



E-ISSN: 2278-4136

P-ISSN: 2349-8234

JPP 2019; 8(3): 3149-3156

Received: 16-03-2019

Accepted: 18-04-2019

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Nutritional and medicinal potential of *Amaranthus spinosus*

Anjali Ganjare and Nishikant Raut

Abstract

This review deals with the nutritional and medicinal value of plant *Amaranthus spinosus*. *Amaranthus* species are highly popular group of vegetables to which leaves, shoots, tender stems and grains are eaten as potential herb in sauces or soups, cooked with other vegetables, with a main dish or by itself. The plants are used as feed for farm animals. Traditionally, the boiled leaves and roots are used as laxative, diuretic, anti-diabetic, antipyretic, anti-snake venom, antileprotic, anti-gonorrhreal, expectorant and to relieve breathing in acute bronchitis. It also has anti-inflammatory, immunomodulatory, anti-androgenic and anthelmintic properties. The main phytoconstituents is 7-p coumaroyl apigenin, 4-O-beta-D-glucopyranoside, spinosidexylofuranosyl uracil, beta-D-ribofuranosyl uracil, beta-D-ribofuranosyladenine, beta sistorsterol glucoside, hydroxycinnamates, quercetin and kaempferol glycosides, betalains, betaxanthin, betacyanine and isoamaranthine gomphrenin, betanin, b-sistorsterol, stigmasteron, linolic acid, 0.15% rutin and beta carotene. Apart from these important phytoconstituents it contains carbohydrates, proteins, fats, fibres, minerals such as iron, calcium, manganese, copper and zinc revealing its nutritional potential. As the plant possess such nutritional values and therapeutic potential it should be included as food supplement.

Keywords: *Amaranthus Spinosis*, medicinal potential, phytochemistry, nutritional potential

Introduction

Worldwide, about four hundred *Amaranthus* species occur in tropical, subtropical and temperate climate zones out of which around 20 species are either cultivated or found wild in India^[1]. Some of the *Amaranthus* species are known for allelopathic potential which means acting as antibiotic substances^[2]. *Amaranthus blitoides*, *Amaranthus gracilis*, *Amaranthus hybridus*, *Amaranthus palmeri*, *Amaranthus retroflexus*, *Amaranthus spinosus* and *Amaranthus viridis* are the species with allelopathic potential. The allelochemicals present in *A. spinosus* are reported to inhibit the germination and the growth of seedlings of various species^[3-5]. *Amaranthus spinosus*, is commonly known as *Kate Wali Chaulai* or *Kantabhaji* in Hindi and *Pigweed* in English. This plant is used as vegetable, ornamental plants and other species are utilized as food, leaf vegetables and cereals cultivated throughout in India, Sri Lanka and many tropical countries^[6].

Amaranthus spinosus annual and perennial herb belongs to family Amaranthaceae, grows as an erect, up to 100-130 cm tall, much branched, monoecious herb with purplish or greenish stem widely distributed throughout the India and all tropical and subtropical regions of Africa, Southeast Asia and USA. The leaves are alternate and simple without stipules; petiole is approximately as long as the leaf blade; the blade shape is ovate-lanceolate to rhomboid, 3.5-11 cm × 1-4.5 cm. It is widely used for its nutritional and medicinal properties (as mentioned in traditional systems of medicine) for the treatment of several diseases all over the world^[7].

Materials and Methods

A comprehensive review of literature was carried out through search engines, various journals and data bases available till date. Published Scientific data and reports available offline and online journal were collected and reviewed. The main source of data collection was research and review articles published by reputed publishers such as Elsevier, Informa, Springer, Taylor and Francis, and several others; online databases such as PubMed, Google scholar, Science hub, Research gate, Scopus and Science Direct; and various books from the libraries of R.T.M. Nagpur University, Nagpur. Data regarding the morphological identification and characteristics of the plant was compared with herbarium specimen number 10217 in the Department of Botany, RTM Nagpur University, Nagpur with the help of expert botanist Dr. Nitin Dongarwar of the same department.

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Ethnopharmacological history of *A. spinosus* recommends use of whole plant for the treatment of various ailments which clearly indicates that *A. spinosus* have enormous nutritional and medicinal potential. Hence the present review provides a comprehensive updated account on scientific literature of phytochemical constituents, nutritional values and medicinal values of *Amaranthus spinosus*.

Review of ethnopharmacology of *A. spinosus*

There are several ethanopharmacological claims for *A. spinosus* reported in the literature and traditionally it is used for variety of ailments. Some of them are described in the following section. The smooth paste of leaves and roots are applied as poultice to get relief from skin diseases/ disorders such as abscesses, bruises, burn, eczema, inflammation, gonorrhea, monorrhagia and wound. The sudorific and febrifugic actions are also used to induce sweat and to reduce fever. The boiled leaves are administered for 2-3 days to cure jaundice, some kinds of rheumatic pain and stomach ache⁸. The paste of root is also possesses several beneficial effects when used internally and externally⁹. The root paste with equal volume of honey controls vomiting, when mixed with sugar and water controls Dysentery (stools and mucus), when mixed with black pepper in 1:3 proportion (1 part black pepper and 3 parts root paste) administered twice daily is beneficial in Rabies¹⁰. The root paste when applied externally, it cures contagious skin infection⁹. The root is given to

children for laxative action and also possesses good diuretic property. The seed are also used internally for the treatment of internal bleeding, diarrhoea and excessive menstruation and externally as poultice for broken bones. Whole plant of *A. spinosus* is used as a diuretic, purgative, refringent and to treat cholera, piles and snake bite^[11].

Traditional medicinal uses of *A. spinosus* are not limited to India but all over the world it is known for several traditional therapeutic effects. In Nepal and India, certain tribes use this plant to induce abortion. In Africa, it is known for its usefulness in disorders related to nutritional deficiency and various other diseases. In China traditionally it is used for the treatment of diabetes whereas in South-East Asian countries the decoction of the root is employed to treat gonorrhea, externally applied as an emmenagogue and antipyretic. In Malaysia, it is known for its beneficial effects in acute bronchitis to relieve breathing and as an expectorant^[12].

Traditionally, *A. spinosus* is also known for its nutritional values and therefore leaves and stems are cooked, steamed or fried and then consumed. Due to its bitter taste it is consumed in small quantities mostly as substitute for other vegetables. Though it is sold in market, it attracts lower price due to its bitter taste. The other nutritional uses of *A. spinosus* includes forage for livestock, the ash is a tenderizer while cooking tough vegetables and pigeon peas. The ash of plant is also used as salt by certain tribes^{7, 13}. All the uses are compiled in Fig. 1.

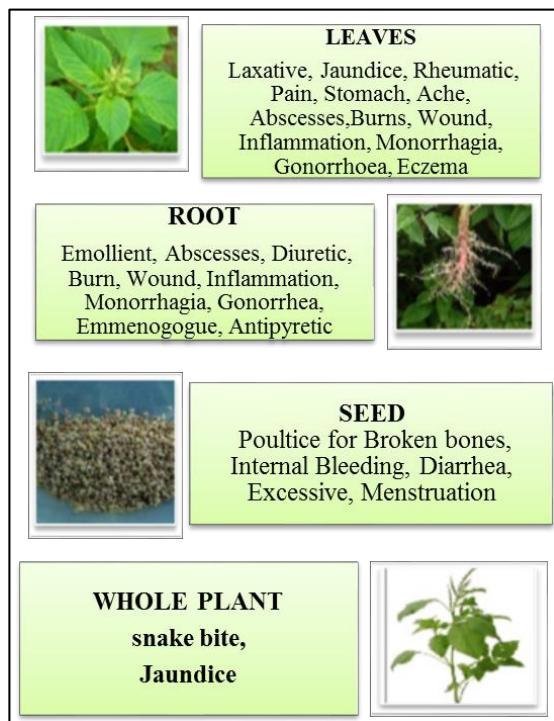


Fig 1: Ethnomedical uses of *A. Spinosus*

Ayurvedic Importance

Amaranthus spinosus is having great history in the Ayurvedic literature and it is known since the period of Acharya Charaka, Acharya Sushrata and Acharya Vaghbata who were considered it as vegetable. There are several uses for this herb prescribed by these stalwarts. It is recommended for the treatment of *pradar*, *sarva visha* and *rakta pitta* by Acharya Charaka, *arsha*, and *mushika visha* by Acharya Sushrata and Acharya Vaghbata recommended this for elimination of *sroto dusti* such as *vimarga gamana* and *atipravritti*^[14]. There are several other ethno-botanical practices utilizing it for variety

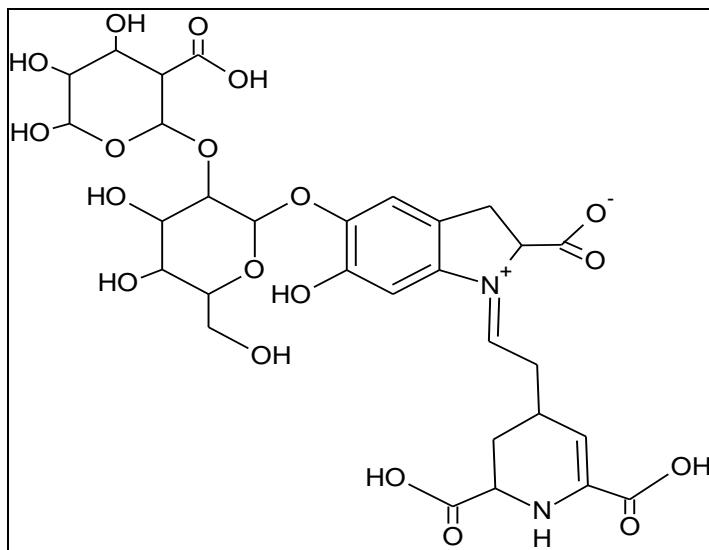
of indications worldwide by different tribes and communities. In India also it is used for several ailments by different tribes and folks as folklore medicine which are not mentioned in the Ayurvedic literature. Some of these claims have been scientifically validated by the scientists across the globe described in following section.

Phytochemistry

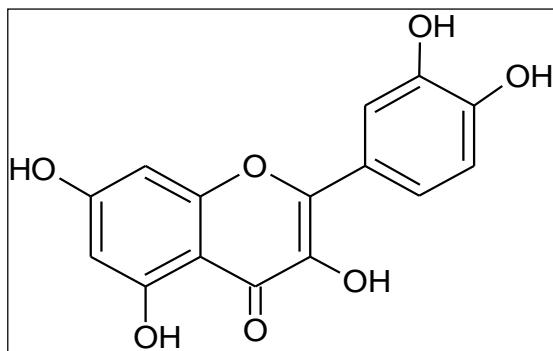
A. spinosus is reported to contain numerous active phytoconstituents belonging to alkaloids, amino acids, flavonoids, glycosides, lipids, phenolic acids, terpenoids,

steroids, saponins, betalains, catechuic tannins and carotenoids. The betalains in stem bark of *A. spinosus* were identified as amaranthine, isoamaranthine, hydroxycinnamates, quercetin and kaempferol glycosides. It

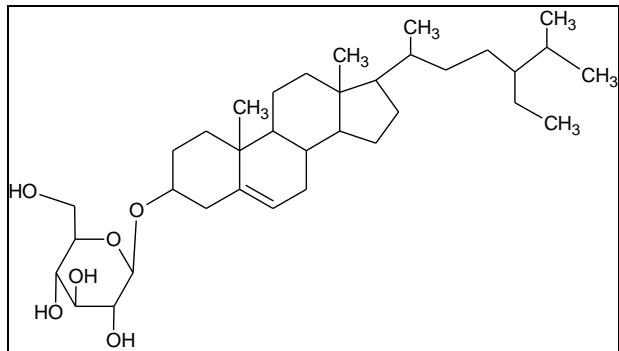
also contains amaranthoside, a lignan glycoside, amaricin, and a coumaroyl adenosine along with stigmasterol glycoside, betaines such as trigonelline and glycine betaine^[15-19].



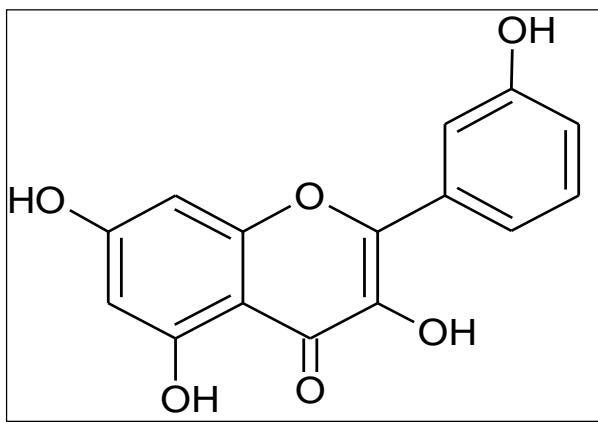
Amaranthine



Quercetin



Beta-sitosterol glucoside



Kaempferol

It also contains 7-p-coumaroyl apigenin 4-O-beta-D-glucopyranoside, a new coumaroyl flavone glycoside called spinoside, xylofuranosyl uracil, beta-D-ribofuranosyl adenine, beta-sitosterol glucoside, betacyanin; betaxanthin, betanin, gomphrenin, and beta-carotene^[20, 21]. The leaves and stems also reported to contain hentriacontane, octacosanoid, α -spinasterol, saponin and fatty acids^[16]. The roots contain α -spinasterols octacosanoate and saponin, viz. saponin of oleanolic acid^[22].

Vitamin C, phenolics and flavonoids are phytochemical compounds responsible for most of the antioxidant activity in fruit and vegetables^[23]. Phenolics and flavonoids reduce the threat of cardiovascular, chronic and neurodegenerative diseases and some kinds of cancer^[24-26]. Antioxidant activity is associated with several health benefits, and has been reported to provide anticarcinogenic, anti-inflammatory, hypoglycemic and antiatherogenic effects^[24, 27, 28]. Although, the consumption of phenolics, flavonoids and antioxidant compounds is highly recommended, there currently there are no specific recommendations for daily intake amounts for these compounds. The presence of vitamin C, phenolics, and flavonoids in amaranth leaves might be directly related to some of the medicinal properties of these vegetables^[29].

Nutritional Potential

A. spinosus is an extremely interesting crop because its vegetable and seeds are known to be highly nutritious and therefore consumed by human as well as animals, as nearly all essential nutrients for humans are available in plants^[30, 31]. Among vegetables, amaranths are rich sources for micronutrients and dietary minerals; an interesting group of crops to answer mounting demand for food. They are a promising group of crops with exclusive nutritional compositions that could enrich the biological value of processed foods^[32]. Hence the genus *Amaranthus* has

received considerable attention in many countries because of the high nutritional value of some species like *A. Spinosa* which are important sources of food, either as vegetable or grain. The leaves encompass 17.5 to 38.3% dry matter as protein of which 5% is lysine^[33]. Vitamin A and C are also present in significant levels almost three times as that of spinach^[34]. The nutritional value of amaranth has been extensively studied and along with chemical composition it is depicted in Fig. 2^[35-38].

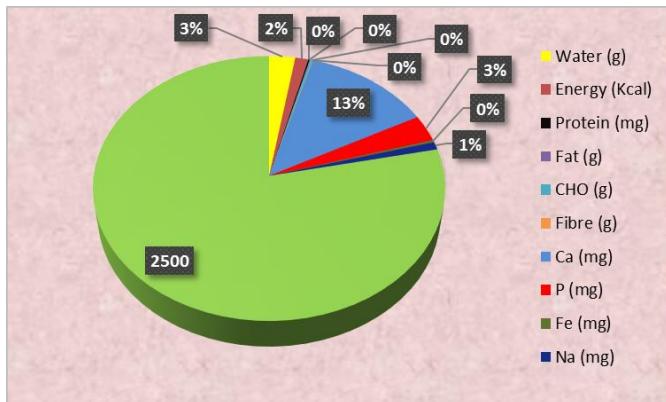


Fig 2: Nutritional value and chemical composition (Per 100 gm of edible portion) of *A. spinosus* (Sources: Alegbejo, 2013; Srivastava, 2011)

Srivastava^[34] performed comparative analysis of fresh leaves of four species *A. spinosus*, *A. viridis*, *A. blitum* and *A. tricolor* for protein and carbohydrate content whereas oven dried leaves for Fe, Ca, K and Na contents. Protein content was varied from 6.10-9.00g/100g of fresh leaves while the amount of carbohydrate in fresh leaves of all four species was observed to be varied from 9.75 g-21.29 g. Among the species, *A. spinosus* was reported to contain highest amount of carbohydrates (21.29g) which is almost two folds higher than *A. tricolor* (9.75g). The results of protein analysis also showed that *A. spinosus* contains higher amount of protein (9g/100g). The protein content values obtained in this study are comparable to the amount of protein in seeds with significant marginal differences^[39, 40]. *A. spinosus* is a good source of manganese and molybdenum. In addition, *Amaranthus* leaves contribute from 2% to 3% of the daily value of phosphorus (P) and zinc (Zn), and from 1 to 4 % of iron (Fe) per serving^[23].

The leaves and stem of *A. spinosus* contain α -spinasterols and hentricontane^[41], the roots contain ester of octacosanoic acid with α -spinasterols. Massimo *et al.* (2004)^[42] reported presence of β - sitosterols and three major phytosterols such as μ -sitosterols, campesterol, and stigmasterol in *A. spinosus*. The saponins present in roots of *A. spinosus* are β -D-glucopyranosyl (1 \rightarrow 4)- β -D-glucopyranosyl(1 \rightarrow 4)- β -D-glucuronopyranosyl(1 \rightarrow 3)-oleanolic acid^[41, 43], β -D-glucopyranosyl (1 \rightarrow 2)- β -D-glucopyranosyl(1 \rightarrow 2)- β -D-glucopyranosyl (1 \rightarrow 3)- α -spinasterol and β -D-glucopyranosylm (1 \rightarrow 4)- β -D-glucopyranosyl (1 \rightarrow 3)- α -spinasterol^[43].

Medicinal Potential

Literature reports several medicinal properties of *A. spinosus* in traditional system of medicine which have been scientifically substantiated by group of scientists. The pharmacological activities of *A. spinosus* has been discussed in the following sections.

Analgesic and Antipyretic Activity

Traditional claims of *A. spinosus* for the treatment of various types of pain conditions have been scientifically validated by various researchers worldwide. Taibab *et al.* (2011)^[44] investigated the analgesic activity of petroleum ether, ethyl acetate and methanol extracts of the whole plant of *A. spinosus* using acetic acid induced writhing and radiant heat tail-flick models in mice. The methanol extract administered orally to mice (500 mg/kg of body weight) reported to produce significant antinociceptive action against chemical (acetic acid-induced visceral pain) and thermal (radiant heat tail-flick test) models of nociception. In addition, methanolic extract of leaves of *A. spinosus* showed significant ($P<0.01$) antipyretic activity by yeast induced pyrexia method at concentration of 200 and 400 mg/kg using paracetamol as standard drug^[45].

Antioxidant activity

Antioxidant activity of *A. spinosus* has been demonstrated by Kumar and his colleagues (2010)^[46] against 1, 1-diphenyl-2-picryl-hydrazile (DPPH) free radicals, superoxide anions, 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) also known as ABTS radicals, nitric oxide radicals and hydroxyl free radicals.

Immunological effects

In recent years there has been a rapid development in the use of herbal medicines around the globe. Many researchers have focused on exploring the immuno-stimulating actions of certain foods and dietary herbs. *A. spinosus* also been demonstrated to possess immuno-modulatory effects by Lin *et al.* (2005)^[47] wherein they reported the stimulatory effect of wild *A. spinosus* water extract on spleen cells from female BALB/c mice. This study showed that a novel protein with a molecular weight of 313 kDa displayed strong immuno-stimulating activity, and could directly activate primary B cell proliferation. This is a potentially valuable substance for nutraceutical or immune pharmacological use^[47].

Antidepressant activity

Antidepressant activity of *A. spinosus* extracts was reported by Kumar and his colleagues (2014)^[48] using Forced Swimming Test (FST) and Tail Suspension Test (TST). In this study the methanolic extract of *A. spinosus* showed significant ($p<0.01$) antidepressant activity comparable to Escitalopram and Imipramine^[48].

Antifertility activity

Satyanaarayanan and his co-workers (2008)^[49] have demonstrated anti-fertility activity of alcoholic extracts of *A. spinosus* Linn to interrupt pregnancy in rats. Alcohol extract of *A. spinosus* at dose of 150 and 175 mg/kg body weight exhibited significantly interrupted pregnancy in rat. Contrary, Jhade *et al.* (2011)^[18] reported weak anti fertility effect in aqueous and alcoholic extracts of root of *A. spinosus* in rats.

Hepatoprotective activity

Traditional system of medicine recommends use of whole plant of *A. spinosus* for the treatment of jaundice and other liver disorders. Hussain and coworkers (2008)^[50] substantiated this traditional claim and scientifically demonstrated usefulness of alcoholic extract of whole plant of *A. spinosus* in CCl_4 induced hepatotoxicity in rats. The extract at dose of 100, 200 and 400 mg/kg body weight of rats normalised the elevated serum enzyme such as glutamate

oxaloacetate transaminase, glutamate pyruvate transaminase, alkaline phosphatase and total bilirubin in dose dependent manner. The study was supported by histopathological examination of liver sections of rat confirming biochemical findings. Presence of phytoconstituents such as flavonoids, phenolics, triterpenes, steroids and saponins were attributed for hepatoprotective property of *A. spinosus*^[50].

Haematological activity

Akinloye and Olorede (2000)^[51] studied the effect of aqueous extract of leaves of *A. spinosus* on hematological parameters along with blood coagulation time in rat model. The study reported insignificant changes in the haematological parameters and levels of several enzymes such as alkaline phosphatase (ALP), serum glutamate pyruvate transaminase (SGPT) and serum glutamate oxaloacetate transaminase (SGOT). Although, the significant reduction in serum biochemical parameters such as glucose and cholesterol were observed in rats, the alcoholic extract of *A. spinosus* reported to affect various haematological parameters such as packed cell volume (PCV), red blood cell (RBC) and white blood cell (WBC) counts, and haemoglobin (HB) in pigs^[52] and rats^[53] as experimental animals. Significant reduction in the PCV, RBC, and Hb post seven days treatment with improvement in final and average weight gains in pigs and rats. Bhande and Wasu (2016)^[54] also reported that the extract of whole plant of *A. spinosus* significantly reduce the RBC, hemoglobin, PCV and mean corpuscular hemoglobin concentration (MCHC) and increase the WBC and mean corpuscular volume (MCV)^[54].

Diuretic activity

Aqueous extract of whole plant of *A. spinosus* reported to possess diuretic activity by increasing concentration of all the urinary electrolyte ions such as Sodium (Na+), Potassium (K+) and Chlorides (Cl-) comparable to furosemide. The extract produced diuretic effect at a dose of 500 mg/kg and not in dose dependant manner. Treatment increased the urine volume significantly and increased electrolyte concentration in urine caused alkalinisation of urine inhibiting saluretic and carbonic anhydrase activity^[55, 56].

Antiulcer activity

Antiulcer activity of *A. spinosus* has been reported by several researchers using different animal models. Hussain *et al.* (2009)^[19] demonstrated antiulcer potential of *A. spinosus* which significantly inhibited small-gastrointestinal propulsive movement and reduced lipid peroxidation associated with decrease in ulcer index in ethanol and aspirin induced ulceration in mice comparable with the standard drug cimetidine.

In an interesting study conducted by Mitra and his colleagues (2014)^[57] aqueous suspension of powdered leaves of *A. spinosus* demonstrated antiulcer activity against aspirin induced gastric ulcers. Suspension of leaves believed to produce antisecretory effect by lowering acidity and gastric volume. During the formation of gastric ulcer, there is significant elevation in level of gastric pepsin probably involved in mechanism of gastric ulceration, which was observed to be lowered after administration of suspension of leaves of *A. spinosus*. It also showed gastro-protective effect by increasing mucin. Increase in antioxidant enzymes, prevention of loss of gastric protein, DNA and lipid peroxidation were the other beneficial effects observed with administration of leaves in suspension^[57]. In another study, Mitra *et al.* (2013)^[58] demonstrated efficacy of roots, stem and leaves of *A. spinosus* against ethanol, indomethacin, hydrochloric acid, stress and pyloric ligation induced ulceration in albino rats comparable to omeprazole. Ghosh *et al.* (2013)^[59] reported antiulcerative activity *A. spinosus* against peptic ulcer induced by ethanol and cyst amine in rats. In the recent study conducted by Panda *et al.* (2017)^[60] ethanolic extract of leaves of *A. spinosus* demonstrated ulcer protective effect in Shay rat model dose dependently. Study reported significant reduction in gastric ulcer at a dose of 400 mg/kg body weight whereas, treatment with 800 mg/kg body weight showed complete absence of gastric ulceration comparable to the effect produced by 2 mg/kg of Famotidine (per oral). The details pharmacological action along with phytochemical constituents is given in table 1.

Table 1: Pharmacological activities and phytoconstituents of *A. spinosus*

Plant part	Extract	Pharmacological Activity	Phytoconstituents
Whole plant	Ethanol	Hepatoprotective Activity ^[46, 61-63] , Anti-diarrheal and anti-ulcer activity, Anti-inflammatory activity ^[64, 65]	7-p-coumaroyl apigenin 4-O-β-D-glucopyranoside, α-xyloturanosyl uracil, β-D-ribofuranosyl adenine and β-sitosterol glucoside ^[81] Rutin and quercetin ^[82, 83] Amaranthoside- a lignan glycoside, Amaricin- a coumaroyl adenosine stigmasterol glycoside ^[84]
	Methanol	Antioxidant Activity ^[66, 67] , Heamatological Activity ^[68] , Anti-inflammatory activity ^[69]	
	Chloroform	Antioxidant Activity ^[66, 67]	
	Petroleum ether	Antioxidant Activity ^[66, 67] , Anti-inflammatory activity ^[65]	
	Aqueous extracts	Antioxidant Activity ^[66, 67] , Anthelmintic activity ^[68, 69] , Diuretic activity ^[55, 56]	
	Aqueous-methanolic extract	laxative, spasmolytic and bronchodilator ^[70]	
Leaves	Chloroform	Antioxidant Activity ^[15, 67] , Antibacterial Activity ^[15]	α-spinasterol, hectriacontane, oleanolic acid, D-glucose and D-glucuronic acid ^[41]
	Ethyl acetate Extract	Antioxidant Activity ^[15, 67] , Antibacterial Activity ^[15]	
	n-hexane	Antioxidant Activity ^[15, 67] , Antibacterial Activity ^[15]	
	Methanol	Antidiabetic activity ^[71] , Antitumor activity ^[15] , Antibacterial Activity ^[72] , Anti-inflammatory activity ^[73]	
	Ethanol	Heamatological Activity ^[52] , Anti-inflammatory activity ^[64] , Antitumor activity ^[74] , Antibacterial Activity ^[15] , anti-gastric ulcer activity ^[60]	
	Aqueous extracts	Antibacterial Activity ^[15] , Immunomodulatory activity	

		[75, 76]	
Stem	Dichloromethane	Antibacterial Activity [72]	Amaranthine, isoamaranthine, hydroxycinnamates, quercetin and kaempferol glycosides [85]
	Methanol	Antidiabetic activity [77, 78]	
	Aqueous extracts	Antimalarial Activity [79]	
Root	Hexane	Antibacterial activity [80]	aliphatic ester- α -spinasterol octacosanoate saponin- β -D-glucopyranosyl-(1-4)- β -D glucopyranosyl -(1-4)- β -D-glucuronopyranosyl-(1-3)-oleonolic acid [86] Saponin I- β -D- glucopyranosyl-(1-2)- β -D-glucopyranosyl -(1-2)- β -D-glucopyranosyl-(1-3)- α -spinasterol, Saponin-II- β -D- glucopyranosyl-(1-4)- β -D-glucopyranosyl-(1-3)- α -spinasterol [87]
	Ethyl acetate,	Antibacterial activity [80]	

Conclusion

The review of the literature available on *A. spinosus* and subsequent discussions it is clear that *A. spinosus* possess nutritional potential with several medicinal properties. The traditional system of medicines, particularly Ayurveda depends on the principle of healthy leaving rather than treating the symptoms of disease or illness by maintaining harmony in diet and exercise. Following healthy diet and incorporation of functional food materials such as *A. spinosus* having both nutritional and medicinal values will definitely keep the human beings healthy. So, we recommend *A. spinosus* as the regular part of diet for the well beings of human kind.

Acknowledgement: The authors are highly thankful to University Grant Commission, for providing fellowship to Miss Anjali Ganjare. The authors are thankful to the Head of the Department of Pharmaceutical Sciences, RTM, Nagpur University, Nagpur for her valuable support.

Conflict of interest

Authors declare no conflict of interest.

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