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BIOACTIVE CONSTITUENTS, PHYTOCHEMICAL AND PHARMACOLOGICAL PROPERTIES OF *CHENOPODIUM ALBUM*: A MIRACLE WEED

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ABSTRACT: *Chenopodium album* L. (family Chenopodiaceae), a noxious weed globally distributed that is a large genus commonly known as white goosefoot and fat-hen, melde, pigweed, lamb's quarters, lambsquarters or local names. It has nutritious value and more than thirteen compounds accounted and subsistence food crop; seed are processed into flour for pancakes and bread. It is boiled and mixed with other ingredients to make a kind of gruel, or is roasted and ground for porridge or also used for preparing fermented and alcoholic beverages. Medicinally it is used to cure the diseases of blood, heart, spleen, and eye and in biliousness conditions, anti-cancer property, antipruritic and antinociceptive activities. The plant traditionally used as a laxative, anthelmintic, blood-purifier, antiscorbutic, appetizer, aphrodisiac and tonic. It is nutraceutical food, an alternative source for nutrients. The plant contains essential oils, besides alkaloids, trigonelline, chenopodine, potassium and vitamin C, total phenol flavonoid glycosides (quercetin, rutin, and kaempferol). The major class of phytoconstituents includes nonpolar lipid, phenols, and lignins, alkaloids, flavonoids, glycosides and saponins.

INTRODUCTION: India is a varietal emporium of medicinal plants. It is a one of the richest countries in the world regarding genetic resources of this medicinal since Ayurveda or Siddha systems of medicine. These plants contain some active chemical substances that produce a definite physiological action on the human body. *Chenopodium album* or other species of Chenopodium had a high nutritional composition, extensively cultivated and consumed as a food crop.

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It is found as weed in cropland, old fields, gardens, nursery plots, vacant lots, weedy meadows, construction sites and miscellaneous waste areas, particularly where the soil has been recently disturbed.

Botany of Plant: *Chenopodium album* L of Chenopodiaceae (chromosome $2n = 36$) is a large genus (100-150 species), commonly known as white goosefoot and fat-hen, melded, pigweed, lamb's quarters, lambsquarters or bathua (Hindi) or *bathuwa* (Marathi), Pappukura (Telugu), Paruppukkirai (Tamil), Kaduoma (Kannada), Vastuccira (Malayalam) and Chakvit (Konkani) is a weedy plant found all over world. It gained renowned popularity these days due to its high nutritional composition especially amino acids. *Chenopodium album* is extensively cultivated and consumed in Northern India as a food crop.

It is an erect annual herb having an angular stem with ribbed longitudinal dark green or red streaks. Leaves are simple, alternate, exstipules, ovate-rhomboid, irregularly and coarsely toothed or incised, elliptical- oblong- lanceolate. The inflorescence is large, axillary and terminal, panicle which consisting of clusters of flowers. Flowers are bisexual, regular, pentamerous; stamens opposite to tepals; ovary superior, depressed globose, one-celled, style short with two stigmas. Fruit is nut entirely enclosed by the incurved tepals, thin-walled, indehiscent, single-seeded. Seed nearly smooth, lenticular, testa thin and leathery, blackish-brown; embryo annular, surrounding the endosperm. Seedling has epigeal germination and cotyledons leafy stalked.

Chenopodium murale much resembles *Chenopodium album* but differs in its rhombic-ovate leaves with numerous teeth, clearly cymose inflorescences and sharply keeled, closely pitted seeds. The large mature plant has a bushy appearance, tapering gradually toward the apex. The blooming period can occur from mid-summer through the fall and lasts about 1-2 months for a colony of plants.

Ecologically, it has a wide range of distribution as a weed to a broad tolerance of climates; temperatures (5-30 °C) and tolerates night frost. *Chenopodium* is mainly found in temperate zones throughout the world. Some species have naturalized in the mountainous regions of the tropics. It is often intercropped with finger millet, potato, maize, rice, amaranth, foxtail millet, sesame, soybean, taro, cowpea or common bean.

Origin and Geographical Distribution: *Chenopodium album* is mainly known as a noxious weed globally distributed, occurring from 70°N to 50°S, in the tropics mostly at higher altitudes including all African countries. It was well-known weed from prehistoric times to the old and the New World. It has been domesticated and grown in the Himalayan region of northern India including Nepal as a grain crop.

In India, it is also cultivated as a traditional leafy vegetable. Its native range is obscure due to extensive cultivation but includes most of Europe. Plants native in eastern Asia are included under *C. album* but often differ from European specimens. It is widely introduced elsewhere, as Africa, Australia Asia, North America, Oceania and now occurs almost everywhere in soils rich in nitrogen, especially on wasteland.

Uses, Phytochemical and Pharmacological Properties: The nutritional composition of *Chenopodium album* leaves per 100 g edible portion is: water 84 g, energy 184 kJ (44 kcal), protein 4.3 g, fat 0.8 g, carbohydrate 7.3 g, fibre 2.1 g, Ca 280 mg, Phosphorus 81 mg, vitamin A 11,300 IU, thiamin 0.15 mg, riboflavin 0.4 mg, niacin 1.3 mg, ascorbic acid 90 mg. The nutritional composition of the seed of Himalayan cultivars per 100 g is energy 1654 kJ (395 kcal), protein 16 g, fat 7 g, carbohydrate 66 g. The seed of the weedy types of *Chenopodium album* (in Africa and elsewhere), is probably of inferior quality and less nutritious as compared to cultivated.

In Africa, wild Chenopodium species are used as vegetables. In Madagascar and Zambia *Chenopodium giganteum* D. Don (syn: C. amaranticolor (Coste & Reyn.) Coste) is considered an excellent cooked vegetable which is closely related to Chenopodium album. The species are cultivated as a grain or vegetable crop as well as animal feed in Asia, Africa, Europe, and North America. In southern Africa young parts of *Chenopodium murale* L. are used as a cooked vegetable, in West Africa, they are sometimes used in sauces [39].

In the Himalayan range, it is a subsistence food crop and seeds are processed into flour for pancakes and bread. It is boiled and mixed with other ingredients to make a kind of gruel, or is roasted and ground for porridge or also used for preparing fermented and alcoholic beverages.

The leaves and young shoots of this plant are used in dishes such as soups, curries, and paratha-stuffed bread, especially popular in Punjab. The seeds or grains are used in *phambra* or *laafi*, gruel-type dishes in Himachal Pradesh and mildly alcoholic fermented beverages such as *soora* and *ghanti*. The seed is also used as poultry and livestock feed [13].

In Ayurveda, the plant is used to cure the diseases of blood, heart, spleen and biliousness conditions. The seed of it has also been used traditionally to improve the appetite and as an anthelmintic,

laxative, aphrodisiac and tonic [42]. The grains of quinoa (*C. quinoa* Wild.), a pseudo-cereal has high nutritious values due to its outstanding protein quality, a wide range of minerals and vitamins. The grain protein is rich in amino acids like lysine and methionine that are deficient in cereals [6, 7].

Jardim *et al.* (2008) [16] identified about thirteen tentatively compounds (relative percent) (EO) accounted for 90.4% of the total volatile oil: α-terpinene (0.9), *p*-cymene (2.0), benzyl alcohol (0.3), *p*-cresol (0.3), *p*-mentha-1,3,8-triene (0.2), *p*-cimen-8-ol (0.6), α-terpineol (0.5), (*Z*)-ascaridole (61.4), piperitone (0.9), carvacrol (3.9), (*E*)-ascaridole (18.6), (*E*)-piperitol acetate (0.5), and (*Z*)-carvyl acetate (0.3).

Autobiographic thin layer chromatography of the EO to separate the principal fungitoxic fraction yielded only one fraction that completely inhibited the growth of all test fungi at a concentration of 0.1%. This fraction was characterized by RIs and GC-MS presenting a composition (%) of *p*-cymene (25.4), (*Z*)-ascaridole (44.4), and (*E*)-ascaridole (30.2).

It is a weed and does a salt-tolerant species inhabit semi-arid and light-saline environments in China. The methanol extract of *C. album* leaves exhibited maximum anti-breast cancer activity. The methanol extract of inflorescence of *C. album* exhibited highest antifungal activity resulting in up to 96% reduction in fungal biomass production. It has the antioxidant capacity, total phenol flavonoid glycosides (quercetin, rutin, kaempferol), thus, should be considered as a nutraceutical food and an alternative source for nutrients and free radical scavenging compounds [31].

Hydrodistilled leaves of *C. album* yielded 0.64% v/w of essential oil that displayed strong anti-inflammatory activity against 12-O-tetradecanoyl phorbol-13-acetate (TPA) induced ear edema in mice [38]. Pande and Pathak (2010) [29] reported that its leaves have great medicinal value. Pharma-cognostic (including phytochemical screening, qualitative chemical examinations) evaluation including examinations of morphological and microscopic characters, determination of leaf constant, ash value, powder analysis, and extractive values was carried out.

The plant contains essential oils, besides alkaloids, trigonelline, and chenopodine. Leaves are rich in potassium, and vitamin C. Comparative histo-pharmacognostic studies of *Chenopodium album* growing in industrial (Atlas Industry, Ghaziabad) and control land (ALTT Centre, Ghaziabad) areas have been done, and observations were enumerated [37]. It is evaluated the antibacterial activities of *C. album* against five human pathogenic bacteria. The aqueous and methanolic extracts were tested against human pathogenic bacteria *viz*. *Escherichia coli, Salmonella typhimurium, Staphylococcus aureus, Proteus vulgaris, and Pseudomonas aueruginosa* through paper disc diffusion method. The aqueous extract revealed the strongest antibacterial activity on *Staphylococcus aureus*, and methanol leaf extract showed the strongest antibacterial activity on *Pseudomonas aeruginosa* [32].

Antifungal activity of methanolic and n-hexane leaf, stem, root and inflorescence extracts (1, 2, 3 and 4% w/v) of three chenopodium species namely *C. album* L., *C. murale* L., and *C. ambrosioides* L. was investigated against *Macrophomina phaseolina.* All the extracts of these species significantly suppressed the test fungal growth. Methanol inflorescence extract of *C. album* exhibited highest antifungal activity resulting in up to 96% reduction in fungal biomass production. The various methanols extracts of *C. murale* and *C. ambrosioides* decreased fungal biomass by 62-90 and 50-84% respectively [18, 23].

The effect of sowbane mosaic sobemovirus [sowbane mosaic virus] (SoMV, isolate H) infection and autecological factors on the germination and seed viability of *Chenopodium album L., C. murale* L. and *C. quinoa* Willd were investigated. Autecological factors influenced the germination of Chenopodium spp. seeds to a greater extent than SoMV infection. SoMV infection caused an average reduction in germination of 6% for *C. quinoa*, 15% for *C. album* and 21% for *C. murale* stored seeds. The opposite effect was observed for *C. quinoa* [19].

Quinoa (*Chenopodium quinoa* Willd.) is an important seed crop for human consumption in the Andean region of South America. This genetic map provides a key starting point for genetic dissection

of agronomically important characteristics of quinoa, including seed saponin content, grain yield, maturity, resistance to disease, frost, and drought [24].

Jabbar, Zaman, Iqbal, Yaseen, and Shamim (2007) [15] carried out the study to determine the anthelmintic activity of *Caesalpinia crista* seed kernel and *C. album* whole plant to justify their traditional use in veterinary medicine. These data show that both plants possess anthelmintic activity *in-vitro* and *in-vivo*. *C. album* showed antiulcer activity in rats evaluated by three models.

Protective action of its methanol extract was evaluated in an animal model of hepatotoxicity induced by carbon tetrachloride (CCl_4). Serum bilirubin and protein levels were evaluated and scientifically validate the traditional use of *C. album* for liver disorders [35.]

Fine powder of leaves of *C. album* is dusted to ally irritation, and leaf juice is used for treating burns. A decoction of aerial parts mixed with alcohol is rubbed on the affected parts by arthritis and rheumatism. They also reduced the elevated level of serum alkaline phosphatase (ALP), serum acid phosphatase (ACP) and serum bilirubin. Reduced enzymic and nonenzymic antioxidant levels and elevated lipid peroxidase level were restored to normal by administration of methanol and acetone extract of *C. album*. The result compared with silymarin (100 mg/kg; oral), the standard drug and concluded that acetone and methanolic extract at (400 mg/kg, oral) showed significant $p<0.001$ hepatoprotective activity similar to that standard drug, silymarin [27, 1].

It investigates the effect of ethanolic extract of chenopodium on general mating behavior, libido, potency along with its likely gastric ulceration and adverse effects on sexually normal male albino mice. A significant and sustained increase in the sexual activity of normal male mice, without any conspicuous gastric ulceration and adverse effects was reported [28, 29].

It was studied the leaves of four *C. album* cultivar was analyzed for the anti-nutritional composition viz. tannins, simple phenols, total phenols, phytic acid, oxalates, flavonoids, alkaloids, trypsin inhibitor activity (TIA), phytic acid and phytate phosphorus using standard methods. Certain anti-nutrients among these besides being an anti-nutrient also exert positive health effect especially phenolic compounds, flavonoids, alkaloids thus can also be utilized for pharmaceutical purpose [34].

Singh, Shivhare, Singhai, Sharma, and Narain (2010) [33] reported a major class of phyto-constituents includes nonpolar lipid, phenols, and lignins, alkaloids, flavonoids, glycosides and saponins in Chenopodium. The plant has been traditionally used as a laxative, anthelmintic against round-and hookworms, blood-purifier, anti-scorbutic. Pharmacologically studies have revealed that the plant has been exhaustively explored for its anthelmintic, sperm immobilizing and contra-ceptive action, antipruritic and antinociceptive action.

The leaves of *Chenopodium ambrosioides* have been used to treat many diseases. The treatment with a small dose (5 mg/kg) of hydroalcoholic extract (HE) from its leaves has immuno-stimulatory effects. The subchronic treatment with HE induced punctual alterations in the groups treated with the highest doses. The HE treatment was not lethal and did not induce toxic alterations using the therapeutic dose, suggesting that it is safe to use this product in the adequate dose [30].

Two antiviral proteins (AVPs) named CAP-I and CAP-II isolated and purified from the leaves of *C. album* cv Pusa Bathua 1 were found to inhibit tobacco mosaic virus (TMV) and sunnhemp rosette virus (SRV) infection on their respective host plants. They differed concerning the amino acid composition and N-terminal sequence. They also differed concerning IC_{50} values, and CAP-I was found to be 2.5 fold more effective than CAP-II in inhibiting viral infection [12].

Superoxide dismutase is the first line of defense against oxidative stress and thus helps in maintaining cellular integrity. *C. murale*, a weed species adapted to widely varying climatic conditions faces extremes of temperatures ranging from 4 °C to 45 °C (T_{max}) during growth and development. The presence of stable monomeric chloroplastic Cu/Zn superoxide dismutase might help the plants to maintain the cellular homeostasis against adverse environmental conditions [36].

Thermal stability of antioxidant defense enzymes was investigated in leaf and inflorescence of heat adaptive weed *C. album*. Superoxide dismutase was the most heat stable enzyme followed by ascorbate peroxidase. These showed activity up to 70 °C in both leaves and INF. DHAR activity was stable up to 60 °C while GR and MDHAR declined sharply after 40 °C. Constitutive heat stable isozymes of SOD and APX in leaves and INF may contribute towards heat tolerance in *C. album* [11]. Most of the exotic accessions of *C. giganteum* were both stable and high yielding, reflecting the potential of these accessions for future breeding programs/variety release [6, 7, 8, 9, 17].

Biotechnological Approaches and Future Perspectives: The pollens of *C. album* are one of the main sources of pollen allergy in desert and semi-desert areas and contain three identified allergens. Diagnostic potential of the allergenic cocktail was investigated in 32 individuals using skin prick test, and obtained results were compared with the acquired results from *C. album* pollen extract. Specific IgE reactivity against the pollen extract and allergenic cocktail was determined by ELISA and western blotting tests.

The reliable results obtained from this study confirmed that the allergenic cocktail with high diagnostic potential could be replaced with natural *C. album* allergen extracts in skin prick test and serologic tests [26].

In a combined study like ethnobotanical, morphological, phytochemical and genetic information was conducted for analyzing differences between managed and unmanaged populations of the Mexican edible weed. The effects of nine novel 2-benzylamino-1, 3, 5-triazines on photosynthetic reactions were measured in thylakoids isolated from wild-type and atrazine-resistant plants of *C. album*. All the nine novel 2-benzylamino-1,3,5-triazines were almost as active in wild-type as in atrazine-resistant thylakoids, indicating that the benzylamino substitution may be important for the lack of resistance in the atrazine-resistant plants [20, 6, 7, 10].

The 3′ end of the chloroplast (ct) psbA gene is present in the mitochondrial genome of *C. album* and is expressed in mitochondria from atrazine-resistant plants. Short, specific chloroplast psbA gene probes reveal a 270 bp homolog with the 3′ end of the chloroplast psbA gene. Comparison of susceptible and resistant plants has not given evidence of modification in the mitochondrial (mt) genome; however, the homologous 3′ end of the ct psbA gene present in the mitochondria is expressed as part of a 0.8 kb transcript only in atrazine-resistant plants and not insusceptible ones [5].

Protoplasts of *C. album* suspension culture show large, up to 5-fold, changes in the surface area upon hypertonic or hypotonic treatment. Fluid-phase uptake experiments with the fluorescence dyes 5, 6-carboxyfluorescein and Lucifer yellow CH, demonstrated osmotic shrinkage of protoplasts is accompanied by vesicular uptake of the external medium into protoplast cytoplasm. The rate of osmocytotic vesicle uptake was higher in the presence of calcium chloride than in the presence of EDTA in the external medium [40].

Mitochondrial (mt) DNA of higher plants is unique in its large size and complexity. About 2.0-8.5% of the chromosomal mtDNA from a suspension culture (depending on the growth stage) and 6.5% of the chromosomal mtDNA from whole plants of *C. album* were found to be in ss form by dot-blot hybridization after neutral transfer. Similar amounts of ss mtDNA were observed by binding of the single-strand binding (SSB) protein of *E. coli* under the electron microscope [3].

Reactive oxygen species (ROS) such as superoxide anions, hydrogen peroxide, and hydroxyl, nitric oxide radicals, play an important role in oxidative stress related to the pathogenesis of various important diseases. Flavonoids and phenolic compounds widely distributed in plants which have been reported to exert multiple biological effects, including antioxidant, free radical scavenging abilities, anti-inflammatory, and anticarcinogenic activities.

Aqueous leaf extract of *C. album* and methanolic fruit extract of *Vitis trifolia* exhibit significant reducing power and free radical scavenging effect on DPPH, hydroxyl superoxide, hydrogen peroxide radicals. Leaf extract of *C. album* was found to contain 0.94% total phenolic contents (gallic acid equivalent) and 0.27% total flavonoid contents (catechin equivalent). The fruit extract of *V. trifolia* was found to contain 1.23% phenolic compounds

as gallic acid equivalent (GAE) and 0.38% flavonoid content as catechin equivalent (CE) [22].

The effects of long-term NaCl and KCl treatment on plant growth and antioxidative responses were investigated in *C. album*, a salt-resistant species widely distributed in semi-arid and light-saline areas of Xinjiang, China. Growth level of oxidative stress activity of antioxidant enzymes the contents of non-enzymatic antioxidants [carotenoids (Car) and ascorbic acid (AsA)] and expression of selected genes was investigated. These results suggest that efficient antioxidant machinery is important for overcoming oxidative stress induced by treatment with high NaCl concentrations in *C. album*. Other strategies of ion regulation may also contribute to the differential tolerance to Na and K at higher concentrations [43]. To identify genes expression in *C. album* exposed to NaCl stress and screen ESTs related to salt stress, subtractive suppression hybridization (SSH) library of *C. album* under salt stress was constructed. The results suggested that genes corresponded to these ESTs might be involved in stress response or regulation. The complete sequences and detailed function of these ESTs need to be further studied [14].

Production of heat-shock proteins (Hsps) is a key adaptation to acute heat stress and will be important in determining plant responses to climate change. To understand intraspecific variation in plant Hsps and its relevance to global warming, five naturally occurring populations of *C. album* from contrasting thermal environments grown at low and high temperatures. Physiological thermotolerance was partitioned into basal and induced components. As with Hsps, induced thermotolerance decreased with increasing temperature variability [4]. Chenopodium commonly consumed as vegetable worldwide. It is generally propagated by seed that is slow and labor intensive method. To meet the growing demand of crop or its large scale cultivation plant tissue culture techniques offer an opportunity for rapid clonal propagation of the desired crop. It may be a future crop due to its nutritive value.

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