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Prickly Amaranth (*Amaranthus spinosus* Linn.): a Review on Phytochemistry and Pharmacological Activities

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ABSTRACT

This paper reviews the traditional, clinical potential, ethnopharmacology, phytoconstituent studies and safety profile of Prickly Amaranth (*Amaranthus spinosus* Linn.) with a view to explore the potentiality of the plant and proclaim it to the nature product researchers throughout the world. Phytochemical investigations prove its importance as valuable medicinal plant. It is known as a 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. Various researchers have carried out wide spectrum studies on its pharmacological actions and preliminary work has been reported on antidiabetic, antitumour, analgesic, antimicrobial, anti-inflammatory, spasmolytic, bronchodilator, hepato-protective, antifertility, antimalarial, antioxidant properties etc. Hence Prickly Amaranth holds a great potential for in depth biological evaluation.

Keywords: Prickly Amaranth, *Amaranthus spinosus*, Traditional medicine, Phytochemistry, Pharmacological activities, Ethnopharmacology, Clinical study.

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INTRODUCTION

Prickly Amaranth (*Amaranthus spinosus* Linn.) is a very common herb which is known for its many medicinal properties and edibility as a vegetable. As the name indicates “amara” meaning bitter and “spinosus” meaning spiny and so it is commonly known as ‘spiny amaranth’ also known as ‘pig weed’ and ‘Kate wali Chaulai (Kantabhaji)’ in Hindi¹. This plant is considered as one of the vegetables having high concentration of antioxidant components and nutritional values due to the presence of fibres, proteins and high concentration of essential amino acids, especially lysine². It is cultivated throughout India, Sri Lanka and distributed throughout the tropical and warm temperate regions of Asia³. It is a common weed of waste places, roadsides and path sides and near rivers in Ghana³. The tender leaves are eaten as vegetable and root is taken for intestinal diseases in the Kathmandu valley. Root juice is taken with cold water in the morning to treat painful urination and crushed leaves and root paste are applied on skin infections, wounds and rheumatic areas⁴. The tribal people of Kerala (India) consume the juice of Prickly Amaranth to prevent swelling around stomach while the leaves are boiled without salt and consumed to cure jaundice⁵. In Manipur, Prickly Amaranth plant is cooked-eaten by patients suffering from diabetes and high blood pressure and also by poor rural people⁶.

Phytochemicals

Photochemical studies of Prickly Amaranth by various researchers have revealed that *Amaranthus spinosus* contains a new coumaroyl flavone glycoside called spinoside xylo furanosyl uracil, hydroxycinnamates, quercetin and kaempferol glycoside, betalains, betaxanthin, betacyanin, phenolic compounds, amaranthin and isoamaranthine, β -sitosterol glycoside, campesterol. Chemical analysis of leaves and stem gave hentriacontane and α - spinasterol, linoleic acid, rutin and beta carotene, as prime phytoconstituents⁷. Phytochemicals like phenolic compounds, terpenoids, alkaloids, etc. have been found to be suitable reducing agents with high efficiency⁸.

PHARMACOLOGICAL ACTIVITY:

Antiprotozoal activity and Anti-malarial activity:

The dichloromethane extract of Prickly Amaranth (2mg per mL) was moderately inhibitory to *Blastocystis hominis*, a common human protozoan. The reference antiprotozoal agent, metronidazole (40 μ g/mL) killed 97% of the protozoan and inhibited all protozoan samples at 1.25-20 μ g/mL concentrations⁹.

The aqueous extract of Prickly Amaranth bark obtained from mature stems was screened for anti-malarial properties in mice inoculated with erythrocytes parasitized with *Plasmodium berghei*. The

bark extract showed a dose-dependent anti-malarial activity in a 4 day suppressive anti-malarial assay using chloroquine as the reference anti-malarial drug. ED 50 values for the anti-malarial activities of the extract and chloroquine were 789.4 and 14.6 mg/kg, respectively⁹.

Anti-inflammatory activity and Analgesic properties:

The 50% ethanol extract of Prickly *Amaranth* (ASE) has been studied for anti-nociceptive and anti-inflammatory activities. The analgesic and anti-inflammatory 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 (400 mg/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 whereas pre treatment with naloxone rigorously induced the analgesic potential 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 Prickly *Amaranth* possess significant and dose dependent anti-inflammatory activity, it has also central and peripheral analgesic activity¹⁰.

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 extract 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 observed¹¹.

The methanol extracts of Prickly *Amaranth* 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 produce 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 as reduction in paw licking induced by injection of formalin in mice. These results demonstrate the anti-inflammatory properties of the leaf extract of Prickly *Amaranth*. It is also suggested that the plant extract probably acts by the inhibition of prostaglandin biosynthesis¹².

Antioxidant and antipyretic properties:

Production of free radicals in the biological system results in the imbalance in the level of pro-oxidant and antioxidant known as oxidative stress¹³. Leafy vegetables are good source of antioxidants. Methanolic extract of *Amaranthus spinosus* leaves was screened for antioxidant and antipyretic activities. Antioxidant activity was measured by 1,1-diphenyl-2-picryl-hydrazil (DPPH) free radical scavenging, superoxide anion radical scavenging, hydroxyl free radical scavenging, nitric oxide radical scavenging, 2,2'-azinobis-3-ethylbenzothiazole-6-sulfonate (ABTS) radical scavenging assays and total phenolic content was also determined. Antipyretic activity of methanolic extract of Prickly Amaranth 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 potent antioxidant activity. The IC₅₀ value was (87.50±3.52) µg/mL, (98.80±1.40) µg/mL, (106.25±0.20) µg/mL, (88.70±.62) µg/mL and (147.50±2.61) µg/mL, for DPPH, superoxide, hydroxyl, nitric oxide and ABTS radical scavenging activities¹⁴.

The antioxidant capacity of Prickly Amaranth was studied in roadside plants which were postulated to be continuously exposed to the high levels of nitrogen oxides and sulphur dioxide from automobile emissions. The plant was shown to possess a very good free radical scavenging system for combating air pollution through analysis of the enzymes superoxide dismutase, catalase, ascorbate peroxidase, glutathione reductase and phenolic peroxidase activities. Amaranthaceae plants contain betalain pigments which showed strong antioxidant activities by the DPPH assay. Their EC₅₀ values range from 3.4 to 8.4 µM. The antioxidant activity of Prickly Amaranth extract may be due to its betalain content².

Most of the anti pyretic drugs inhibit COX-2 expression to reduce the elevated body temperature by inhibiting PGE₂ biosynthesis moreover this synthetic agents irreversibly inhibit COX-2 with high selectivity but are toxic to the hepatic cells, glomeruli, cortex of brain and heart muscles, whereas natural COX-2 inhibitors have lower selectivity with fewer side effect. Search for herbal remedies with potent antipyretic activity received momentum recently as the available antipyretics such as paracetamol, nimusulide, etc have toxic effect to the various organs of the body. The results showed that methanol extract of three plants of *Amaranthus* possesses a significant antipyretic effect in maintaining reduced yeast induced elevated body temperature in rats and their effects were comparable to that of the standard antipyretic drug paracetamol¹⁴.

Anti-diabetic:

The ethanolic extract of Prickly Amaranth 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 phosphatase activity and increase the hepatic glycogen content with a concurrent increase in hexokinase activity in both Type-1 and Type-2 diabetic rats. It also significantly lowered the plasma and hepatic lipids, urea, creatinine and lipid per oxidation with an improvement in the antioxidant profile of both type-1 and type-2 diabetic rats. It is concluded that Prickly Amaranth plant has potential anti-diabetic activity and significantly improves disrupted metabolism and antioxidant defence in type 1 and type 2 diabetic rats¹⁵.

The methanolic extracts of *A. spinosus* stem were investigated for its anti-hyperglycemic and anti-hyperlipidaemic effects in male Wister albino rats. Diabetes was induced in the albino rats by administration of a single dose of alloxan monohydrate (150mg/kg,i.p). The methanol extract of *A. spinosus* (MEAS) was administered daily at single doses of 250 and 500 mg/kg, orally 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 antidiabetic agent, glibenclamide. It is established by the pharmacological evidence which support the folklore claim that MEAS is an anti-diabetic agent¹⁶.

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 maltotrioxide) and in vivo antioxidant potential of malondialdehyde (MDA), glutathione (GSH), catalase (CAT) and total thiols (TT) in alloxaninduced diabetic rats of a methanolic extract of *A. spinosus*. This study provides evidence that the methanolic extracts of *A. spinosus* has potent alpha amylase, antidiabetic and antioxidant activities¹⁷.

Anti-helminthic activity:

Water extracts of whole plant of Prickly Amaranth was evaluated for anti helminthic activity on adult Indian earthworms (*Pheritima posthuma*) and *Tubifex tubifex*) using tiperazine citrate as reference standard. Aqueous extract showed antihelminthic 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 *T. Tubifex*¹⁸.

Biochemical role:

This study carried out by Gul *et.al.*2001 was done to investigate the biochemical role of methanolic extract of *Amaranthus spinosus* on liver of Sprague Dawley rats. Female albino rats were divided into two groups: one group served as control which was fed on normal diet, the second group

served as experimental which received a dose level 250 mg/kg of methanolic extract of *A.spinosus* plant. Protein concentration was estimated in liver homogenate using the Lowry method (1951) with bovine serum albumin (BSA) as standard. Also, glycogen concentration was estimated with tested organ by using Seifter Method (1950). Result showed significant increase for both acute as well as chronic studies in protein and glycogen contents at 250 mg/kg dose level¹⁹.

Immuno-modulatory properties:

The aqueous extract of Prickly Amaranth leaves showed immuno-modulatory effects by significantly stimulating splenocyte proliferation in primary splenocytes from female BALB/C mice. The extract stimulated isolated B lymphocytes, not T lymphocytes, in a dose response manner. The water extract (1250 µg/mL) elicited a much higher proliferation rate in bulk splenocytes than in isolated purified B and T cells, suggesting some sort of interaction between these cells. Thus the immuno stimulating effects of the water extract may lead to B lymphocytes activation which will subsequently, through secondary signalling, lead to T lymphocyte proliferation. A novel immuno-stimulatory protein (GF1) with a molecular weight of 313kDa was obtained after sequential purification of the water extract. GF1 which was assumed to be a glycoprotein and was heat labile, had an immuno-stimulatory activity which was 309 times higher than that of the water extract²⁰.

Hematological properties:

Shrivastava*et al.* 2011 had designed this study to investigate the hematocellular indices i.e. Red blood cell count (RBC), White blood cell count (WBC) and haemoglobin (Hb) following oral administration of methanolic extract of Prickly Amaranth at a dose of 250 mg/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 Prickly Amaranth²¹.

Hepatoprotective Activity:

This study show hepatoprotective activity of the 50% ethanol extracts of the whole plant of *Amaranthus spinosus* Linn. against D-galactosamine/lipopolysaccharide (d-GalN/LPS) – induced liver injury in rats was evaluated. d- GalN/LPS (300mg/kg body weight/ 30µg/kg body weight)-induced hepatic damage was manifested increase in the activities of marker enzymes (aspartate transaminase, alkaline phosphatase, lactate dehydrogenase and gamma glutamyl transferase) and bilirubin level in serum while phospholipids significantly decrease. All other parameters, i.e. cholesterol, triglycerides and free fatty acids were increased significantly in both serum and liver compared to the control group. Pre-treatment of rats with *A. spinosus* extract (400mg/kg) reversed

this alteration to normal compared to the intoxicated group. The biochemical observations were supplemented by histopathological examination of liver sections. Results of the study revealed that *A. spinosus* extract could afford a significant protection against d-GalN/LPS - induced hepatocellular injury²².

Spermatogenic activity:

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 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 weights²³.

Anti-peptic ulcer activity:

Anti-peptic ulcer activity of the leaves of *Amaranthus spinosus* Linn, 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 omeprazole²⁴.

Anti-gastric ulcer activity of root, stem and leave extracts 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 leave extracts of *A. spinosus* Linn. Root extract of the plant, however, showed highest activity which was comparable to that of omeprazole²⁵.

Antibacterial and cytotoxic activity:

Ishrat*et al.* (2011) had done a study 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 invitro 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 8-15 mm. The Brine shrimp lethality bioassay method was used to determine the cytotoxic activity and Vincristine Sulphate was used as positive control. The LC50 values of standard vincristine sulphate, chloroform, n-hexane and ethyl acetate extract were 7.55 µg/ml, 18.15 µg/ml, 29.51 µg/ml and 18.15 µg/ml respectively for the Prickly Amaranth²⁶.

Ethanol and aqueous extracts of *A. spinosus* (roots) were investigated for their antibacterial activity against 10 bacterial strains including gram positive and gram negative bacteria using the agar-well diffusion method. The ethanol extract presented the best results while the aqueous extract showed moderate inhibition of the microbial growth. Each extract is unique against different microorganisms²⁷.

Anti-diarrhoeal activity:

The ethanolic extract (50%) of the whole plant of *Amaranthus spinosus* Linn. significantly inhibited travel of a charcoal meal at three different doses of *Amaranthus spinosus* extract (ASE), but when 400mg/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 the 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 accumulations were 8.9, 48.16 and 68.06% at doses of 100, 200 and 400mg/kg of ASE, respectively, compared to the control, while inhibition with yohimbine was 50.78%. Anti-diarrhoeal indices of ASE were 23.55, 49.16 and 76.53 at the three different doses of ASE while morphine had a maximum index (88.4)²⁸.

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. This result indicates that *A. spinosus* possesses laxative activity partially mediated through cholinergic action. Thus spasmolytic effects 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 the plant in gut and airways disorders¹.

CONCLUSION

Medicinal plants have been in use for treating various ailments since time immemorial. The use of food plants as medicine and medicinal plants as food is a novel idea that can integrate in holistic approach in health care sector. In recent years the use of the medicinal plants has attracted the interest of many researchers due to various reasons like least side effect, readily available and cost effective. Therefore, it is essential for the researchers to investigate about these traditional plants to

know the exact potentiality of the plants against conventional illness. From the extensive literature review it has been observed that *Amaranthus spinosus* Linn. (Prickly Amaranth) is an important medicinal plant which is used traditionally for curing various ailments since ages. Pharmacological published reports revealed that the plant has anti-protozoal, anti-inflammatory and analgesic property, antioxidant and anti-pyretic activity, hepatoprotective, antimalarial, antibacterial, haematological, anti-diabetic, anthelmintic, spermatogenic activity, anti peptic ulcer, anti-diarrhoeal, bronchodilator and spasmolytic activity. The *A. spinosus* has several active constituents like alkaloids, flavonoids, glycosides, phenolic acid, steroid, amino acid, terpenoids, lipids, saponins, betalains, β -sitosterol, stigmasterol, linoleic acid, rutin, catechuic tannins and carotenoids. The whole plant part of *A. spinosus* is known to contain many medicinally active constituents and hence due to these medicinal properties the plant has a huge scope for further research in various treatments and recommends that further phytochemical, pharmacological investigation and clinical research should be conducted to investigate the unexploited potential of this plant for the discovery of safer and more affordable drugs.

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