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Phytochemical and Biological Activities of *Chenopodium album*

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Abstract: *Chenopodium album Linn.* (Chenopodiaceae) is an annual shrub used as folk medicine and widely grown in Europe, North America, Asia, and Africa. As therapeutic agents, it is used as laxative, anthelmintic against round and hook worms, as blood purifier in hepatic disorders, spleen enlargement, intestinal ulcers and burns. Various bioactivities such as antifungal, antipruritic, antinociceptive and hypotensive properties of crude and isolated compounds from the plant justified its uses in traditional medicine. The plant is very nutritious and rich in protein, vitamin A, vitamin C, calcium, phosphorus, iron and potassium content.
It has been found to have flavonoid as phenolic amide, saponin, cinnamic acid amide, alkaloid chinoalbicin, apocortinoid , xyloside , phenols and lignans as active phytoconstituents.
A comprehensive account of the morphology, phytochemical constituents, ethnobotanical uses and pharma cological activities reported are included in this review for exploring the immense medicinal potential of this plant.
Keywords: *Chenopodium album*, Pharmacological activities.

INTRODUCTION

India is a rich source of plant and animal wealth, which is due to its varied geographical and agro-climatic regions. Besides it's varied biodiversity, it has a diverse cultural heritage. Though at present Indian health care system consists of both traditional and modern systems of medicines, traditional systems of medicine like Ayurveda, Siddha and Unani and unorganized systems like folk medicine have been flourishing well. Ayurveda and Siddha are of Indian origin and accounted for about 60% health care system in general and 75% of rural Indian population. These two systems of medicine use plants, minerals, metals and animals as source of drugs, in which plants being the major source. It is estimated that roughly 1500 plant species in Ayurveda and 1200 plant species in Siddha have been used for drug preparation. [01.02]

The leaves of *Chenopodium album* known as bathua sag in Hindi, pigweed in English and are distributed throughout world. About 21 species occur in India [03], particularly in Western Rajasthan, Kulu valley and Shimla[04]. This plant is a polymorphous, mealy white, erect herb, up to 3.5m in height, and found wild in altitude of 4,700 meters. It is reputed to be a medicinal plant in scientific and folkloric literature and its medicinal values are well documented. It has been found to have antipruritic, antinociceptic[05], sperm immobilizing activity[06]. Medicinally, this plant has been used to treat various symptoms attributable to nutritional deficiencies. It's also said to have sedative and refrigerant properties, and people have used the poulticed leaves to soothe burns.

The herb is a common weed during summer and winter in waste places in the field of wheat, barley, mustard, gram and reduces their yield. The tender shoots are eaten raw in salad or with curd; they are also cooked as vegetable It is also used as fodder. [07]

MATERIALS AND METHODS:

Plant profile:

Chenopodium album

a) Common names:

Fat Hen, Lamb's-quarters, Pigweed (English)

Bathua (Hindi),

Paruppukkirai (Tamil)

Chandanbethu (Bengali)

Vastukah (Sanskrit)

Bathua (Oriya)

Kaduoma (Kannada)

Pappukura (Telugu)

Vastuccira (Malayalam)

Chakvit (Konkani)

b) Taxonomy:

Kingdom: *Plantae* (plants)

Subkingdom: *Tracheobionta* (vascular plants)

Superdivision: *Spermatophyta* (seed plants)

Division: *Magnoliophyta* (flowering plants)

Class: *Magnoliopsida* (dicotyledons)

Subclass*: Caryophyllidae*

Order: *Caryophyllales*

Family: *Chenopodiaceae* (Goosefoot family)

Genus: *Chenopodium (*goosefoot)

Species: *Chenopodium album*

c) Morphology: [07]

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. (Figure1)

Flowers: Radial, symmetrical and grow in small cymes on a dense branched inflorescence, 10-40 cm long, contains shining black seeds. (Figure2)

Figure 1:

Plant

Figure 2:

Inflorescence

Figure 3:

Seeds

d) Ethnobotanical Claims: [08-15]

In Rigveda, it is reported to cure all diseases. In Atharvaveda (vaidyakakalpa), it is reported to be beneficial in piles, clearing worms and act as a laxative. Charak Samhita has mentioned that it enhances digestive power. Sushruta Samhita reports that it is pungent, enhances memory, appetite, digestive power, strength of the body and destroys all worms. Rajanighantu has mentioned that it is sweet, cooling, increases appetite, antipyretic and useful in piles. In Ayurveda it is reported to be useful in curing anorexia, cough, dysentery, diarrhea, oedema, piles and kills small worms. [34]

e) Microscopy: [07]

Leaves: In powder microscopy straight walled polygonal collenchyma and yellow coloured bean shaped mass with mesh like striations were present. It contains multicellular covering type of trichome distinctly observed with bunch of parenchymatous polygonal cells. A single piece of xylem and phloem with centrally located cambium layers was also present.

In the TS of leaves presences of circular arch of xylem covered with phloem was obeserved. Thick walled parenchymatous cells were present in upper epidermis but in lower epidermis replaced by round thin walled collenchyma. Further the multicultural covering trichome was also observed on horizontal layers of parenchyma.

f) Physicochemical Evaluation: [07, 16]

The proximate analysis revealed that total ash value 9.55, water soluble ash 3.85, acid insoluble ash 8.33, alcohol soluble ash 7.28, sulphated ash 10.11, stomatal no 20-23, stomatal index 4.9- 8.8, veinislet no 8-11, veinislet termination no 5.5-7 and palisade ratio 9.5-11.9 values were observed in fresh leaves (Table 1).

g) Phytochemical studies [07]

Successive solvent extraction values in various organic solvent were observed as petroleum ether 3.53%, benzene 2.33%, chloroform 2.83%, acetone 2.66%, methanol 5.44% and ethanol 4.5%.

The preliminary phytochemical studies with the help of Thin Layer Chromatography method revealed the presence of alkaloid in chloroform, acetone, and methanol extract prominently. The flavonoid was present in chloroform, acetone, and ethanol respectively. The essential oil was observed in petroleum ether and benzene extract. (Table 2).

h) Phytoconstituents reported [17, 24]

b-sitosterol, lupeol, 3 hydroxy nonadecyl henicosanoate, ascorbic acid, b-carotene, catechin, gallocatechin, caffeic acid, p-coumaric acid, ferulic acid, campesterol, xanthotoxin, stigmasterol, imperatorin, ecdysteroid, cinnamic acid amide alkaloid, phenol, saponin, apocarotenoids, crytomeridiol, n-trans-feruloyl-4-O-methyl dopamine and syringaresinol.

The abundant constituents of the oil were: p- cymene (40.9 %), ascaridole (15.5 %), pinane-2-ol (9.9 %), α-pinene (7.0 %), β-pinene (6.2 %) and α-terpineol (6.2 %).

Table 1: Physicochemical Analysis of leaves of *Chenopodium album*

S. No.	Parameters	Values obtained w/w on dry weight basis
1.	Ash value	9.55
2.	Water soluble ash	3.85
3.	Acid Insoluble ash	8.33
4.	Alcohol soluble ash	7.28
5.	Sulphated ash	10.11
6.	Stomatal number	20 -23
7.	Stomatal index	4.9-8.8
8.	Veinislet number	8-11
9.	Veinlet Termination No	5.5-7
10.	Palisade ratio	9.5-11.9

Table 2: Phytochemical screening of various extracts of *Chenopodium album* (P- petroleum ether), (B-benzene), (C-chloroform), (A-acetone), (M-methanol), (E- ethanol)

Solvent system used	Detection Reagent	Observation	Inference	P	B	C	A	M	E
Ethyl acetate: Methanol: Water (75.5:13.5:1)	KOH	Red. (Vis) Yellow	Anthraquinone Anthrone	_	_	_	_	_	_
	Vanillin sulphuric acid	Red/yellow/brown/ bluegreen	Bitter principle	_	_	_	_	_	_
	Dragendorffs reagent	Orange Red (vis)	Alkaloid	_	_	+	+	+	_
	NP/PEG and UV	Yellow/green/orange	Flavonoid	_	_	+	+	_	+
	VS reagent	Blue (vis)	Saponin	_	_	_	_	_	_
Toluene : ethyl acetate (93: 7)	VS reagent	Red/yellow/brown/ bluegreen	Essential oil	+	+	_	_	_	_
	HCL/Acetic acid	Blue brown	Valepotriate	_	_	_	_	_	_
	NH3 / KOH	Light Blue brown	Coumarin	_	_	_	_	_	_

i) Pharmacological Studies

Hepatoprotective activity [25, 26]

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 using biochemical markers and by histopathological method. The aqueous extract at a dose of 400 mg/kg was found to be more potent when compared to Silymarin. Alcoholic and aqueous extracts [200 & 400 mg/Kg] showed significant hepatoprotective activity against paracetamol induced hepatotoxicity as evident by restoration of serum transaminases, alkaline phosphatase and bilirubin content. Histopathology of the liver tissue further confirmed the reversal of damage induced by hepatotoxin. Study showed that 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.

Antibacterial activity [27, 28]

Aqueous and methanol extracts were prepared and observed their antibacterial activity against human pathogenic bacteria Viz. *Escherichia coli, Salmonella typhimurium, Staphylococcus aureus, Proteus vulgaris* and *Pseudomonas aueruginosa* The significant results were obtained by aqueous as well as methanol leaf extract on tested pathogens using paper disc diffusion method. The aqueous extract revealed strongest antibacterial activity on *Staphylococcus aureus* and methanol leaf extract showed strongest antibacterial activity on *Pseudomonas aeruginosa.*

Spasmolytic and analgesic activity [29]

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 administered to rabbit's intestine at 15 mg/ml dose. The ethyl acetate and chloroform fractions of *C. album* exhibited relaxation of the intestinal muscles (43.48 and 51.52%, respectively); whereas, *n*-butanol fraction of *C. album* produced strong relaxant effect (91.18%). The contractile effect was only observed in aqueous fraction (29.41%). Overall, the activity produced by *n*-butanol fraction was found to be highly significant (by statistical analysis). Analgesic effect of the crude extract was

carried out by tail flick method in mice. Significant analgesic effect was observed at 500 mg/kg dose from 30 min up till 210 min.

Antimicrobial and anthelmintic activity [30]

From the different solvent extract methanol and ethyl acetate extracts were selected for the anti microbial test. The anti microbial activity was found with extracts in the form of zone of inhibition (*Staphylococcus aureus* ATCC 25923 (17.3 mm), Bacillus *subtilis* UC 564 (19.7mm), Bacillus *polymexia* 474 (18.3mm), *Streptococcus faecalis* ATCC 29212 (16.7mm), *Pseudomonas aerugenosa* 25619 (17.7mm), *Salmonella typhi* 57 (16.7mm), *Vibrio cholerae* 824 (17.3mm) and *Shigella dysenteriae* ATCC C3 (17.3mm) *Escherichia coli* NCTC 8196(18 mm) , *Penicillum notatum* ATCC 11625(15 mm), *Aspergillus niger* AB 41 (16.3), *Candida albicans* ATCC 18804(18.3 mm) .

The anthelmintic activity was evaluated on adult Indian earthworm, Pheretima posthuma due to its anatomical and physiological resemblance with the intestinal roundworm parasites of human beings. The method of Mathew et al was followed for anthelmintic Screening. Eleven groups of approximately equal sized Indian earthworms consisting six earthworms in each group were released into 50ml of desired formulation. Each group was treated with one of the following: vehicle (1% gum acacia in normal saline), piperazine citrate (15mg/ml) or extracts (50mg/ml,25mg/ml,12.5mg/ml). Observations were made for the time taken to paralyse and/or death of individual worms. Paralysis was said to occur when the worms do not revive even in normal saline. Death was concluded when the worms lose their motility followed with fading away of their body colour.

Antipruritic and antinociceptive effects [05]

The ethanolic extract from the fruits of Chenopodium album L. (FCAL), orally administered at doses of 100-400 mg/kg, dose-dependently inhibited scratching behavior induced by 5-HT (10 micro g per mouse, s.c.) or compound 48/80 (50 micro g per mouse, s.c.) in mice. 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. In addition, FCAL (200 and 400 mg/kg) significantly attenuated the writhing responses induced by an intraperitoneal injection of acetic acid and the inflammatory pain response induced by an intraplantar injection of formalin in mice. At a dose of 400 mg/kg, it also inhibited the neurogenic pain response of formalin test. In conclusion, FCAL possesses antipruritic and antinociceptive activities and the antinociceptive effects are not secondary to anti-inflammatory effects. The findings support evidence for the clinical use of FCAL to treat cutaneous pruritus.

As antibreast cancer bioagent [31]

Study was aimed to investigate the effects of Chenopodium album (leaves) 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 TBE (Trypan blue exclusion) and MTT [3-(4, 5-dimethyl thiazol-2-yl)-2, 5-diphenyl tetrazolium] bioassay. These cells were cultured in MEM (minimum essential medium) medium and incubated with the dilution series of extracts (10-100 mg/ml) in CO(2) incubator at 37^{o}C for 24 h. Among the various extracts studied for two cell lines, methanolic extract of C. album (leaves) exhibited maximum antibreast cancer activity having IC(50) (the concentration of an individual compound leading to 50% inhibition) value 27.31 mg/ml against MCF-7 cell line. Significant percent inhibition (94.06%) in the MeOH extract of C. album (leaves) at 48 h of exposure and concentration 100 mg/ml ($p < 0.05$) against MCF-7 breast cancer cell line, indicates the presence of some structural moiety responsible for this observed antiproliferative effect. In vivo study and structural elucidation of its bioactive principle are in progress. Our findings highlight the potential of this plant for its possible clinical use to counteract malignancy development as antibreast cancer bioagent.

Sperm-immobilizing agent [06]

Aqueous decoction of *Chenopodium album* seeds (CAD) was assessed for its sperm-immobilizing and contraceptive efficacy in laboratory mammals. Spermicidal efficacy was evaluated in vitro by a modified Sander–Cramer test. The mode of spermicidal action was assessed by (a) supravital and double fluoroprobe staining of sperm, (b) hypoosmotic swelling tests and (c) transmission electron microscopy. Contraceptive

efficacy was evaluated by intrauterine and vaginal application of CAD in rats and rabbits, respectively, followed by their mating and evaluation of pregnancy outcomes.

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, while these events occurred unhindered in the untreated contralateral side. In rabbit, intravaginal application of CAD significantly blocked the establishment of pregnancy. CAD possesses appreciable spermicidal potential, which may be explored as an effector constituent of vaginal contraceptive.

Evaluation of safety margins and microbicidal activity studies [32]

Study was carried out to explore the safety standards of CAD along with microbicidal properties as prerequisite for its use as a topically applicable vaginal contraceptive .The safety standards of CAD were assessed by a) Hemolytic index determination using rabbit erythrocytes, to set the doses of the other experiments, b) Dermal irritancy test using refined version of Draize scoring system on rabbits, c)Possible effects on local tissues and reproductive performacnce in female rats after fourteen daily single dose application, d) PCNA staining –to evaluate the effect of CAD on vaginal tissue proliferation,e) TUNEL assay-to examine its ability to induce *in situ* apoptosis in the vaginal tissue sections of the treated animals, and f) Microbicidal activity –to explore the effect of CAD on the growth of *Lactobacillus acidophilus* and *Candida albicans. In vitro* irritation studies on rabbit erythrocytes revealed the hemolytic index of CAD to be 8.2 mg/ml. The dermal irritation test showed it to be a non-irritant even at higher dosed.Intra vaginal application of CAD in rat vagina for 14 consecutive days caused slight reversible inflammation on vaginal epithelial cells at dosed 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 TUNNEDL assay, Fertility and fecundity were restored 4-15 days after withdrawl of CAD applicaton. At dose level 10 times that of its spermicidal MEC (minimum effective concentration), CAD did not block the growth of *Lactobacillus*, although the size of individual colony was marginally reduced .However, growth of the pathogenic fungus *Candida albicans* was completely indhibited with 20 mg/ml of CAD .The overall result evolved from the study strengthens the candidature of CAD as a safe microbicidal spermicide. It is almost non-irritant to rabbit skin and rat vaginal tissues at doses 10 fold higher than its hemolytic index .The effect of CAD on *Lactobacillus* culture was not highly encouraging but it prevented the growth of the fungal pathogen *Candia albicans* at 20 mg/ml of CAD.

Anti-inflammatory activity [17]

It has been established that anti-inflammatory activities of essential oils are attributable to the presence of substituent such as; limonene, linalool, linalyl acetate and α-pinene. The result revealed that the anti-inflammatory action of the oil is concentration dependent. Hence, the percentage reduction in the ear edema increases with increase in concentration of the oil. Furthermore, the oil caused significant reduction ($p < 0.05$) in the ear edema except at 0.625 mg concentration.

CONCLUSION

The medicinal properties of this plant were attributed to its variety of active phytochemical constituents. Although this plant had received interest for the phytochemical investigations since many years, more work has to be done on its isolation and characterization.

The pharmacological studies reported in this review confirm the therapeutic value of Chenopodium album. However very less information is available regarding the phytoanalytical properties of this plant. Phytochemical studies have been reported but still it needs to progress. If the ethnobotanical claims are sufficiently evaluated, then it can provide good remedies and can help the mankind for various ailments.

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