food, the efficiency of crops such as corn, rice, and maize is being called into question. As a result, scientists around the world are embarking on new research into the potential of alternate grains to feed the world in the future. Quinoa, buckwheat, and other forgotten pseudocereals are gaining popularity due to their great nutritional value and ease of development. In all of these areas, amaranth leads the way.

The first global Amaranth conference was organized in 2018, with 135 attendees from East and Southern African countries where the crop is most needed. Nutrition, quality food production on African land, processing, and assisting communities in changing mentalities about amaranth as a poor man's crop were the key topics highlighted. The crop appears to be underutilized, particularly in places where its nutritional benefits are most needed. Efforts to modify public perception are effective, as seen by African continent attendance.

It is also critical to promote work leading to the development of new technologies, as well as to support research and development efforts that result in the manufacture of food and cosmetics from this plant. This should result in the speedy and effective commercialization of these technologies and their introduction into the market as specialized products. Further research is required on the biological effects of amaranth preparations on human health.

7. CONCLUSIONS

Amaranth is a significant plant, it has been used as food for millennia and, in the future, it can be utilized to generate plant medicines. Amaranth may have a wide range of applications in the prevention and treatment of several modern diseases, including ischemic heart disease, allergies, type II diabetes, and celiac.

Because of the growing worldwide population's need to control world hunger and supply nutrition to the malnourished, amaranth has become a viable option for a variety of reasons. One of these factors is its weed-like nature and capacity to tolerate harsh environments. Another advantage is its potential to offer considerable amounts of micro- and macronutrients in a single crop, as contrasted to the world's present food crops.

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