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Review Article

AN INSIDE REVIEW OF *AMARANTHUS SPINOSUS* LINN: A POTENTIAL MEDICINAL PLANT OF INDIA

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ABSTRACT

Amaranthus spinosus Linn. (Family Amaranthaceae), a very common Indian plant is known for its medicinal properties and commonly known as 'spiny amaranth' or 'pig weed', ''Kate wali Chaulai (Kanatabhajii)" in 'Hindi", cultivated throughout in India, Sri Lanka and distributed throughout the tropics and warm temperate regions of Asia from Japan to Indonesia, the Pacific islands and Australia as a weed in cultivated as well as fallow lands. It is erect spinous annual or perennial herb varying in color from green to purple, native to tropical America. In Indian traditional system of medicine (Ayurveda) the plant is used as febrifuge, antipyretic, laxative and diuretic. Besides its culinary value, it is used to repute for treat digestible, bronchitis, appetizer, biliousness, galactagogue, haematinic, stomachic, nausea, flatulence, anorexia, blood diseases, burning sensation, leucorrhoea, leprosy and piles. Phytochemical investigations prove its importance as valuable medicinal plant. It is known as rich source of alkaloids, flavonoids, glycosides, phenolic acids, steroids, amino acids, terpenoids, lipids, saponin, betalain, b-sitosterol, stigmasterol, linoleic acid, rutin, catechuic tannins and carotenoids. The studies on *A. spinosus* have been carried out by various researchers and a wide spectrum of its pharmacological actions have been explored which may include antidiabetic, antitumor, analgesic, antimicrobial, anti-inflammatory, spasmolytic, bronchodilator, hepato-protective, spermatogenic, antifertility, antimalarial, antioxidant properties, etc. The present review is an effort to provide a comprehensive review on morphology, traditional uses, phytochemical constituents and pharmacological activities of *A. spinosus*.

Keywords: *Amaranthus spinosus*, Amaranthaceae, spiny amaranth, pig weed.

INTRODUCTION

Medicinal plants are part and parcel of human society to combat diseases, from the dawn of civilization. Medicinal plants can be important source of previously unknown chemical substances with potential therapeutic effects[1]. The use of natural products with therapeutic properties for a long time, mineral, plant and animal products were the main sources of drugs serve as an important therapeutic agents as well as important raw material for the manufacture of traditional and modern medicines[2]. In spite of modern development of sophisticated pharmaceutical chemicals to treat illnesses, medicinal plants remain an important tool for treating illness[3].

The plant kingdom comprises many species of plants containing substances of medicinal value, which are yet to be explored. A large number of plants are constantly being screened for their possible medicinal value[2]. The healing powers of traditional herbal medicines have been realized since antiquities. About 65% of the world populations have access to local medicinal plant knowledge system. India is sitting on a gold mine of well-recorded and traditionally well practiced knowledge of herbal medicine. India has an officially recorded list of 45,000 plant species and estimation put the list of 7500 species of medicinal plants growing in its 16 agro-climatic zones under 63.7 million hectares of forest coverage[4].

India is one of the most medico-culturally diverse countries in the world where the main traditional systems of medicine include Ayurveda, Unani and Siddha. With the emerging worldwide interest in adopting and studying traditional systems and exploiting their potential based on different health care systems, the evaluation of the rich heritage of traditional medicine is essential[5]. Medicinal plants contain number of medicinal properties. One of such plants is *Amaranthus spinosus* commonly known as 'spiny amaranth' or 'pig weed'. It is an annual or perennial herb, native to tropical America and found throughout India as a weed in cultivated as well as fallow lands. It has been reported to have some pharmacological properties such as antidiabetic, antipyretic, anti-inflammatory, antioxidant and hepatoprotective etc. *Amaranthus spinosus* also use in internal bleeding, diarrhoea and in excessive menstruation[6].

Taxonomic Classification

Kingdom: Plantae
Division: Magnoliophyta
Class: Magnoliopsida
Order: Caryophyllales
Family: Amaranthaceae
Genus: *Amaranthus*
Species: *spinosus*[7]

Vernacular names

English: Prickly Amaranth, Needle burr, Spiny amaranth, Thorny amaranth
Hindi: Kanta chaulai,
Gujarati: Kantalo dhimdo, Kantanu dant
Manipuri: Chengkruk
Marathi: Kante bhaji, kante math
Tamil: Mullukkeerai
Malayalam: Kattumullenkeera
Telugu: Mullatotakura
Kannada: Mulluharive soppu
Bengali: Kantanotya
Oriya: Kantaneutia
Sanskrit: Tanduliuyah[8]

GEOGRAPHICAL SOURCE

Amaranthus spinosus Linn. is an erect, spinous annual or perennial herb varying in colour from green to purple, is widely distributed throughout the tropics and warm temperate regions of Asia from Japan to Indonesia to India, the Pacific islands, native to tropical America and Australia as a weed in cultivated as well as fallow lands[8-9]. It is a common weed of waste places, roadsides and path sides and near rivers in Ghana. The plant has a long history of usage in traditional medicine against various ailments around the world[10]. It is also growing wild in all parts of Bangladesh. The plant is commonly found throughout tropical, subtropical and Himalayan regions and is distributed in lower to middle hills (3000–5000 ft) of entire north eastern Himalayas[11-12].

Amaranthus spinosus Linn. one of the medicinal plants of Eastern Himalaya especially of Sikkim Himalaya, is known as "prickly amaranthus" in English and "ban lure" or "dhuti ghans" in Nepali[13]. It is commonly known as Prickly amaranth and locally in Paksitan as Khaddar-chaulai, and ''Kate Wali Chaulai (Kanatabhajii)" in 'Hindi", also used as vegetable and cultivated throughout in India, Sri Lanka and many tropical countries[14-15].

MORPHOLOGY

Amaranthus spinosus Linn are erect, monoecious perennial, up to 1 m. Stem are terete or obtusely angular, glabrous or slightly pubescent, green, reddish-brown, glabrous, and branched. The leaves alternate and are simple without stipules; petiole is approximately as long as the leafblade[16-17].The blade shape is ovate-lanceolate to rhomboid, acute and often slightly decurrent at base, obtuse, rounded or slightly ret use and often short mucronate at apex, entire, glabrous or slightly pubescent on veins when young[18-19].

The inflorencence are terminal and axillary, spike-like, erect, slender and elongated, with remote axillary spikes at base, lower clusters, pistillate, upper staminate. Bracteole are longer than or as long as tepal, scarious, ovate weakly spiny-tipped. Staminate flowers with 3, oblong-ovate, obtuse or acute or shortly spiny tipped tepals. Pistillate flowers with 5, 1-1.5 mm long, white-membranous, acute or shortly spiny-tipped tepals[16-17].The fruit is ovoid shaped, mostly dehiscent, compressed, ellipsoidal, acute or obtuse, with a short inflated neck below the style base, circumsessile a little below the middle or indehiscent **(Figure 1)**. The seed is about 1 mm in diameter, shiny, compressed, black or brownish-black in colour[16-19].

TRADITIONAL USES

The juice of *A. spinosus* is used by tribal of Kerala, India to prevent swelling around stomach while the leaves are boiled without salt and consumed for 2–3 days to cure jaundice. It is used as anti-inflammatory, antimalarial, antibacterial, antimicrobial, antidiuretic, antiviral and hepatic disorders. The plant possess hepatoprotective, antioxidant activity, water extract of plant showed significant immune-stimulating activity and stem extract showed antimalarial

activities[2,15,20]. It used internally in the treatment of internal bleeding, diarrhoea and in excessive menstruation[6,19]. In Indian traditional system of medicine (Ayurveda) the plant is used as febrifuge, antipyretic, laxative and diuretic. Besides its culinary value, it is a popular medicinal plant used to reputed for treat digestible, bronchitis, appetizer, biliousness, galactagogue, haematinic, stomachic effects, nausea, flatulence, anorexia, blood diseases, burning sensation, leucorrhoea, leprosy, piles and as a treatment for hallucination, healing of wounds and rheumatism, and to arrest the coughing up of blood. All parts of the plant are known to contain medicinally active constituents[9, 12,13,14,20].

Medicinal uses of *Amaranthus spinosus* Linn. as mentioned in Ayurvedic text is: Leaf infusion is diuretic and used in anemia. Root paste is used in gonorrhoea, eczema, menorrhoea etc. Ethnic use of this plant is mainly with village people of Sikkim who use leaf infusion of in stomach disorder especially in case of indigestion and peptic ulcer[12]. The leaves and roots are applied as poultice to relief bruises, abscesses, burns, wound, inflammation, menorrhagia, gonorrhoea, eczema, gastroenteritis, gall bladder inflammation, arthritis and for the treatment of snakebites. The plant is used in the treatment of abdominal pain, chicken pox, dysentery, dysurea, fever, hysteria, malaria, mania, tonsillitis & vomiting[2,20]. Recent studies showed antidiabetic property of *Amaranthus spinosus* Linn. Ethnic use as reported in literature is mainly in peptic ulcer. Leaf juice of the plant, two tea spoonful thrice a day, is given to patients suffering from peptic ulcer[13].

The Chinese use *A. spinosus* as a traditional medicine to treat diabetes. The seed is used as a poultice for broken bones. The root is known as an effective diuretic. In South-East Asia a decoction of the root is used to treat gonorrhoea and is also applied as an emmenagogue and antipyretic. The Nepalese and some tribes in India apply *A. spinosus* to induce abortion. In Thai traditional medicine, *A. spinosus* is used to treat diarrhoea. The root is also used for toothaches. In many countries, including those in Africa, the bruised leaves are considered a good emollient and applied externally in cases of ulcerated mouths, eczema, burns, wounds, boils, earache and hemorrhoids. The plant ash in a solution is used to wash sores. The plant sap is used as an eye wash to treat ophthalmia and convulsions in children. In Malaysia, *A. spinosus* is used as an expectorant and to relieve breathing in acute bronchitis. In mainland South-East Asia, during the rainy season which is also malaria endemic season, *A. spinosus* bark decoction is taken in a volume of about one liter three times a day to ward off malaria[19]. In India the root extract is given as a vermicide among the Santhali and Paharia in eastern Bihar, while an aqueous decoction of the plant is given to check chronic diarrhoea in Southern Orissa[20].

PHYTOCHEMISTRY

Phytochemical studies revealed that the plant *A. spinosus* have several active constituents like alkaloids, flavonoids, glycosides, phenolic acids, steroids, amino acids, terpenoids, lipids, saponins, betalains, b-sitosterol, stigmasterol, linoleic acid, rutin, 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, betaine such as glycinebetaine and trigonelline **(Figure 2, Figure 3)**[2, 11, 14, 15, 20].

Amaranthus spinosus 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, betaxanthin, betacyanin; gomphrenin, betanin and beta-carotene[9,19,21]. The leaves and stems also revealed contain hentriacontane, octacosanoid, α-spinasterol, saponin and fatty acids[11].The roots contain α-spinasterols octacosanoate and saponin, viz. saponin of oleanolic acid[22].

PHARMACOLOGICAL ACTIONS

Antidiabetic

The ethanolic extract of *Amaranthus spinosus* leaves was administered (150, 300 and 450 mg/kg bw) to type-1 and type-2 diabetic rats. Standard drugs, glibenclamide and metformin were used as a positive control for comparison. Changes in carbohydrate and lipid metabolism and antioxidants were assessed and compared with control and standard drug treated animals. Higher doses of extract significantly decreased plasma glucose levels, hepatic glucose-6-phophatase activity and increased the hepatic glycogen content with a concurrent increase in hexokinase activity in both type 1 and 2 diabetic rats. It also significantly lowered the plasma and hepatic lipids, urea, creatinine levels and lipid peroxidation with an improvement in the antioxidant profiles of both type-1 and type-2 diabetic rats. It is concluded

that *A. spinosus* has potential antidiabetic activity and significantly improves disrupted metabolisms and antioxidant defense in type-1 and type-2 diabetic rats[23].

The methanol extract of *Amaranthus spinosus* stem was investigated for its anti-hyperglycemic and antihyperlipidaemic effects in male Wister albino rats. Diabetes was induced in the albino rats by administration of a single dose of alloxan monohydrate (150 mg/kg, i.p). The methanol extract of *A. spinosus* (MEAS) was administered daily at single doses of 250 and 500 mg/kg, p.o to diabetes-induced rats for a period of 15 days. The effect of MEAS on blood glucose level was measured in the diabetic rats. Serum lipid profiles were also determined. The activities were also compared to the effect produced by a standard anti diabetic agent, glibenclamide. It is established the pharmacological evidence which support the folklore claim that MEAS is an anti diabetic agent[24].

This study deals with the scientific evaluation of alpha amylase and the antioxidant potential of methanol extract of *A. spinosus* (MEAS). The aim of this study was to investigate in vitro alpha amylase enzyme inhibition by CNPG3 (2-chloro-4-nitrophenol a-D-maltotrioside) and in vivo antioxidant potential of malondialdehyde (MDA), glutathione (GSH), catalase (CAT) and total thiols (TT) in alloxan-induced diabetic rats of a methanolic extract of *A. spinosus*. This study provides evidence that the methanolic extract of *A. spinosus* has potent alpha amylase, anti-diabetic and antioxidant activities[25].

Anti-cholesterolemic activity

In this study, the anti-diabetic and anti-cholesterolemic activity of methanol extracts of leaves of *Amaranthus caudatus, Amaranthus spinosus* and *Amaranthus viridis* was evaluated by using normal and streptozotocin (STZ) induced diabetic rats at a dose of 200 mg/kg and 400 mg/kg p.o. daily for 21 days. Blood glucose levels and body weight were monitored at specific intervals, and different biochemical parameters, serum cholesterol, serum triglyceride; high density lipoprotein, low density lipoprotein and very low density lipoprotein were assessed. Histology of pancreas was performed. It was found that all the three plants showed significant anti-diabetic and anti-cholesterolemic activity[26].

Diuretic activity

The diuretic potential of *Amaranthus spinosus* aqueous extract (ASAE) in rats was evaluated. Different concentrations of ASAE (200, 500, 1000, 1500mg/kg), thiazide (10mg/kg) and vehicle were orally administered to rats (n=6 animals per group) and their urine output was collected after 24h. Volume, pH, Na^+, K^+ and Cl^- concentrations of urine were estimated. ASAE produced increase in Na^+, K^+, and Cl^- excretion, caused alkalinization of urine, and showed strong saluretic activity and carbonic anhydrase inhibition activity. These effects were observed predominantly at 500mg/kg dose and suggested that the *A. spinosus* is acting as a thiazide like diuretic[27].

Hepatoprotective and antioxidant activity

This study show hepatoprotective activity of the 50% ethanol extracts of the whole plant of *Amaranthus spinosus* Linn. (Amaranthaceae) against d-galactosamine/lipopolysaccharide (d-GalN/LPS)-induced liver injury in rats was evaluated. d-GalN/LPS (300 mg/kg body weight/30 µg/kg body weight)-induced hepatic damage was manifested increase in the activities of marker enzymes (aspartate transaminase, alanine transaminase, alkaline phosphatase, lactate dehydrogenase and gamma glutamyl transferase) and bilirubin level in serum while phospholipids significantly decreased. All other parameters, i.e. cholesterol, triglycerides and free fatty acids were increased significantly in both serum and liver compared to the control group. Pretreatment of rats with *A. spinous* extract (400 mg/kg) reversed these altered parameters to normal compared to the intoxicated group. The biochemical observations were supplemented by histopathological examination of liver sections. Results of this study revealed that *A. spinosus* extract could afford a significant protection against d-GalN/LPS-induced hepatocellular injury[28].

The hepatoprotective and antioxidant activity of 50% ethanolic extract of whole plant of *Amaranthus spinosus* (ASE) was studied against carbon tetrachloride (CCl4) induced hepatic damage in rats. The ASE at dose of 100, 200 and 400 mg/kg were administered orally once daily for fourteen days. The substantially elevated serum enzymatic levels of serum glutamate oxaloacetate transaminase (AST), serum glutamate pyruvate transaminase (ALT), serum alkaline phosphatase (SALP) and total bilirubin were restored towards normalization significantly by the ASE in a dose dependent manner. Higher dose exhibited significant hepatoprotective activity against carbon tetrachloride induced hepatotoxicity in rats. The biochemical observations were supplemented with histopathological examination of rat liver sections. Meanwhile, in vivo antioxidant

activities as malondialdehyde (MDA), hydroperoxides, reduced glutathione (GSH), superoxide dismutase (SOD) and catalase (CAT) were also screened which were also found significantly positive in a dose dependent manner. The results of this study strongly indicate that whole plants of *A. spinosus* have potent hepatoprotective activity against carbon tetrachloride induced hepatic damage in experimental animals[29].

The 50% ethanolic extract (ASE) of *Amaranthus spinosus* (whole plant) was evaluated for in vitro antioxidant and hepatoprotective activity. The total phenolics and reducing capacity of ASE was determined using standard curve of gallic acid (0-1.0mg/ml) and butylated hydroxy anisole (BHA). In vitro antioxidant activity was determined by DPPH, superoxide, hydroxyl radicals, hydrogen peroxide and nitric oxide scavenging methods. The hepatoprotective activity of ASE was evaluated at 6, 7, 8, 9 and 10 microg/ml concentration against CCl_4 (1%) induced toxicity in freshly isolated rat hepatocytes and HepG2 cells. ASE was found to contain 336+/-14.3mg/g total poly phenolics expressed as gallic acid equivalent while the reducing capacity was 2.26 times of BHA. ASE possesses significant hepatoprotective activity which might be due to antioxidant defence factors and phenolics might be the main constituents responsible for activity[30].

Amaranthus spinosus roots were extracted successively with petroleum ether (80-100°C), ethyl acetate and methanol by Soxhlet process. All the extracts were subjected to Total phenolic content, total flavonoid content and antioxidant activity using DPPH assay and Ferric Reducing Antioxidant Power assay (FRAP). Ethyl acetate extract showed the highest antioxidant activity with 61.47 ± 4.8 % inhibition at a higher concentration. The three solvents; Methanol, ethyl acetate and Pet-ether extracts showed moderate activity when compared with the standard. In all, ethyl acetate extract generally, exhibited the highest values of antioxidants[10].

Analgesic and anti-inflammatory activity

The 50% ethanol extract (ASE) of *Amaranthus spinosus* (whole plant) has been studied for antinociceptive and antiinflammatory activities. The Analgesic and antiinflammatory activities were studied by measuring nociception by formalin, acetic acid, hot plate, tail immersion method while inflammation was induced by carrageenan. ASE had significant dose dependent percentage protection against acetic acid (0.6% of 10 ml) induced pain and the effects were also compared to aspirin, morphine and naloxone while formalin induced pain (0.05 ml of 2.5%) was significantly blocked only at higher dose (400mg/kg) in first phase. ASE significantly blocked pain emanating from inflammation at all the doses in second phase. The reaction time in hot plate was increased significantly and dose dependently where as pretreatment with naloxone rigorously reduced the analgesic potentials of ASE. Further in tail immersion test the same dose dependent and significant activity was observed. Aspirin had no effect on thermal induced pain i.e. hot plate and tail immersion tests but showed an effect on writhing test. This studied show that *A. spinosus* possess significant and dose dependant anti-inflammatory activity, it has also central and peripheral analgesic activity[31].

Successive petroleum ether, ethyl acetate and methanol extracts of the whole plant of *Amaranthus spinosus* Linn. were investigated for the analgesic activity. Experiments were carried out with these extracts for their peripheral and central anti-nociceptive potentials on acetic acid induced writhing and radiant heat tail-flick models in mice, respectively. In both the models, methanolic extract showed significant writhing inhibition as well as the elongation of tail-flick time at a dose of 500 mg/kg body weight. A linear dose response relationship was also observed[11].

The methanol extracts of *Amaranthus spinosus* Linn. leaves were evaluated for anti-inflammatory activities in different animal models. The extract (25–100 mg/kg) inhibited the carrageenan-induced rat paw edema and produced significant inhibition of acetic acid–induced increased vascular permeability. Inhibition of the cotton pellet granuloma was also inhibited by 100 mg/kg of the plant extract. Analgesic activity was exhibited with the significant and dose-related reduction in the number of writhings induced with acetic acid, as well reduction in paw licking induced by injection of formalin in mice. These results demonstrate the anti-inflammatory properties of the leaf extract of *A. spinosus*. It is also suggested that the plant extract probably acts by the inhibition of prostaglandin biosynthesis[32].

The petroleum ether and ethanolic extract of whole plant of *Amaranthus spinosus* Linn. were tested for anti-inflammatory activity at the dosed of 250,500 and 750 mg/kg body weight. The extract produced dose dependent and significant inhibition of carrageenan induced paw oedema. The exhibited anti-inflammatory activity of this plant was comparable with the standard drug Ibuprofen. The presence of steroids, alkaloids & flavonoids in the extracts

may be contributory to its anti-inflammatory activity[22].

Spermatogenic activity

Anti-diabetic, anti-hyperlipidemic and spermatogenic effects were studies with methanolic extract of stem of *Amaranthus spinosus* Linn. in diabetic rats. In streptozotocin (STZ)-induced diabetic rats, it was observed that both the standard drug (Glibenclamide) and methanolic extract of *A. spinosus* Linn. significantly exhibited control of blood glucose level on a 15 day model. Further, the methanolic extract also showed significant anti-hyperlipidemic and spermatogenic effects in STZ-induced diabetic rats. The methanolic extract has also accelerated the process of spermatogenesis by increasing the sperm count and accessory sex organ weights[33].

Anti-hyperlipidemic activity

The anti-hyperlipidemic activity of methanol extracts of leaves of three plants of *Amaranthus caudatus, Amaranthus spinosus, Amaranthus viridis* were studied. In this study, the anti-hyperlipidemic effects investigated by using normal and triton-WR 1339 induced rats at the dose of 200, 300 and 400 mg/kg p.o. The serum harvested was analyzed for total cholesterol, triglycerides, high density lipoprotein and low density lipoprotein. It was found that all the three plants at 400 mg/kg dose showed significant anti-hyperlipidemic effect, whereas 300 mg/kg dose is less significant in the entire parameters used for evaluation of anti hyperlipidemic effect[34].

Heamatological properties

This study is designed to study the hematocellular indices i.e. Red blood cell count (RBC), White blood cell count (WBC) and Hemoglobin (Hb), following oral administration of methanolic extract of *Amaranthus spinosus* at a dose of 250mg/kg body weight in albino rats. The study was carried out by single and daily administration of dose for 5, 7 & 14 days. Results revealed that the RBC and WBC count as well as Hb% was significantly altered due to administration of methanolic extract of *A. spinosus*[6].

Antipepticulcer activity

Anti peptic ulcer activity of the leaves of *Amaranthus spinosus* Linn., a plant of Eastern Himalaya, was studied in peptic ulcer models in rats. Gastric and duodenal ulcers were induced by ethanol and cysteamine respectively. Results were compared with omeprazole, a known drug for peptic ulcer. It was found out that the leaves of *A. spinosus* Linn. exerted anti peptic ulcer activity against ethanol and cysteamine induced peptic ulcerations but the activity was less than that of omeprazole[12].

Anti gastric ulcer activity of root stems and leaves of *Amaranthus spinosus* Linn. were studied against ethanol, hydrochloric acid, indomethacin, stress and pyloric ligation induced gastric ulceration in albino rats. Omeprazole was used as standard anti gastric ulcer drug. Significant anti gastric ulcer activity was noted in root, stem and leaves of *A. spinosus* Linn. Root of the plant, however, showed highest activity which was comparable to that of omeprazole[13].

Antibacterial and cytotoxity activity

This study was to find out the antibacterial and cytotoxic activity of chloroform, n-hexane and ethyl acetate extracts of *Amaranthus spinosus*. Disc diffusion technique was used for in vitro antibacterial screening against gram positive and gram negative human pathogenic bacteria. In case of *A. spinosus* all extracts showed good antibacterial activity against both gram positive and gram negative & average zone of inhibition 8-15mm. The Brine shrimp lethality bioassay method was used to determine the cytotoxicity activities and Vincristine Sulphate was used as positive control. The LC50 values of standard vincristine sulphate, chloroform, n-hexane and ethyl acetate extract were 7.55µg/ml, 18.15 µg/ml, 29.51µg/ml & 18.15µg/ml respectively for the *A. spinosus*[2].

Ethanol and aqueous extracts of *Amaranthus spinosus* (roots) were investigated for their antibacterial activity against ten bacterial strains including Gram-positive and Gram-negative bacteria using the agar-well diffusion method. The extracts tested, the ethanol extract presented the best results while the aqueous extract showed moderate inhibition of the microbial growth. Each extract is unique against different microorganisms[35].

Antidiarrhoeal activity

The ethanol extract (50%) of the whole plant of *Amaranthus spinosus* Linn. (ASE) significantly inhibited travel of a charcoal meal at three different doses of ASE, but when 400 mg/kg of ASE was repeated in the presence of yohimbine, intestinal propulsive inhibition decreased, while morphine reversed the activity. The percentages related to controls for the onset of diarrhoea were 16.58, 83.42, and 116.18% at doses of 100, 200, and 400 mg/kg of ASE, while with morphine this value was 123.93% compared to controls. The

percentage purging frequency related to controls was 41.09, 64.38, 71.23, and 86.30% at three different doses of ASE and with morphine, respectively. The inhibitions in intestinal accumulation were 8.9, 48.16, and 68.06% at doses of 100, 200, and 400 mg/kg of ASE, respectively, compared to control, while inhibition with yohimbine was 50.78%. Antidiarrahoeal indices of ASE were 23.55, 49.16, and 76.53 at the three different doses of ASE, while morphine had a maximum index of 88.4[20].

Bronchodilator and spasmolytic activity

The aqueous-methanolic extract of *Amaranthus spinosus* Linn. whole plant, was studied *in-vivo* for bronchodilator and laxative activities and in-vitro using isolated tissue preparations which were mounted in tissue baths assembly containing physiological salt solutions, maintained at 37°C and aerated with carbogen, to assess the spasmolytic effect and to find out the possible underlying mechanisms. These results indicate that *A. spinosus* possesses laxative activity partially mediated through cholinergic action. The spasmolytic effect was mediated through calcium channel blocking (CCB), while bronchodilator activity through a combination of β-adrenergic and CCB pathways, which may explain the traditional uses of *A. spinosus* in gut and airways disorders[14].

Anthelmintic activity

Water extracts of whole plant of *Amaranthus spinosus* Linn. was evaluated for anthelmintic on adult Indian earthworms (*Pheritima posthuma*) and *Tubifex tubifex*, using piperazine citrate as reference standard. Aqueous extract showed anthelmintic activity in dose-dependent manner giving shortest time of paralysis(P) and death(D) with 50 mg/ml concentration, for both the worms. Extract shows more potent activity (15 mg/ml) against *Tubifex tubifex*[22].

Antipyretic activity

Methanolic extract of *Amaranthus spinosus* leaves was screened for antipyretic activities. Antipyretic activity of methanolic extract of *A. spinosus* was measured by yeast induced pyrexia method at concentration of 200 and 400 mg/kg using paracetamol as standard drug. Methanolic extract of *A. spinosus* showed significant ($P<0.01$) antipyretic activity[36].

Antitumor activity

The antitumor potentials of *Amaranthus spinosus* against EAC bearing Swiss albino mice. The ethanol extract of its leaves given orally to mice at the dose of 100 and 200 mg/kg body weight for 16 days. It was observed that decrease in tumor volume and viable cell count, while increase in mean survival time and non viable tumor cell count, when compared to the mice of the EAC control group. Restoration of hematological and biochemical parameters towards normal was also observed. The results suggest that the ethanol extract of *A. spinosus* leaves exhibits significant antitumor effects in EAC bearing mice[37].

Antimicrobial activity

Amaranthus spinosus L. was screened for antimicrobial activity. The bioparts, namely, root, stem, leaves and flower, extracted in distilled water, hexane and methanol were assayed against five bacterial strains such as Staphylococcus sp., Escherichia coli, Pseudomonas sp., Klebsiella sp., Paracoccus sp. and three fungal strains, namely, Fusarium sp., Aspergillus sp. and Alternaria sp. Preliminary qualitative analysis was also done. Stem and flower of *A. spinosus* displayed more antibacterial activity among the bioparts. Maximum zones of inhibition in E. coli (14 mm) and Pseudomonas (13 mm) were noticed in stem extract in distilled water (4.7 mg/disc) and methanol (3.8 mg/disc), respectively. Distilled water fraction of flower inhibited all strains under investigation. Maximum zones of inhibition in respect of Staphylococcus (10 mm), Paracoccus (9 mm) and Klebsiella (15 mm) were evident in flower extracted in various solvents. The methanol fraction of the bioparts exhibited total inhibition of fungal growth. Root, stem and leaves of *A. spinosus* extracted in hexane imparted partial inhibition on all fungal strains[38].

Antimalarial activity

Extracts obtained from two Burkinabe folk medicine plants, *Amaranthus spinosus* Linn., and *Boerhaavia erecta* Linn., were screened for antimalarial properties with the aim of testing the validity of their traditional uses. The plant extracts showed significant antimalarial activities in the 4-day suppressive antimalarial assay in mice inoculated with red blood cells parasitized with *Plasmodium berghei berghei*. We obtained values for ED (50) of 789 and 564 mg/kg for *A. spinosus* and *B. erecta* extracts, respectively[39].

Antifertility activity

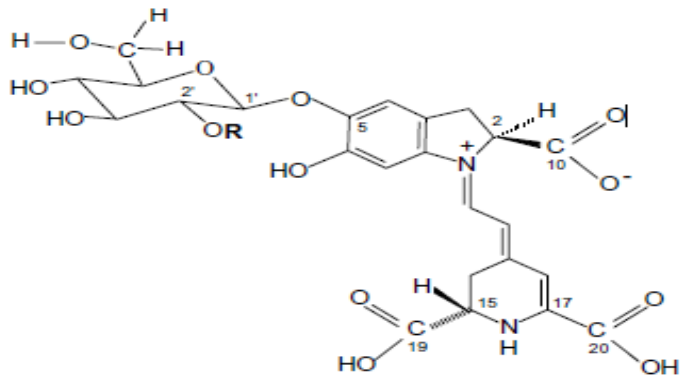
The aqueous and ethanolic extracts of root of *Amaranthus spinosus* Linn. was exploring antifertility activity in rats. Antifertility

screenings of water and ethanolic extract of *A. spinosus* were done by the reproductive outcome in mice, anti-implantation, abortifacient, estrogenic and anti estrogenic activity in rats. The water extract of the root of plant showed the decrease in number of implants and number of litters when compared with the ethanolic extract as the percentage of implantation failure increased. The extract shows furthermore, non significant increase in uterine weight in immature ovariectomised rats. Simultaneous administrations of extracts with ethinyl estradiol cause significant antiestrogenic activity. All these observations suggest that aqueous and ethanolic extracts of *A. spinosus* Linn. have weak antifertility effect[40].

CONCLUSION

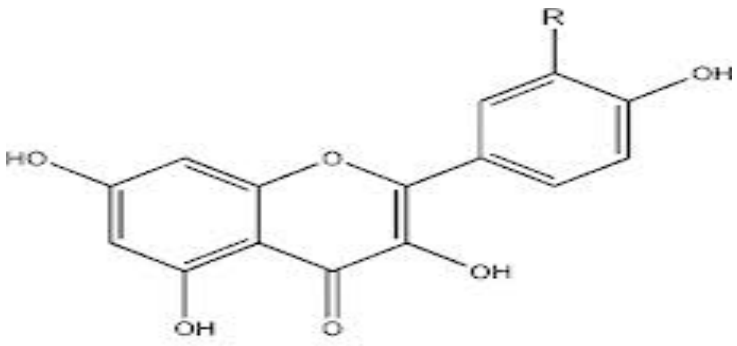
Medicinal plants have attracted considerable global interest in recent years. Investigation of traditional medicine is very important for the welfare of rural and tribal communities for the treatment of conventional illness. The extensive survey literature reviewed that *Amaranthus spinosus* Linn. is an important medicinal plant with diverse pharmacological spectrum. Lot of pharmacological studies has been carried out with extract of the different parts of the plant. The plant is widely used in traditional medicinal system of India and has been reported to possess antidiabetic, antipyretic, anti-inflammatory, antioxidant, hepatoprotective, antimalarial, antibacterial, antimicrobial, antidiuretic, antiviral and in hepatic disorders . The whole plant parts of the plant are known to contain medicinally active constituents. Due to medicinal properties there is enormous scope for future research on *Amaranthus spinosus* Linn. in various treatments and recommend that further phytochemical, pharmacological investigation and clinical research should be conducted to investigate unexploited potential of this plant for the discovery of safer drugs.

Fig. 1: Morphological view of *Amaranthus spinosus* Linn



R = H: Betanin
R = Glucuronic acid: Amaranthine

Fig. 2: Structure of betanin and amaranthine



Quercetin R=OH
Kaempferol R=H

Fig. 3: Structure of quercetin and kaempferol

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