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THE CHEMICAL CONSTITUENTS AND PHARMACOLOGICAL EFFECTS OF *CHENOPODIUM ALBUM* - AN OVERVIEW

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ABSTRACT

Chenopodium album was reported to contain trypsin inhibitor activity 0.11-0.17 TIU/mg, total phenols 224.99-304.98 mgGAE/100g, simple phenols 72.50-101.007 mgGAE/100g and tannins 152.49- 203.91 mgGAE/100g, saponin 0.043-0.867 g/100g, phytic acid 238.3-268.33 mg/100g, phytate phosphorus 67.16-75.62 mg/100g, alkaloids 1-27-1.53 mg/100g, flavonoids 220.0-406.67 mg/100g, oxalates 394.19-477.08 mg/100g, oils, proteins , trace elements amd many other bioactive contents . It was reported that *Chenopodium album* exerted anti-inflammatory, analgesic, gastroprotective, hepatoprotective, anticancer, antioxidant, antimicrobial , anthelmintic, insecticidal and many other effects. The present review will highlight the chemical constituents and the pharmacological and therapeutic effects of *Chenopodium album*.

key words: *Chenopodium album*, pharmacology, constituents.

INTRODUCTION

Since the dawn of civilization, man utilized plants for their medicinal and edible value. By trial and error, and before the introduction of chemical medicines, man distinguished between the beneficial and poisonous plants. Each population in the world developed its own traditional medical knowledge and experiences. World Health Organization estimates that about 80% of the world populations rely almost exclusively on traditional medicine for their primary healthcare needs. *Chenopodium album* was reported to contain trypsin inhibitor activity 0.11-0.17 TIU/mg, total phenols 224.99-304.98 mgGAE/100g, simple phenols 72.50-101.007 mgGAE/100g and tannins 152.49- 203.91 mgGAE/100g, saponin 0.043-0.867 g/100g, phytic acid 238.3-268.33 mg/100g, phytate phosphorus 67.16-75.62 mg/100g, alkaloids 1-27-1.53 mg/100g, flavonoids 220.0-406.67 mg/100g, oxalates 394.19-477.08 mg/100g, oils, proteins , trace elements amd many other bioactive contents . It was reported that *Chenopodium album* exerted anti-inflammatory, analgesic, gastroprotective, hepato protective, anticancer, antioxidant, antimicrobial , anthelmintic, insecticidal and many other effects. The present review will highlight the chemical constituents and the pharmacological and therapeutic effects of *Chenopodium album.*

Synonyms

Chenopodium album L. var.*lanceolatum* (Muhl. Ex Willd.) Coss & Germ., *Chenopodium album* L. var. *polymorphum* Aellen, *Chenopodium amaranticolor* Coste & Reyn., *Chenopodium gigantum* D. Don, *Chenopodium lanceolatum* Muhl. Ex Willd., *Chenopodium suecicim* J. Murr [1].

Nomenclature and Common names

The Greek name Chenopodium means (goose) and (foot), which refer to the shape of the leaves of some species. The Latin species name album means white and alludes to the waxy covering on the plant.

Common names

Arabic: Rejil Alwaz, Thanb Alkalb, Atrah**;**

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Bengali: Chandanbethu; Chinese: Li; English: Lambsquarters, Common goose foot, Fat Hen, Lamb's-quarters, Pigweed; Fijian: Marvel lahan, Marvel mothi; French: Lamb's quarter, Pigweed, All-good, Fat hen, Muck-weed; *Chenopode sauvage* (French) Hindi: Bathua; Italian: Farinaccio; Japanese: Akaza, Iwa-akaza, Shiroza, Yamā-akaza; Kannada: Kaduoma;Konkani: Chakvit; Malayalam: Vastuccira; Oriya: Bathua; Sanskrit: Vastukah; Spanish: Ceniglo blanco; Tamil: Paruppukkirai; Telugu: Pappukura; Unani: Bathuaa, Baathu [2-3].

Taxonomic classification
Kingdom: Plantae
Subkingdom: Tracheobionta
Superdivision: Spermatophyta
Division: Magnoliophyta
Class: Magnoliopsida
Subclass: Caryophyllidae
Order: Caryophyllales
Family: Chenopodiaceae
Genus: Chenopodium
Species: *Chenopodium album* [2].

Discription

It is a fast-growing, very common in temperate regions, growing almost everywhere in soils rich in nitrogen, especially on wasteland. It tends to grow upright at first, reaching heights of 30-80 cm. **Stems:** Rarely slender, angled, often striped green, red or purple. **Leaves:** Simple, rhomboid, deltoid to lanceolate, upper entire, lower toothed or irregularly lobed, extremely variable in cultivated forms, 10-15 cm long, petioles often as long as thick blade, 1 to 1.3 cm in length. The opposite leaves can be very varied in appearance. The first leaves, near the base of the plant, are toothed and roughly diamond-shaped, 3-7 cm long and 3-6 cm broad. It has been found in dark green colour with smooth undersurface. The leaves are waxy-coated, unwettable and mealy in appearance, with a whitish coat on the underside. **Flowers:** Radial, symmetrical and grow in small cymes on a dense branched inflorescence, 10-40 cm long, contains shining black seeds. Its pollen can contribute to hayfever-like allergies [3-4].

History and Distribution

It is native of Europe and Western Asia [5-6], bathua is an ancient plant, according to the book (Food in China), bathua has been a food source of several old civilizations: it was likely cultivated in Neolithic Europe (7,000-1700 BC), and was also found in China circa 5th century AD. Most botanists agree that its origins are indeed in Europe, and evidence supports the claim that hunter-gatherers ate bathua throughout the Bronze age and Iron age. A number of interesting anecdotes describe bathua's unusual history: For example, Neolithic architects discovered bathua seeds in early Britain's earthen pots. Scandinavia's Tollund Man, a mummified corpse of a person thought to live circa 4th century BCE, had lamb squarters seeds found in his stomach at his execution site in a Danish bog. Many other accounts mention it as a source of food for the early Vikings, and Peter Kalm's 1749 writings describe the ways in which Scandinavians boil the greens in meat-infused water. Even Napoleon Bonaparte relied on bathua seeds to feed his troops during lean times. Curiously, archeological remnants reveal that North American Blackfoot Indian tribes were using the weed in the early 1600s [6].

However, now, it is one of the most widely distributed species of weeds in the world, especially the temperate zones [7].

Traditional uses

In India, the plant is used as a laxative, diuretic, sedative and the infusion of the plant is used for the treatment of rheumatism [8]. It was also used as an antidiarrhoeal, antiphlogistic, antirheumatic, contraceptive, odontalgic, cardiotonic, antiscorbutic, blood purifier, digestive, carminative, aphrodisiac, for the treatment of dyspepsia, flatulence, strangury, seminal weakness, pharyngopathy, splenopathy, hemorrhoids, ophthalamopathy, cardiac disorder, hepatic disorder, spleen enlargement, biliousness, intestinal ulcers, and general debility [9-12].

The plant was also used traditionally as, anthelmintic against round-and hookworms, antiscorbutic [13], for treatment of abdominal pain, eye disease, throat troubles and cardiovascular disorders [14]. Boiled tender shoot is used in constipation [15]. Fine powder of *Chenopodium album Linn.* leaves was dusted to ally irritation and leaf juice was used for treating burns. Decoction of aerial parts mixed with alcohol was rubbed on the body part affected by arthritis and rheumatism [16].

Physicochemical properties

The proximate analysis of the fresh leaves revealed that total ash value was 9.55%, water soluble ash 3.85%, acid insoluble ash 8.33%, alcohol soluble ash 7.28% and sulphated ash 10.11%. Successive solvent extraction values in various organic solvent revealed that the extractive percents were: petroleum ether 3.53%, benzene 2.33%, chloroform 2.83%, acetone 2.66%, methanol 5.44% and ethanol 4.55% [4,17].

Chemical constituents

Analysis of the leaves of four *Chenopodium album* cultivars showed that they contained trypsin inhibitor activity 0.11-0.17 TIU/mg, total phenols 224.99-304.98 mgGAE/100g, simple phenols 72.50-101.007 mgGAE/100g and tannins 152.49- 203.91 mgGAE/100g, saponin 0.043-0.867 g/100g, phytic acid 238.3-268.33 mg/100g, phytate phosphorus 67.16-75.62 mg/100g, alkaloids 1-27-1.53 mg/100g, flavonoids 220.0-406.67 mg/100g and oxalates 394.19-477.08 mg/100g [18-19].

However, the major phytoconstituents isolated from different parts of the plant included non polar lipid, phenols, lignins, alkaloids, flavonids, glycosides, saponins, ascorbic acid, β-carotene, catechin, gallocatechin, caffeic acid, p-coumaric acid, ferulic acid, β-sitosterol, campesterol, xanthotoxin, stigmasterol, n-triacontanol, imperatorin, ecdysteroid [13,20], crytomeridiol [21], n-transferuloyl- 4-O-methyl dopamine , β- sitosterol, lupeol and 3 hydroxy nonadecyl henicosanoate [22-23].

The analysis of the aqueous solution of the hydro-alcoholic extract from the leaves of *Chenopodium album* after acetone precipitation, led to the isolation of many lignans: pinoresinol, syringaresinol, lariciresinol and its derivative compound and three sesquilignans [22]. Eighteen apocarotenoids were isolated from the weed *Chenopodium album* [24]. Three saponins were isolated from the roots of *Chenopodium album* [25]. Four phytoecdysteroids, 20-hydroxyecdysone, 20-hydroxy-24-methylen-ecdysone, 20,26-dihydroxyecdysone and phenolic glycoside, chenoalbuside were also isolated from the methanol extract of the seeds of *Chenopodium album* [26]. Two proteins, CAP-I and CAP-II were purified from the leaves of *Chenopodium album* [27]. However, Che a 1 protein was also isolated from the plant, it is a glycoprotein of molecular mass 17.088 kD and 143 amino acid residues, it is structurally related to the Ole e 1-like protein family [28]. Seven cinnamic acid amides were also isolated from *Chenopodium album* [29].

The leaves of C*henopodium album* gave 0.64% oil v/w. The oils of the leaves of C*henopodium album* contained (%): tricyclene: trace, α-thujene: trace, α-pinene: 7.0, camphene: trace, sabinene: trace, β-pinene: 6.2, myrecene: trace, p-cymene: 40.9, limonene: 4.2, benzyl alcohol: trace,1,8-cineole: trace, cis-ocimene: trace, γ-terpinene: trace, linalool: trace, pinane-2-ol: 9.9 , allo ocimene: trace, citronellal: trace, borneol: trace, terpinen-4-ol: trace,α-terpineol:6.2, citronellol: trace, ascaridole:15.5, neral: trace, linalyl acetate: 2.0, geranial: trace, borneol acetate: trace, thymol: trace, carvacrol: trace, ethyl cinnamate: 3.7, acetyl eugenol: trace, elemicin: trace and benzyl benzoate: trace [30].

Trace elemental analysis in mg/100 g/dry weight (dw) indicated that the leaves contained sodium, potassium, calcium, magnesium, iron, zinc, phosphorus, copper, manganese, and nitrogen [18].

Arora et al found that the polyphenolic and flavonoid content of different *Chenopodium album* aerial parts extracts were in the range of 14.56±0.21-42.00±0.2mg (gallic acid equivalent/g extract) and 2.20±0.003-7.33±0.5 mg (rutin equivalent/g extract) respectively [8].

Many phenolic compounds were isolated from different parts of the plant. Analysis of the aqueous solution of the hydro-alcoholic extract from the twigs of *Chenopodium album* led to the isolation of 4-vinyl phenol . The analysis of the aqueous solution of the hydro-alcoholic extract from the leaves of *Chenopodium album* after acetone precipitation, led to the isolation of vanillic alcohol and 4-methyl benzaldehyde. A phenolic glycoside, chenoalbuside was isolated from the methanol extract of the seeds of *Chenopodium album*. Cinnamic ac

The effect of selected processing and storage methods on the concentration of ascorbic acid and beta-carotene in *Chenopodium album* leaves were studied. Methods included storage of leaves with or without polythene bags for 24 and 48 h in a refrigerator at 5 degrees C; at 30 degrees C in polythene bags; drying (sun and oven); blanching (5, 10, 15 min); open pan and pressure cooking. Ascorbic acid content of fresh leaves was 220.97 to 377.65 mg and beta-carotene content was 19.00 to 24.64 mg/100 g, dry weight. The percent loss of ascorbic acid ranged from 2.03 to 8.77 and 45.15 to 66.9 while lower losses (0.0 to 1.75 and 1.63 to 2.84) of beta-carotene were observed in leaves stored in the refrigerator and at 30 degrees C, respectively. A markedly greater reduction in ascorbic acid and beta-carotene was observed in dried, blanched and cooked leaves. The study data suggest that storage of leaves in refrigeration, drying in oven, blanching for a short time and cooking in a pressure cooker results in better retention of these two vitamins [32].

Pharmacological effects

Antioxidant effect

Total oxidative status (TOS) and the total antioxidative status (TAS) levels were determined to evaluate the antioxidant activity of *Chenopodium album* ethanolic leaf extract (CAE). Results indicated that there was a good correlation between dose of CAE and TAS levels [33].

The anti-oxidant activity (expressed as percent inhibition relative to control, using β-carotene bleaching method) of aqueous and ethanolic extracts of *Chenopodium album* were 64.5 and 60.5% respectiviley [34]. The extracts also caused DPPH radical scavenging activities which were comparable to those of ascorbic acid. This was also the same for BHT scavenging activity [18]. The protective effects of CAE was evaluated on both yeast and human mononuclear leukocytes' genomic DNA upon oxidative shock.*Chenopodium album* ethanolic leaf extract (CAE) protected the DNA of both yeast and mononuclear leukocytes against the damaging effect of hydrogen peroxide [33].

Antimicrobial, anthelmintic and insecticidal effects

The extracts of the plant caused varied inhibition of some bacterial strains[18]. The antibacterial effects of *Chenopodium album* ethanolic leaf extract (CAE) was studied against gram positive and gram negative microorganisms. Antibacterial activity was recorded against *Bacillus subtilis* with 13 mm of inhibition zone [33].

The *in vitro* antimicrobial activities of the flowers and leaves methanolic and ethanolic extracts of *Chenopodium album* was studied against 4 bacterial strains [*Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853), *Bacillus cereus* (ATCC 1274) and *Staphylococcus aureus* (ATCC25923)] [34].

However, in other studies, the antibacterial activities of *Chenopodium album* was investigated against five human pathogenic bacteria (*Escherichia coli, Salmonella typhimurium, Staphylococcus aureus, Proteus vulgaris* and *Pseudomonas aueruginosa*). The leaf extracts of *Chenopodium album* (aqueous and methanol) exhibited significant antibacterial activity against all the tested bacteria. The aqueous extract performed strongest antibacterial activity against *Staphylococcus aureus* with (25 mm) zone of inhibition and the least antibacterial activity was observed against *Salmonella typhimurium* with (17.75 mm) zone of inhibition. On the other hand, methanol leaf extract of *C album* also displayed potential antibacterial activity against all the tested bacteria. The strongest activity was recorded against *Pseudomonas aeruginosa* with (28.30 mm) zone of inhibition, while, the lowest antibacterial activity was observed against *Salmonella typhimurium* with (14.00 mm) zone of inhibition [5].

The zones of growth inhibition of methanol and ethyl acetate extracts of the plant were: 17.3mm against *Staphylococcus aureus* ATCC 25923, 19.7mm against *Bacillus subtilis* UC 564 (19.7 mm), 18.3mm against *Bacillus polymexia* 474, 16.7mm against *Streptococcus faecalis* ATCC 29212, 17.7mm against *Pseudomonas aerugenosa* 25619), 16.7mm against *Salmonella typhi* 57, 17.3mm against *Vibrio cholerae* 824, 17.3mm against *Shigella dysenteriae* ATCC C3, 18.0mm against *Escherichia coli* NCTC 8196, 15.0mm against *Penicillum notatum* ATCC 11625, 16.3mm against *Aspergillus niger* AB 41 and 18.3mm against *Candida albicans* ATCC 18804 [35].

However, Amjad and Alizad mentioned that the flowers and leaves methanolic and ethanolic extracts of *Chenopodium album* don't have any activity against the tested bacterial strains [36].

Antifungal activity of methanol and n-hexane leaf, stem, root and inflorescence extracts of *Chenopodium album* (1, 2, 3 and 4% w/v) was investigated against *Macrophomina phaseolina*, a soil-borne fungal plant pathogen that has a broad host range and wide geographical distribution. The n-hexane extracts of *Chenopodium album* reduced fungal biomass by 60-94% [37].

Two proteins, CAP-I and CAP-II purified from the leaves of *Chenopodium album* induced systemic resistance against tobacco mosaic virus (TMV) and sunnhemp rosette virus (SRV) in both hypersensitive as well as systemic hosts. Both CAP-I and CAP-II caused in vitro degradation of TMV RNA. It is suggested that the CAP-I and -II are multi-functional and may be acting at multiple levels to ensure maximum possible inhibition of viral infection [27].

The anthelmintic activity of the plant (50, 25 and 12.5 mg/ml) was recorded against adult Indian earthworm, *Pheretima posthuma* [36].

In vitro anthelmintic activity of crude aqueous methanolic extract (AME) of of *Chenopodium album* whole plant was studied using mature *Haemonchus contortus* and their eggs in adult motility assay and egg hatch test respectively. *In vivo* anthelmintic activity was evaluated in sheep naturally infected with mixed species of gastrointestinal nematodes by administering crude powder (CP) and AME in increasing doses (1.0-3.0 g/kg). Extracts exhibited dose- and time-dependent anthelmintic effects by causing mortality of worms and inhibition of egg hatching. LD_{50} for *Chenopodium album* was found to be 0.449 mg/ml in egg hatch test. In vivo, maximum reduction in eggs per gram (EPG) of faeces was recorded as 82.2% at 3.0 g/kga of *Chenopodium album* AME [38].

Insecticidal effect was exerted by the petroleum ether, carbon tetrachloride and methanol extract of *Chenopodium album* against malaria vector, *Anopheles stephensi* Liston. It influenced the early life cycle of *Anopheles stephensi* by reducing the percentage of hatching, larval, pupal and adult emergence and also lengthening the larval and pupal periods. The growth index was also reduced significantly [39].

The biological effect of polar and non-polar secondary metabolites from the aerial parts (leaves and inflorescences) of *Chenopodium album* against *Oryzaephilus surinamensis* was studied. The results show that the aqueous extract of *C album* was effective with low percentage survival of adult and larval stages [40].

Anti-inflammatory and analgesic effects

The topical anti-inflammatory activity for C*henopodium album* oil (5-0.625 mg) was evaluated by inhibition of the 12-O-tetradecanoylphorbol-13-acetate (TPA) induced ear edema in mice. The result revealed that the anti-inflammatory action of the oil is concentration dependent, the percentage reduction in the ear edema increases with increase in concentration of the oil. However, the oil caused significant reduction ($p < 0.05$) in the ear edema with all concentrations except at 0.625 mg [30].

The ethanolic extract from the fruits of *Chenopodium album*, 100-400 mg/kg orally, caused dose-dependently inhibition of scratching behavior induced by 5-HT (10 micro g per mouse, sc) or compound 48/80 (50 micro g per mouse, sc). But it failed to affect hind paw swelling induced by 5-HT or compound 48/80 in mice at doses of 100 and 200 mg/kg and only showed a relatively weak inhibition on the swelling at a higher dose of 400 mg/kg [41].

The role of NF kappa B (NFκB) in the antiarthritic potential of extracts of aerial parts of *Chenopodium album* was explored and evaluated. The result indicated that the acetone extract of *Chenopodium album* (ACCA) has shown significant reduction in rat paw edema (80.13%) at dose level of 200mg/kg orally in 21 days of the experiment. On 22nd day, it was observed that the altered hematological parameters (Hb, RBC, WBC and ESR), biochemical parameters (serum creatinine, total proteins and acute phase proteins) and loss in body weight in the arthritic rats were significantly brought back to near normal level by the ACCA extract. ACCA extract significantly decreased the NFκB expression in paraventricular nucleus of hypothalamus and this effect is comparable with standard indomethacine [8].

Significant analgesic effect was observed for the crude extract at 500 mg/kg dose from 30 min - 210 min using tail flick method in mice [42].

Spasmolytic effect

The plant was extracted in ethanol and fractionated in ethyl acetate, chloroform, *n*-butanol and water. The crude extract and its fractions were tested *in vitro* on intestinal smooth muscles of rabbit. The crude extract exhibited a dose-dependent increase in relaxation of smooth muscles, starting from 5 mg/ml and maximum effect was found at 20 mg/ml (92.86%). All the fractions were added to rabbit's intestine at 15 mg/ml dose. The ethyl acetate and chloroform fractions of C*henopodium album* exhibited relaxation of the intestinal muscles (43.48 and 51.52%, respectively); whereas, *n*-butanol fraction of C*henopodium album* produced strong relaxant effect (91.18%) [42].

Gastroprotective effect

The effect of alcoholic extract of *Chenopodium album* was investigated in rats to evaluate the antiulcer activity by using three models, pyloric ligation, ethanol and cold restraint stress induced ulcers. Alcoholic extract significantly decreases the volume of gastric acid secretion, free acidity, total acidity and ulcer index with respect to control. Sections of ulcerated area revealed that there was a significant increase in regenerated glandular epithelium width after treatment with the alcohol extract. The collagen content in the ulcerated tissue was significantly increased by alcohol extract and ranitidine as positive control. No significant difference on capillary density in scar tissue was observed after treatment with alcohol extract or ranitidine [43].

Hepatoprotective effect

The antioxidant and hepatoprotective efficacy of C*henopodium album* extract (300 mg/kg and 450 mg/kg) was evaluated in carbon tetrachloride (CCl_4) induced hepatotoxicity in rats. C*henopodium album* extract was found to exhibit excellent antioxidant and free radical scavenging activity, when compared with ascorbic acid, in *in vitro* studies, C*henopodium album* extract at a dose of 450 mg/kg showed inhibition of elevated biochemical parameters associated with induction of hepatotoxicity by CCl_4. It was also attenuated histopathologic effects of CCl4 [14].

Alcoholic and aqueous extracts of the aerial parts of *Chenopodium album* at the doses of 200 and 400 mg/Kg were evaluated for hepatoprotective activity against paracetamol induced hepatotoxicity. The aqueous extract at a dose of 400 mg/kg was found to be more potent when compared to Silymarin. The alcoholic and aqueous extracts of *Chenopodium album* significantly restore physiological integrity of hepatocytes. Aqueous and alcoholic extract did not show any sign of toxicity up to oral dose of 5 g/Kg in mice [44].

The hepatoprotective activities of dried whole plant of *Chenopodium album Linn*, acetone and methanol extracts in ratio of (50:50), was also evaluated against paracetamol induced hepatic injury. Acetone and methanol extract at adose of 400mg/kg orally, showed significant ($p<0.001$) hepatoprotective activity, their effect was similar to the standard drug, silymarin [16].

Anticancer effect

The effects of *Chenopodium album* (leaves) was evaluated on the growth of estrogen dependent (MCF-7) and estrogen independent (MDA-MB-468) human breast cancer cell lines. The different solvent extracts (petroleum ether, ethyl acetate and methanol) were assessed for their cytotoxicity using Trypan blue exclusion and MTT [3-(4, 5-dimethyl thiazol-2-yl)-2, 5-diphenyl tetrazolium] bioassay. Methanolic extract of *Chenopodium album* (leaves) exhibited maximum antibreast cancer activity having IC_{50} value 27.31 mg/ml against MCF-7 cell line. Significant percent inhibition (94.06%) was recorded for MeOH extract of *Chenopodium album* (leaves) at 48 h of exposure and concentration 100 mg/ml ($p < 0.05$) against MCF-7 breast cancer cell line [45].

Effect on male reproduction

Ethanolic extract of *Chenopodium album* at doses of 100, 250 and 500mg/kg bw orally, in male albino mice showed significant increase in the mount frequency, intromission frequency, intromission latency as well as aggregate of penile reflexes and significant reduction in the post ejaculatory interval. Moreover 500 mg/kg, orally, was found to be the most effective dose [46].

The ethanolic extract of seeds of *Chenopodium album* was evaluated for its effect on anabolic activity, sexual behavior and sperm count in male rats. Administration of ethanolic extract at a concentration of 200 mg/kg bw resulted in pronounced anabolic effect in treated animals as evidenced by an increased body weight as well as the weight of reproductive organs. Sexual behavior and performance were also markedly improved as

reflected in reduction of mount, intromission and post ejaculatory latency. Furthermore, the extract also enhance sperm count [47].

However, on the other hand, the effect of *Chenopodium album* seed extract (CAE) induced sperm death, the effect which is due to (a) lipid peroxidation of the sperm cell membrane, oxidation of some critical cellular proteins and depletion of intracellular reduced gluthathione, indicating production of ROS; (b) activation of Mn-SOD and inactivation of catalase favoring endogenous accumulation of H_2O_2; (c) generation of O^{2-} at an enhanced rate during oxidative stress as evidenced by increased Mn-SOD activity and protein expression; (d) accumulation of ROS in spermatozoa and (e) increased production of O^{2-} and H_2O_2 induced apoptosis-like death in sperm cells as observed by DNA ladder formation. Therefore, the sperm death caused by CAE is due to oxidative damage of cellular macromolecules by in situ generation of ROS [48]. Aqueous decoction of *Chenopodium album* seeds (CAD) was assessed for its sperm-immobilizing and contraceptive efficacy in laboratory mammals. The minimum effective concentration of CAD that induced instantaneous immobilization of rat spermatozoa *in vitro* was 2 mg/ml. The mechanism of CAD action involved disintegration of sperm plasma membrane and dissolution of acrosomal cap causing sperm death. Fertilization of oocytes and establishment of implantation were prevented in the uterine horn that was administered with CAD. In rabbit, intravaginal application of CAD significantly blocked the establishment of pregnancy. Accordingly, CAD possesses appreciable spermicidal potential, which may be explored as an effector constituent of vaginal contraceptive [49].

Contraindication and adverse effects

Chenopodium album was an allergenic plants. Some preparations of its extracts were used for diagnosis and immunotherapy of patients. The allergic extract of *Chenopodium album* pollen has been prepared and examined in skin prick testing in comparison with a commercial product in Iran [50].

The effects of an extract prepared from *Chenopodium album* pollen was investigated to induce allergic asthma in BALB/C mice. Mice were sensitized by ip injection and an intratracheal instillation of the extract of *Chenopodium album*. *Chenopodium album* extract increased serum levels of specific IgE and production of IL-4 and IL-5 from splenocytes. An airway eosinophilia was also demonstrated in mice [51].

Sun exposure after oral intake of *Chenopodium album* can lead to sunburn-like rashes owing to its furocoumarin content. Many studies recorded that patients developed dermatitis with edema, erythema and necrosis on the face and dorsum of the hands when they exposed to sunlight after eating *Chenopodium album* [52-53].

The safety standards of *Chenopodium album* seed decoction (CAD) was evaluated. In vitro irritation studies on rabbit erythrocytes revealed the hemolytic index of CAD to be 8.2 mg/ml. The dermal irritation test showed that the plant wasn't irritant even at higher doses. Intra vaginal application of CAD in rat vagina for 14 consecutive days caused slight reversible inflammation on vaginal epithelial cells at doses as high as 82 mg/ml. However, at this dose level it neither had any adverse effect on vaginal tissue proliferation nor did it cause in situ apoptosis as evident from PCNA staining and TUNEL assay. Fertility and fecundity were restored 4-15 days after withdrawal of CAD application [54].

However, *Chenopodium album* can cause lethal intoxication in ruminants because it accumulated high nitrate levels (although it can also accumulate soluble oxalates). Levels of 2,500 ppm nitrate-nitrogen were reported in *Chenopodium album* hay associated with mortality in cattle [55].

CONCLUSION

The paper reviewed *Chenopodium album* as promising medicinal plant with wide range of pharmacological activities which could be utilized in several medical applications because of its effectiveness and safety.

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