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REVIEW

Chenopodium album Linn: review of nutritive value and biological properties

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Abstract Green leafy vegetables have generated interest worldwide as they exhibit multiple benefits for health of human beings. Vegetables can form the cheapest and most readily available sources of important vitamins, minerals, fibres and essential amino acids particularly. In most of the developing countries where the daily diet is dominated by starchy staple foods, vegetables can form the cheapest and most readily available sources of important vitamins, minerals, fibres and essential amino acids. Across the globe there are several local and wild vegetables which are underexploited because of inadequate scientific information on knowledge of their nutritional potentials. A resurgence of interest has developed in wild vegetables for their possible medicinal values in diets. C. album is under exploited vegetable which has high functional potential apart from basic nutritional benefits. The plant is used in diet not only to provide minerals, fibre, vitamins and essential fatty acids but also enhance sensory and functional value of the food. The plant has been traditionally used as a bloodpurifier, diuretic, sedative, hepatoprotective, antiscorbutic laxative and as an anthelmentic against round and hookworms. Pharmacological studies have revealed that the plant possesses anthelmentic, sperm immobilizing and contraceptive properties. It is also claimed to be antipruritic and antinociceptive in action. Therefore C. album holds a great potential for in depth biological evaluation. No significant work has ever been carried out for processing parameters for this potentially useful plant. Significance and future scope of C. album for public and dietary awareness of its nutritional status has been discussed in this review.

Keywords Chenopodium · Album · Anthelmentic · Flavonoids · Polyphenolics · Amaranthus asper

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Introduction

Increased reliance on major food crops has been accompanied by shrinking of the food basket which humankind has been relying upon for generations (Prescott Allen 1990). Modern crop production predominantly involves only hundreds of the many thousands of the known food plants globally. Ethnobotanic surveys indicate that thousands of traditional species are largely ignored by scientific researches and food processors. *Chenopodium album* Linn. (*Chenopodiaceae*) a native plant of Western Asia, also falls in under the explored category. This plant falls under genus Chenopodium which has a worldwide distribution and contains about 250 species (Risi and Galwey 1984). In India, it is represented by about 21 species, of which some are cultivated for an end use as vegetable and a few for the grains obtained from the plant. (Yadav et al. 2007). *C. album* have also been reported to grow naturally as weed in the fields of wheat, barley, mustard, gram and other crops (Khurana et al. 1986; Bhattacharjee 2001). The weed is low growing while the cultivated plants are tall and leafy. The whole young plant has reported uses as food and herbal medicine. *C. album* is known by various vernacular names, viz. *Bathua sag* (Hindi), *Chandan betu* (Bengali), *Parupukkirai* (Tamil), *Pappukura* (Telgu) and *Katu ayamoddakam* (Malyalam). *C. album* is regarded as a prospective wild vegetable and is worth exploration and utilization.

Importance

The phytochemicals like flavonoid, isoflavonoid, polyphenol etc., have garnered great interest for their potential role in the maintenance of human health particularly significant reduction in cancer risk (Prakash et al. 1993). Phenolic acids have received particular attention in the past three decades due to their putative role in the prevention of several human diseases exerting a variety of biological actions such as free radical scavenging, metal chelation, modulation of enzymes activity, atherosclerosis, antimutagenic and anticancer activities (Reddy and Aggarwal 1994). Phenolic compounds possess redox properties, which allows them to act as reducing agents, hydrogen donators and singlet oxygen quenchers, finally leading them to be antioxidants (Pietta 2000). They are also found to be strong antioxidants capable of preventing, or delaying the rate of oxidation, a free radical chain reaction, which takes place in autoxidisable materials (Tarnawski et al. 2006). *C. album* been found to have flavonoid as phenolic amide (Horio et al. 1993); and is hypotensive in activity (Gohar and Elmazar 1997). It has saponin (Lavaud et al. 2007), cinnamic acid amide (Cutillo et al. 2003) alkaloid chenoalbicin (Cutillo et al. 2004); apocarotenoids (DellaGreca et al. 2004) xyloside (DellaGreca et al. 2005); phenols and lignans (Cutillo et al. 2006). However, not much attention seems to be paid for trapping anticancer activity of this plant. Khoobchandani et al. (2009) studied the potential of the plant for its possible clinical use to counteract malignancy development as anti breast cancer bioagent. Laghari et al. (2011) reported that *C. album* has seven free phenolic acids i.e. gallic acid, protocatechuric acid, protocatechuric aldehyde, vanillic acid, caffeic acid, syringic acid and vanillin. Gallic and protocatechuric acids were found in the fruits of *C. album*, while vanillin and *m*-coumaric acid in leaves whereas; vanillic, caffeic and syringic acids were present in both fruits and leaves.

Traditional uses

Many species of *Chenopodium* have been reported to possess numerous medicinal properties in ancient texts like Ayurveda, Atharva Veda, Charak Samhita, Sushruta Samhita etc. (Bakshi et al. 1999). *C. album* is traditionally used as anthelmintic, cardiotonic, carminative, digestive, diuretic and laxative. It is also useful in peptic ulcer, dyspepsia, flatulence, strangury, pharyngopathy, splenopathy, opthalmopathy and general debility. A fine powder of leaves is dusted to ally irritation and leaf juice is used for treating burns. The powdered plant (25–50 %), when mixed with normal food was reported to suppress oestrus cycle. A decoction of aerial parts mixed with alcohol is rubbed on the body affected by arthritis and rheumatism (Prajapati et al. 2003; Pal et al. 2011). The tender shoots are eaten raw in salad or with curd. They are also cooked as vegetable or the cooked shoots are mixed with curd and eaten. The dried herb is stored for future use. It is also used as fodder. The leaves are rich in potassium and vitamin C. Its use for the treatment of hepatic disorders, spleen enlargement, intestinal ulcers and burns has also been documented (Sarma et al. 2008).

Biochemical and nutritional composition

Nutritional importance

C. album is nutritious and an edible wild weed found in India (Brand et al. 1993; Devasagayam et al. 2004). Proximate composition of *C. album* leaves is given in (Table 1). *Chenopodium* spp. have been cultivated as a leafy vegetable (*C. album*) as well as an important subsidiary grain crop (*Chenopodium quinoa* and *C. album*) for human and animal food-stuff due to high-protein and a balanced amino-acid spectrum with high lysine (5.1–6.4 %) and methionine (0.4–1.0 %) contents (Prakash and Pal 1998; Bhargava et al. 2003a, b). Interest in *C. album* as a valuable food source has renewed in Asia in recent years because of its versatility and its ability to grow under stressed conditions like low rainfall, high altitude, thin cold air, hot sun, and sub-freezing temperatures. The correlation between the nutrient content of a leaf and its age is an important factor in choosing leaves for harvesting. Having nutritional values, its leaves have been consumed raw in salads or cooked by different civilizations in America and are still part of human diet in Mexico and other developing countries. *C. album* leaves are rich in proteins (4.2 %) with a high proportion of essential amino acids such as lysine, leucine, and isoleucine, and significant amounts of calcium and vitamins A (11,000 IU/100 g) and C (80 mg/100 g) (Gonzalez et al. 2003). Guerrero and Isasa (1997) reported high content of vitamin C (155 mg/100 g) and carotenoids (12.5 mg/100 g) in the leaves of *C. album*. Fibre amounts were also remarkable (4–6 g/100 g), high iron content (Yadav and Sehgal 2002) in *C. album*, than commonly consumed spinach and cabbage but less than amaranth leaves. Pande and Pathak (2010) reported that *C. album*. has high amount of amino acids, leucine, Isoleucine, lycine and vitamin C as main active components.

The genus *Chenopodium* supplies tasty and nutritious leaves as well as pink to cream-coloured edible seeds. Tolerance to cold, drought, salinity and the high lysine content of the seed protein are the attractive features of *C. album*. It is the most frequently consumed species in the Andean regions of South America, Africa, some parts of Asia, and Europe. This review compares and evaluates the nutritional, functional and anti nutritional constituents of the leaves of *C. album,* their conventional counterparts and argues for the acceptance of this plant in human diets.

Table 1 Proximate composition of *C. album* leaves (per 100 g fresh weight)

Moisture (%)	Fat (%)	Ash (%)	Protein (%)	Crude Fibre (%)	Carbohydrate (%)	Reference
87.5a	1.16 (crude)	2.07	3.7 (crude)	0.81	5.36	Singh et al. 2007
71.3 [a]	2.5[a]	2.2 [a]	3.9 [a]	ND	20.0 [a]	Khattak 2011
83.0 [a]	0.8 [a]	2.9 [a]	5.0 [a]	1.9	8.3[a]	Odhav et al. 2007

Proteins

Protein nutritional quality is determined by the proportions of essential amino acids, which cannot be synthesized by humans and hence must be provided in the diet. If only one of these amino acids is limiting, the others will be broken down and excreted, resulting in poor growth of livestock and humans and loss of nitrogen in the diet. Ten amino acids are strictly essential: lysine, isoleucine, leucine, phenylalanine, tyrosine, threonine, tryptophan, valine, histidine and methionine, all of which are present in *C. album* (Table 2). Green matter of *C. album* is a valuable high-protein product (Jacobsen 2003), which is another argument in favour of cultivation of this species. Total protein concentration in vegetation matter is app. 203 g per kg and is higher than in seeds (Gesinski and Nowak 2011). Similarly to seeds, green matter of *C. album* contains protein of well-balanced composition (Balzotti et al. 2008). High concentration of lysine is the result of a combined effect of its synthesis and accumulation in a soluble and protein form. The content of phenylalanine, isoleucine, leucine, threonine and valine in the green matter protein is even higher than in the protein of seeds. Similar results have been reported by (Ahamed et al. 1998).

The total of exogenous amino acids in the green matter is lower but it results from the lower arginine content (app. 44 %). The content of this amino acid in seeds is very high and, except lysine and leucine, over twice exceeds other exogenous amino acids in respect of the amount. From endogenous amino acids in the green matter protein of both species there is also more alanine, glycine, aspartic acid and tyrosine than in seeds High biological value of the green matter protein of *C. album* indicates the alternative possibility of choice of production of this component compared with the seed production. It is confirmed not only by higher protein content in the green matter than in seeds, but first of all higher amino acid yields. The amino acid yields of *C. album* in cultivation for green matter are even over eight times higher compared with the one cultivated for seeds (Gesinski and Nowak 2011).

Mineral content

The Na/K ratio in the body is of great concern for prevention of high blood pressure. Na/K ratio less than one is recommended (Food and nutrition board 2005). Therefore, consumption of *C. album* would probably reduce high blood pressure diseases because of its Na/K is less than one. (Adedapo et al. 2011). The mineral composition of C. album revealed high amounts of macro/micro elements (Table 3). Atomic absorption spectrophotometer (AAS), flame photometer and spectrophotometer were used for mineral estimation on fresh wt. basis. Concentrations were determined with AAS and colorimetrically at 420 nm on dry wt. basis. Iron is an essential trace element for haemoglobin formation, normal functioning of the central nervous system and in the oxidation of carbohydrates, protein and fats (Akubugwo et al. 2007).

Table 2 Amino acids content in the green matter and seeds of *C. album*

Amino acid	Exogenous amino acids (g kg^{-1})		Amino acid	Endogenous amino acids (g kg^{-1})	
	Green matter	Seeds		Green matter	Seeds
Arginine	11.29	17.18	Alanine	7.96	3.35
Phenylalanine	9.26	4.90	Glycine	10.92	10.37
Histidine	4.34	5.28	Aspartic acid	11.59	5.94
Isoleucine	5.36	3.34	Glutamic acid	16.83	13.56
Leucine	13.44	7.58	Serine	7.92	6.46
Lysine	10.11	8.07	Tyrosine	9.54	5.25
Methionine	1.81	2.27			
Threonine	8.18	5.35			
Valine	6.58	3.72			
Total	70.4	57.7	Total	64.8	44.9

Modified from Gesinski and Nowak 2011

Table 3 Mineral content of *C. album* leaves

Mg	Ca	K	P	Na	Zn	Cu	Fe (ppm)	Mn	References
2.54[a]	3.85[a]	3.65[a]	1.55[a]	0.30[a]	ND	ND	0.93[a](%)	ND	Bahadur et al. 2011
0.72[a]	2.17[a]	6.93[a]	0.32[a]	0.37[a]	50[a]	13[a]	255[a]	118[a]	Adedapo et al. 2011
112.10 [b]	98.70[b]	ND	46.30[b]	ND	1.30[b]	ND	4.70[b]	0.90 [b]	Khattak et al. 2007
112.17[b]	178.75 [b]	855.29 [b]	46.37 [b]	4.14 [b]	0.75 [b]	0.04[b]	4.79 [b]	0.55 [b]	Yildirim et al. 2001

[a] mg/100 g dry weight basis [b] mg/ 100 g fresh wt. basis

The zinc content of *C. album* compares favourably to most values for green leafy vegetables reported in the literature (Hassan and Umar 2006). Zinc is involved in normal functioning of immune system. Shahi (1977) conducted field studies for 2 years which revealed that *C. album*. contained very high degree of nitrogen, phosphorus, potassium, calcium, magnesium, iron and manganese. Its nutrient content declined with advancement in age of the plant. Guerrero and Isasa (1997) reported high mineral contents than in other green leafy vegetables. Fibre amounts were also remarkable (4–6 g/100 g). The ω^3 series of essential fatty acids were major in *C. album* (45.33 %). *C. album* was richest in magnesium and sodium contents than other wild plants i.e. *Plantago minor L, Polygonum bistorta L, Astrodaucus orientalis L, Camelina rumelica Boehm., Lathyrus tuberosus L,* and *Galium rotundifolium L* (Yildirim et al. 2001).

Antioxidant Potential

Recently, much attention has been given to naturally occurring antioxidants, which may play an important role in inhibiting both free radicals and oxidative chain reactions within tissues and membranes. Polyphenols are major plant compounds with antioxidant activity, which play an important role in quenching reactive oxygen species (Wichi 1988). Polyphenols are important components of *C. album* (Table 4) and some of their pharmacological effects could be attributed to the presence of these valuable constituents. In polyphenols particularly flavonoid derivatives behave as reducing agents, mostly donating hydrogen and quenching singlet oxygen. They seem to have additive effects on endogenous scavenging compounds. Flavonoids are versatile bioactive secondary metabolites present in almost all plant species. Most representative family members include flavones, flavanes, flavonols, catechins, and anthocyanidins. However, many other natural sources such as edible weeds have not been used yet with this purpose, even when they have been known by ancient civilizations and used as a part of their daily diet. Even when weeds are considered to be a problem in agriculture, from the productivity stand point, it is possible to take advantage of them as alternative vegetables in foods or as a renewable resource to obtain nutraceuticals or other bioactive compounds. Singh et al. (2010) studied the history, morphology, phytoconstituents, pharmacognostical & pharmacological aspects, ecological factors, impact on ecological system and its biology. Major class of pytoconstituents includes non-polar lipid, phenols and lignins, alkaloids, flavonids, glycosides and saponins. Vysochina (2010) has given the composition of flavonoids in the *C. album* species of world flora and the available information on their biological activity. The main flavonoids of *C. album* are 3-*O*-glycosides of caempferol, quercetin, and isoramnetin. Flavones are characteristic of some species. The *Chenopodium* spp. is interesting as a source of raw material containing cinnamic acids amides (Cutillo et al. 2003), flavonoids (Bylka and Kowalewski 1997; Gonzalez et al. 1998) and apocarotenoids (DellaGreca et al. 2004).

Ibrahim et al. (2007) fractionated and chromatographed the crude extract of *C. album*. Eight flavonoid compounds were isolated i.e. kaempferol-3-*O*-(4-β-D-xylopyranosyl)-α-L-rhamnopyranoside-7-*O*-α-L-rhamno-pyranoside,3-*O*-(4-β-D-apiofuranosyl)-α-L- rhamnopyranoside-7-*O*-α-L-

Table 4 Antioxidant profile of leaves extract of *C. album*

Phenolics			
	Acetone	Methanol	Water
Total polyphenol (mg tannic acid/g of dry matter)	13.1	8.6	7.5
Flavonoids (mg quercetin/g of dry matter)	1.82	0.80	0.78
Proanthocyanidins (mg quercetin/g of dry matter)	4.51	3.74	1.43
Total flavonol (mg quercetin/g of dry matter)	1.34	0.98	0.10
Total Phenolics (mg/100g GA Eq.)		0.94	
Total carotenoids (mg/100g dry wt.)		449.90	
DPPH radical scavenging (%)		84.89	
Hydroxyl radical scavenging (%)		58.70	
Free phenolic acids HPLC quivalents (mg/100 g)		8.01	
Percentage scavenging hydrogen peroxide		74.23	
Percentage scavenging of nitric oxide (%inhibition)		78.54	
Superoxide anion scavenging activity (%inhibition)		75.24	

Adedapo et al. 2011; Laghari et al. 2011; Kumar and Kumar 2009

rhamnopyranoside,3,7-di-*O*-α-L-rhamnopyranoside,3-*O*-glucopyranoside and quercetin 3,7-di-*O*-β-D-glucopyranoside, 3-*O*-glucosylglucuronide, 3-*O*-α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranoside,3-*O*-β-D-glucopyranoside.Laghari et al. (2011) studied the antioxidant activity of *C. album* and reported that the leaves extract exhibit better performance in antioxidant assays and have higher total phenolic contents (3,066 mg gallic acid equivalents (GAE)/100 g) when compared to fruits extract (1,385 mg of GAE/100 g). Their results indicate that the extract shows greater antioxidant activity and higher total phenolic content as compared to those of fruits extract. They also revealed that the methanolic extracts of *C. album* from fruits and leaves have great potential as a source for natural health products. Marisiddaiah et al. (2007) found that *C. album* contains higher levels of both β-carotene and lutein in the range of 114.61–187.59 mg/100 g dry wt. which were higher than other green leafy vegetables. Kaempferol, kaempferol 3-*O*-β-glucoside, kaempferol 3-*O*-β-diglucoside, kaempferol-3-*O*-arabinoglucoside, quercetin, quercetin 3-*O*-xylosylglucoside, and quercetin-3- *O* rhamnoglucoside were isolated from the aerial parts *of C. album* (Bylka and Kowalewski 1997). Chludil et al. (2008) isolated six known flavonoid glycosides and their antioxidant activity was determined by DPPHassay.1,quercetin-3-O-(2,6-di-O-R-L-rhamnopyranosyl)-beta-D- glucopyranoside;2,kaempferol-3-O-(2,6-di-O-R-L-rhamnopyranosyl)-beta-D- glucopyranoside;3,quercetin-3-O-beta-D-glucopyranosyl-(1→6)-beta-D-glucopyranoside; 4,rutin; 5,quercetin-3-O-beta-D-glucopyranoside; and 6,kaempferol-3-O-beta-D-glucopyranoside. They suggest that this edible weed, ubiquitously present in cultivated fields, should be considered as a nutraceutical food and an alternative source for nutrients and free radical scavenging compounds, particularly when collected from cultivated fields that seem to increase some of its advantages.

Kumar and Kumar (2009) studied that aqueous leaf extract of C. *album* and methanolic fruit extract exhibit significant reducing power and free radical scavenging effect on DPPH, hydroxyl, superoxide, and hydrogen peroxide radicals. The extracts also inhibit nitric oxide production. In addition, total phenolic and total flavonoids contents were determined as gallic acid and catechin equivalents, respectively. They reported that, *C. album* leaf extract was found to contain 0.94 % total phenolic contents (GAE) and 0.27 % total flavonoid contents (catechin equivalent). Sanjukta and Ghosh (2012) reported that flavonoids like rutin, rutin hydrate and quercetin were identified as few of the phenolic components present in the crude *C. album*.

Biological and medicinal value

Free radicals such as superoxide anions, hydrogen peroxide and hydroxyl nitric oxide radicals, cause degenerative human diseases such as cancer, heart disease and cerebrovascular disease through multiple mechanisms (Wang et al. 1996). Antioxidant components delay or inhibit lipid oxidation, by inhibiting the initiation or propagation of oxidizing chain reactions, and are also involved in scavenging free radicals. In recent years, research in this area has focused on the detection of antioxidants in food, because there is evidence that they could play an important role in the prevention of several illnesses as well as in the retardation of the aging process (Katalinic et al. 2004). It also has numerous pharmacological properties viz. antiviral, antifungal, anti-inflammatory, antiallergic, antiseptic, antipruritic, antinociceptic, sperm immobilizing immunomodulating (Kumar et al. 2007; Kaur and Kapoor 2002; Dai et al. 2002; Mousavi et al. 2005), antiparasitic (Giove-Nakazawa 1996), antispasmodic (Garcia et al. 1997), antibacterial and antifungal (Maksimovic et al. 2005; Ruggeri et al. 1991) and helpful in peptic ulcer and cardiac diseases. (Kaushik and Dhiman 2000; Prajapati et al. 2003). Ahmad et al. (2012) studied that this plant possesses potent spasmolytic activity. The results obtained from their study strongly suggest that *C. album* can be a good candidate for the development of a therapeutic drug for the treatment of muscle spasm and pain.

Jabbar et al. (2007) studied that *C. album* possess anthelmentic activity in vitro and in vivo, thus, justifying their use in the traditional medicine system. Yadav et al. (2007) reported several activities specific to different part of *Chenopodium spp*. plant. The activities are antipruritic, antinociceptive, antimicrobial anthelmintic, inducs tumour, vermifuge, antiviral, haemagglitination, antifungal, immunomodulatory, antiviral, haemagglitination, cytogenetic cytotoxic, hypotensive and spasmolytic. Kumar and Kumar (2009) evaluated in vitro antioxidation and free radicals scavenging effect. Aqueous leaf extract of *C. album* exhibit significant reducing power and free radical scavenging effect on DPPH, hydroxyl, superoxide, hydrogen peroxide radicals. They also reported that the plant and their parts are useful in curing anorexia, cough, dysentery, diarrhoea, piles and kills small worms. Important components of *C. album* and some of their pharmacological effects could be attributed to the presence of these valuable constituents.

Antimicrobial activity

There are different drugs used for the treatment of microbial infections like antibiotics and other antimicrobial agents. These have different modes like inhibition of cell wall synthesis, protein synthesis of the bacteria, binding with 50s ribosomal sub unit so on and so forth. Nayak et al. (2010) demonstrated the antimicrobial activity and anthelmintic activity of various solvent extract of *C. album* belonging to family *Chenopodiace. C. album* shows 17.3 mm zone of inhibition against *Staphylococcus aureus*, 19.7 mm against *Bacillus subtilis*, 18.3 mm against *Bacillus polymexia*, 16.7 mm against *Streptococcus faecalis*, 17.7 mm against

Pseudomonas auerogenosa, 16.7 mm against *Salmonella typhi*, 17.3 mm against *Vibrio cholera*, 17.3 mm against *Shigella dysenteriae*, 18 mm against *Escherichia coli*, 15 mm against *Penicillum notatum*, 16.3 mm against *Aspergillus niger* and 18.3 mm zone of inhibition against *Candida albicans*. C. album reportedly prevented progression of cell growth and enhanced cell toxicity in human breast cancer cell lines (Khoobchandani et al. 2009). Their findings highlight the potential of this plant for its possible clinical use to counteract malignancy development as anti breast cancer bioagent. Singh et al. (2011) studied that aqueous extract of *C. album* have strongest antibacterial activity on *Staphylococcus aureus* and methanol leaf extract showed strongest antibacterial activity on *Pseudomonas aeruginosa*. Methanol inflorescence extract of *C. album* exhibited highest antifungal activity resulting in up to 96 % reduction in fungal biomass production (Javaid and Amin 2009).

Antipruritic and antinociceptive activity

The ethanolic extract of the fruits of *C. album* has shown to inhibit scratching behavior induced by 5-HT (5-hydroxyryptamine) at the dose of 100, 200 and 400 mg/kg. It is well known that 5-HT not only facilitates the inflammatory pain by itself, but also potentiates pain introduced by other inflammatory mediators, such as noradrenaline and prostaglandin E. Therefore, the antinociceptive effect of the extract may be mediated by inhibition of 5-HT. The extract significantly attenuated the writhing responses induced acetic acid (i.p) and by an intraplanetary injection of formalin in mice. At a dose of 400 mg/kg, it also inhibited the neurogenic pain response of formalin test. The species has been clinically used for treatment of cutaneous pruritis (Dai et al. 2002). (Ibrahim et al. 2007) reported that *C. album* was found to be highly safe as a drug plant with no serious adverse effect and can be used for curing inflammation and relieving pain.

Anthelmintic activity

Helmintics are parasitic worms, which infect an estimated 2 billion people worldwide, nearly all in poor developing tropical or semitropical countries. Schistosomiasis and other helmintic infections account for more than 40 % of all tropical disease excluding malaria (Chakraborty 2003). Helminth infections contribute to malnutrition, anaemia, stunted growth, cognitive impairment, and increased susceptibility to other disease. In addition to the human burden, domestic animals are also very susceptible to helminth infections, which adds to the economic burden of developing countries, are used in both veterinary practice and human chemotherapy (Hirano et al. 2001). Foster and Duke (1990) and (Akhtar et al. 1999) have also reported that *C. album* leaves are also anthelmintic, antiphlogistic, antirheumatic, mildly laxative and odontalgic.

Antinutritional factors

Saponins are widely distributed throughout the plant kingdom and have been identified in at least 400 species belonging to 60 different families. Saponins have been found in bulbs, roots, stems, fruits, leaves and in some cases throughout the whole plant. The percentage of saponins varies in different plants, usually from 0.1 % to 5 % (Ewart 1931). *C. album* contains saponins, though usually in quantities too small to do any harm. Although toxic, saponins (5.2 mg /100 g d.w.b) are poorly absorbed by the body and most pass straight through without any problem. They are also broken down to a large extent in the cooking process. Prakash et al. (1993) reported that the leaves of *Chenopodium* species contain from 3 % to 5 % dry weight nitrate. However, most of the nitrate is concentrated in the stem portion, which is generally discarded and oxalate content ranges from 0.9 to 3.9 g/100 g fresh weight, concentrated mainly in the stem.

Raw leaves of *C. album*, also contain some oxalic acid, which in large quantities can interfere with absorption of nutrients in food, but these plants are otherwise very nutritious vegetables in small servings. Cooking of the plant has been known to reduce the content of oxalic acid. The content of oxalic acid in *C. album* is with a range of values from 360 to 2,000 mg/100 g (Guil et al. 1996). Phytic acid is a substance that reduces our absorption of minerals such as calcium, iron, zinc, and magnesium. (Akubugwo et al. 2007) studied the antinutrients contents of many leafy vegetables. The results showed that alkaloid level in and *C. album* is lower than the values reported for the leafy vegetables like *Aspilia africana*, *Bryophyllum pinnatum*, *Cleome rutidosperma* and *Emilia coccinea* consumed in Nigeria. Adedapo et al. (2011) reported that phytate level in *C. album* (18.1 mg/100 g) which is still within the tolerable limits and can easily be detoxified by soaking, boiling or frying. Yadav and Sehgal (2003) compared fresh leaves with the processed and cooked leaves for their anti nutrients like oxalic acid, phytic acid and polyphenol contents. Oxalic acid, phytic acid and polyphenol content of the fresh leaves ranged from 0.91–14.92 g; 129.67–234.50 mg/100 g and 11.96–22.88 mg tannic acid equivalent/g (TAE/g) dry weight, respectively. They also reported that drying and storage had no significant effect on the antinutrient content of these leaves while blanching and cooking resulted in a significant reduction in oxalic acid. Blanching resulted in significant reduction in phytic acid.

Functional potential for human diet

Some leguminosae in combination with some cereals might improve protein profiles of high-quality foods due to amino acid compensation, a good strategy also used with *album* food for children in India. Consumption of nutrient and phytochemical-rich vegetables, like *C. album*, leads to a better

immune response compared to consumption of vegetables that are rich in fibre but lower in nutrient or phytochemical content, like common cabbage. It should be promoted for greater consumption for human use to improve nutrition and strengthen immune functions. Uptake of this plant in February as a food or medicinal ingredient is better, because at this stage, it has good taste and also rich in bioactive phenolics with high antioxidant activities. *C. album* when added to cereals and legumes would result in a wholesome diet suitable for all age groups. Fermented products like *idli, dosa* and bread etc. can also be prepared. Low-fat, fried noodle-like snacks and extruded products can also be prepared using *C. album* and soya bean protein isolate. Singh et al. (2007) prepared value added products from dehydrated *C. album* leaves. They incorporated dehydrated leaves at 3–15% levels in two conventional foods namely green *gram dal* and *paratha*. The potential of *C. album* as antioxidants could be utilized by food industry. This may also provide a vital alternative of synthetic antioxidant. Madsen and Bertelsen (1995).

Conclusions

C. album is good source of functional nutrients and possesses medicinal properties. It can be incorporated in different extruded food products to make them more nutritious, healthier as well as consumer oriented. The addition of its leaves to extruded products can enhance the chemical and nutritional parameters and can improve extruded products as functional foods. The plants also have high biological activities hence may be of great medicinal value. Commercial exploitation of *C. album* in many regions of the world is still far from reality. The active constituents can be isolated and further evaluated for the development of useful drugs. Their antioxidant and antibacterial activities further lend credence to the biological value of this plant. These trials should pave way for the use of *C. album* in regions where the green leafy vegetables are cultivated but yet to see any commercial exploitation. Increased awareness in the society and consequently more use of this plant may go long way towards preventing not only deficiency diseases and age related muscular degeneration-related disorders, but also protect against chronic degenerative diseases, such as cancer and cardiovascular disorders which ultimately will be highly beneficial to the rural community.

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