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Exploring the ethnomedicinal, phytochemical and therapeutic potential of *Amaranthus spinosus* L.N.S. Disha and B.S. Ashok Kumar[♦]

R. L. Jalappa College of Pharmacy, Sri Devaraj Urs Academy of Higher Education and Research, Tamaka, Kolar-563103, Karnataka, India

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Abstract

Amaranthus spinosus L. a member of the Amaranthaceae family, has been widely used in traditional medicine for its diverse therapeutic properties. It exhibits significant pharmacological activities, including antidiabetic, anticancer, antiobesity, hepatoprotective, analgesic, antipyretic, antifertility, and antiarrhythmic effects. The plant is rich in bioactive compounds such as alkaloids, flavonoids, saponins, and terpenoids, which contribute to its medicinal benefits. Additionally, it contains essential minerals and pigments, such as iron, calcium, and carotenoids that further enhance its health-promoting properties. Traditionally, *A. spinosus* has been used for the treatment of wounds, fever, and gastrointestinal disorders. Recent studies have highlighted its potential in cognitive enhancement, demonstrating its ability to improve memory and learning. Its antidiabetic effects are attributed to its role in regulating blood glucose levels and enhancing insulin sensitivity. The plant has also shown promising anticancer activity, inhibiting the growth of various cancer cell lines. Its antiobesity effects stem from its ability to regulate lipid metabolism and reduce fat accumulation. Furthermore, *A. spinosus* has exhibited hepatoprotective properties, protecting against liver damage caused by toxins and oxidative stress. Its analgesic and antipyretic activities make it a potential alternative to conventional pain relievers and fever reducers. The plant's anti-inflammatory and antiarrhythmic properties have been well-documented, showing significant inhibition of inflammation and diarrhea in animal models. Additionally, its antifertility effects suggest its potential use in contraceptive applications by influencing reproductive hormones and fertility-related parameters. Overall, *A. spinosus* demonstrates extensive therapeutic potential, warranting further investigation into its clinical applications and mechanisms of action.

1. Introduction

Amaranthus spinosus L. (Figure 1), belongs to family Amaranthaceae, is a widely distributed plant native to tropical and subtropical regions of the world. Known by several regional names such as “Kate Wali Chaulai” in Hindi, “Mulla-dantu” and “mulluharivesoppu” in Kannada; this plant has been utilized in various traditional systems of medicine, particularly in India, Sri Lanka, and several other tropical countries. This species is an annual, herbaceous plant, commonly found in the wild and cultivated as a leafy vegetable due to its high nutritive and medicinal value (Sarker and Oba, 2019; Kumar *et al.*, 2011).

The genus *Amaranthus* consists of around 60 species, with *A. spinosus* being one of the most significant due to its broad medicinal applications. In Ayurveda and other traditional medicinal practices, *A. spinosus* is known for its diverse therapeutic properties, which span across numerous health issues, including digestive, metabolic, and inflammatory disorders (Gandhi *et al.*, 2020). In traditional Indian medicine, *A. spinosus* is highly valued for its ability to treat various ailments. *A. spinosus* juice is widely used by tribal

communities in Kerala, India, for its anti-inflammatory properties, particularly in reducing swelling. The boiled *A. spinosus* leaves without salt and consumed for 2-3 days to treat jaundice. In addition to these uses, the plant plays a crucial role in enhancing overall health due to its high antioxidant content, making it a valuable dietary staple with therapeutic benefits. The leaves, abundant in antioxidants and essential amino acids, particularly lysine, are widely consumed as a vegetable in various regions of India. The plant also contains fibers and proteins, contributing to its high nutritional profile. Besides its dietary uses, the root of *A. spinosus* serves as an expectorant and is often utilized in treating conditions like leprosy, leucorrhoea, and excessive menstrual flow. The seeds of the plant are used as a poultice for treating broken bones, demonstrating the plant's widespread application in treating physical injuries (Prabha, 2024; Gotyal *et al.*, 2016).

A. spinosus has also found a place in various traditional systems for treating ailments beyond its culinary uses. It is a known remedy for conditions like internal bleeding, diarrhoea, excessive menstruation, and fever (Abbasi *et al.*, 2015). In some regions, *A. spinosus* is used externally in the form of poultices to alleviate pain from burns, abscesses, and bruises. It also plays a vital role in treating wounds, rheumatism, and even hallucinations, showcasing its holistic therapeutic applications. The ethnomedicinal use of *A. spinosus* is not confined to India alone. In various other countries, including those in Africa, it is used as an emollient for ulcerated mouths, eczema, burns, and haemorrhoids (Baral *et al.*, 2011). The

Corresponding author: Dr. B.S. Ashok Kumar

Professor, Department of Pharmacognosy, R.L. Jalappa College of Pharmacy, SDUAHER Tamaka, Kolar-563103, Karnataka, India

E-mail: ashok4vani@gmail.com

Tel.: +91-7019794075

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A. spinosus sap is used as an eye wash to treat ophthalmia, while the plant ash, when dissolved in water, is utilized to wash sores. In some traditions, the plant's use is also associated with the treatment of convulsions in children (Faribaa, 2016). In Sikkim, India, the leaves and roots of *A. spinosus* are commonly applied as poultices to relieve bruises, burns, and wounds, as well as treating conditions like eczema, arthritis, and snakebites (Ghosh, 2019). The infusion of the leaves is particularly popular for treating stomach disorders, including indigestion and peptic ulcers. The widespread use of *A. spinosus* across various regions highlights its importance as a versatile medicinal plant in traditional healing practices. In addition to its medicinal value, *A. spinosus* is recognized for its nutritional contributions. The plant is an excellent source of essential vitamins, minerals, flavonoids and other antioxidants, making it a valuable addition to the diet for maintaining overall health and vitality. The continued use of *A. spinosus* in traditional medicine underscores its potential as both a therapeutic and nutritional resource, offering a promising area for further research into its pharmacological properties (Jabborova *et al.*, 2024).



Figure 1: *Amaranthus spinosus* L.

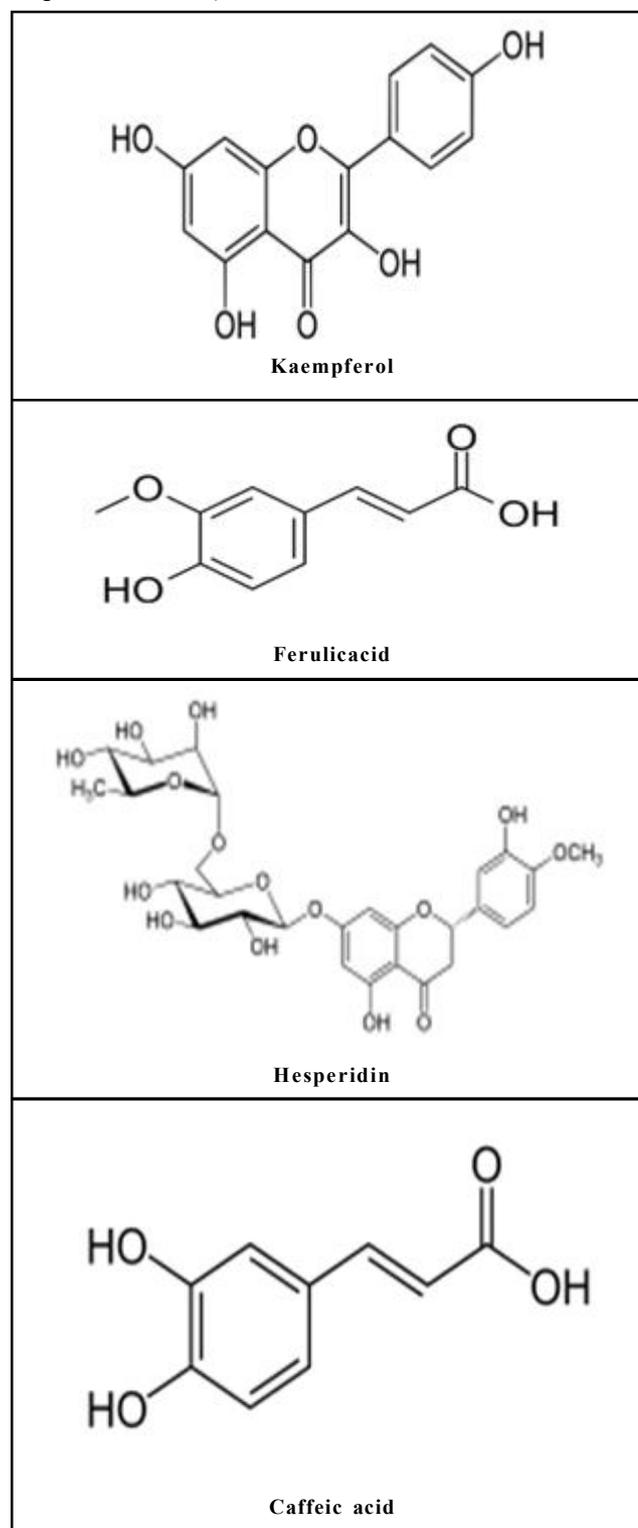
2. Bioactive compounds, minerals, and pigments

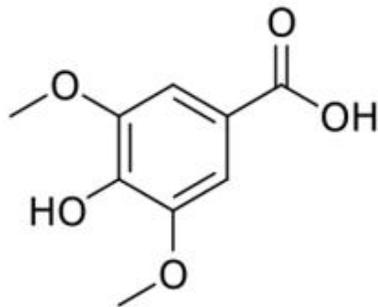
A. spinosus commonly known as spiny amaranth, is a highly valued plant with a rich phytochemical composition, including bioactive compounds, essential minerals, and natural pigments. These constituents contribute to its wide-ranging pharmacological and nutritional benefits, making it a significant plant in traditional and modern medicinal practices (Boro *et al.*, 2023; Jayasingh, 2022; Kar and Bhattacharjee, 2022).

2.1 Bioactive compounds

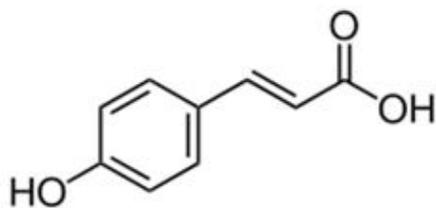
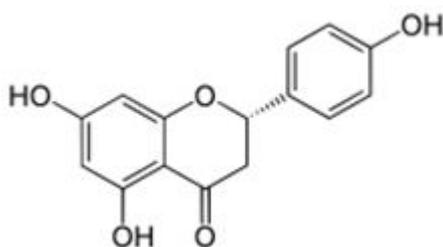
A. spinosus is rich in a diverse array of bioactive compounds that contribute to its medicinal properties. It contains flavonoids, alkaloids, tannins, saponins, terpenoids, and steroids, which are known for their antioxidant, anti-inflammatory, antimicrobial, and hepatoprotective activities. Flavonoids and polyphenolics such as quercetin, kaempferol, ferulic acid, syringic acid, caffeic acid, *p*-coumaric acid, naringenin, apigenin, hesperidin and rutin contribute to the plant's strong antioxidant potential, protecting cells from oxidative stress and free radical damage (Thakur *et al.*, 2020). The alkaloids in *A. spinosus* have been reported to possess analgesic and anti-inflammatory properties, making the plant valuable for pain management and inflammatory conditions. Additionally, saponins contribute to its antimicrobial and immunomodulatory effects,

enhancing its ability to combat infections and regulate immune responses. The presence of tannins provides astringent properties, supporting wound healing and antimicrobial effects, while terpenoids and steroids contribute to anti-inflammatory and anticancer activities (Ganjare and Raut, 2019; Sarker and Oba, 2019; Ijeoma *et al.*, 2023; Singhania *et al.*, 2023).

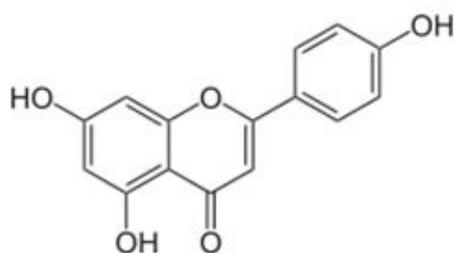




Syringic acid

*p*-Coumaric acid

Naringenin



Apigenin

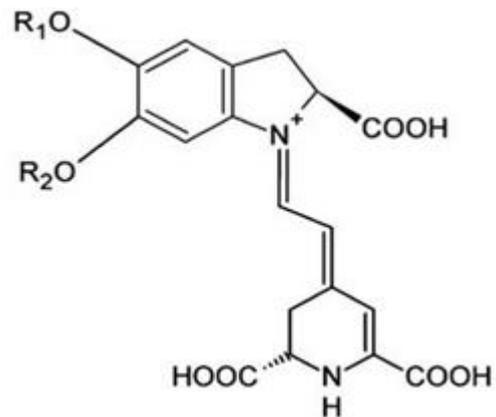
2.2 Essential minerals

In addition to its bioactive compounds, *A. spinosus* serves as a rich source of essential minerals crucial for human nutrition and overall health. It contains significant levels of calcium, iron, magnesium, phosphorus, potassium, and zinc. Calcium supports bone health, muscle function, and nerve signalling, while iron, a key component of haemoglobin, aids in oxygen transport and helps prevent anaemia.

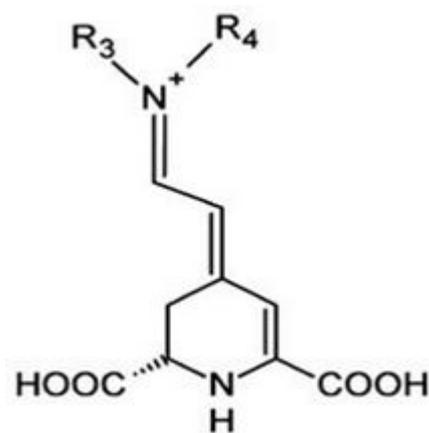
Magnesium plays a vital role in enzymatic reactions, muscle relaxation, and cardiovascular health. Phosphorus plays an important role in energy metabolism and bone formation, while potassium helps regulate blood pressure and maintain fluid balance, contributing to overall cardiovascular health. Zinc, known for its immune-boosting and wound-healing properties, further enhances the medicinal value of *A. spinosus*. These minerals collectively contribute to the plant's role as both a therapeutic agent and a nutritional supplement, particularly in populations with mineral deficiencies (Faruq *et al.*, 2024).

2.3 Natural pigments

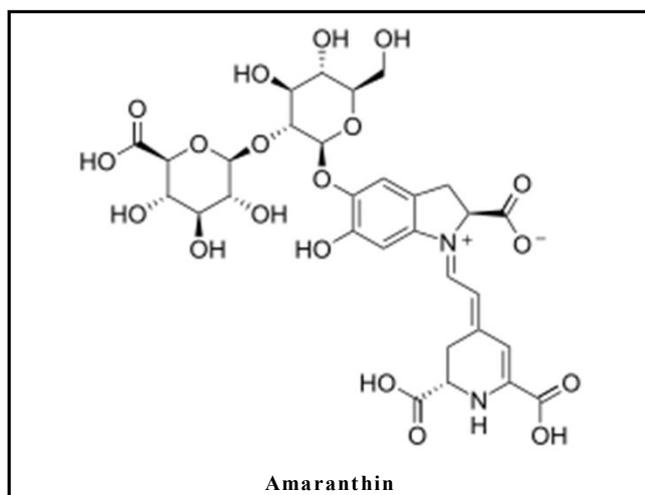
The presence of natural pigments in *A. spinosus* contributes not only to its distinctive coloration but also to its health benefits. The plant contains betalains, including betacyanins and betaxanthins, which are responsible for its red and yellow pigmentation, respectively. Betacyanins, such as amaranthin and isoamaranthin, exhibit strong anti-inflammatory and antioxidant activities, helping to reduce oxidative damage and lower the risk of chronic diseases. Betaxanthins, which provide yellow coloration, also possess antioxidant activity and support cellular protection against environmental stressors. Additionally, the plant contains chlorophyll, which contributes to its green pigment and is known for its detoxifying and wound-healing properties (Hussain *et al.*, 2018).



Betacyanins



Betaxanthins



In summary, *A. spinosus* is a nutritionally and pharmacologically valuable plant, offering a rich profile of bioactive compounds, essential minerals, and beneficial pigments. Its diverse chemical composition supports its traditional medicinal applications and modern therapeutic potential, making it an important resource for both food and medicine.

2.4 Cognitive activity of *A. spinosus*

The cognitive-enhancing potential of *A. spinosus* has been extensively investigated, revealing promising neuroprotective effects. The plant's ethanolic extract has demonstrated significant benefits in learning and memory enhancement, suggesting its potential as a nootropic agent. Studies have shown that pre-administration of *A. spinosus* for eight days enhances inhibitory retention (IR) and reduces transfer latency (TL), indicating improved cognitive function. These effects were particularly evident in healthy mice, where the plant extract enhanced learning and memory retention (Abid *et al.*, 2024).

The memory-enhancing properties of *A. spinosus* were further validated through behavioural models such as the elevated plus maze and radial arm maze tests, which are widely used to assess learning and memory functions. The reduction in transfer latency on the second day of testing suggested improved memory consolidation, a key indicator of cognitive enhancement. Among the tested doses (250 mg/kg and 500 mg/kg), the higher dose showed statistically significant improvements compared to the control group. This suggests that the cognitive benefits of *A. spinosus* are dose-dependent, with a higher concentration yielding more pronounced effects. Histological investigations further supported these findings by showing notable alterations in the brain's pyramidal cells, white matter, and grey matter in animals treated with *A. spinosus*. The increased population of pyramidal cells in the hippocampal region, along with enhanced neuronal connections in the cerebellar cortex, suggests that the plant extract promotes neurogenesis and synaptic plasticity. These structural changes are associated with improved cognitive functions, including memory formation and recall. The bioactive flavonoids in *A. spinosus* play a crucial role in its cognitive benefits. Flavonoids are known to regulate intracellular signaling pathways, enhance neuronal survival, and protect against neurodegeneration. Additionally, the presence of glycosides, alkaloids, and saponins further enhances the plant's neuroprotective effects by modulating neurotransmitter activity and reducing inflammation in the brain.

Comparative studies with Ayurvedic brain tonics such as Shankpushpi suggest that *A. spinosus* exhibits similar cognitive-enhancing effects. Shankpushpi is widely used in Ayurveda for its memory-boosting and neuroprotective properties, and *A. spinosus* has demonstrated parallel benefits in improving intelligence, focus, and recall abilities. The ability of *A. spinosus* to enhance cognitive function without causing cognitive impairment highlights its therapeutic potential in the management of neurodegenerative diseases such as Alzheimer's and dementia. While the existing studies provide strong evidence of the cognitive-enhancing properties of *A. spinosus*, further research involving diverse experimental models is needed to establish its full nootropic potential. The plant's neuroprotective effects, coupled with its safety profile ($LD_{50} > 2000$ mg/kg), make it a promising candidate for future investigations into cognitive health and brain function enhancement (Gautam *et al.*, 2022; Dajas *et al.*, 2003; Kulkarni *et al.*, 2010).

2.5 Antidiabetic activity

A. spinosus has exhibited notable antidiabetic activity in both alloxan-induced and streptozotocin (STZ)-induced diabetic models, underscoring its potential in diabetes management through multiple mechanisms. Experimental studies have shown that the plant extract significantly lowers blood glucose levels, enhances glucose tolerance, and stimulates insulin secretion in diabetic rats. In alloxan-induced diabetic models, *A. spinosus* extract exhibited potent antihyperglycemic effects by protecting pancreatic β -cells from oxidative damage. Alloxan is known to generate reactive oxygen species, leading to β -cell destruction and insulin deficiency. Treatment with *A. spinosus* significantly reduced oxidative stress markers such as malondialdehyde while restoring antioxidant levels, including glutathione, catalase, and total thiols. These effects contributed to improved insulin secretion and glucose homeostasis, preventing complications associated with chronic hyperglycemia (Dubey *et al.*, 2020). In STZ-induced diabetic models, where β -cell destruction results in insulin resistance and impaired glucose metabolism, *A. spinosus* extract demonstrated a significant reduction in fasting blood glucose levels and an improvement in oral glucose tolerance. The extract promoted hepatic glycogen storage by increasing hexokinase activity and reducing glucose-6-phosphatase activity, leading to better glucose utilization. Additionally, the administration of *A. spinosus* improved insulin sensitivity, as evidenced by the regulation of lipid metabolism and reduction in insulin resistance markers. The *A. spinosus* extract protected against diabetic nephropathy and hepatic dysfunction by reducing serum levels of urea, creatinine, and liver enzymes such as AST and ALT. The antidiabetic activity of *A. spinosus* can be attributed to its rich phytochemical composition, including polyphenols, flavonoids, phytosterols, and saponins. These bioactive compounds exhibit antioxidant, anti-inflammatory, and insulin-enhancing properties, contributing to improved glucose metabolism and reduced diabetes-related complications. Overall, the findings suggest that *A. spinosus* may serve as a promising natural therapeutic option for managing both type 1 and type 2 diabetes (Kumar *et al.*, 2011; Girija *et al.*, 2011; Atchou *et al.*, 2011).

2.6 Anticancer activity

A. spinosus has demonstrated significant anticancer potential by both *in vivo* and *in vitro* studies. In an *in vivo* model using Ehrlich ascites carcinoma bearing swiss albino mice, the ethanolic extract of *A. spinosus* leaves effectively decreased tumour volume and viable

cell count while enhancing the non-viable cell count and prolonging mean survival time. The extract also helped restore haematological and biochemical parameters, suggesting a protective effect against tumour-induced physiological imbalances. *In vitro* studies further confirmed its anticancer activity, particularly against HepG2 human liver cancer cells, where a novel fatty acid exhibited strong antiproliferative effects. The MTT assay demonstrated a dose-dependent reduction in cell viability, with an IC_{50} value comparable to the standard anticancer drug doxorubicin. Mechanistic studies revealed that this compound induced apoptosis by downregulating cyclin B1, leading to G2/M phase cell cycle arrest, while also modulating key apoptotic proteins by upregulating Bax and downregulating BCL-2. Additional research on HeLa and drug-resistant HeLa-R cervical cancer cells showed that an *A. spinosus*-derived formulation effectively induced apoptosis, as indicated by increased nuclear fragmentation and apoptotic cell markers. These findings suggest that *A. spinosus* inhibits tumour growth through multiple mechanisms, including apoptosis induction and cell cycle regulation, highlighting its potential as a natural anticancer agent (Prajitha and Thoppil, 2017; House *et al.*, 2020; Joshua *et al.*, 2010).

2.7 Antiobesity activity

A. spinosus has shown significant anti-obesity and antihyperlipidemic effects in experimental models. In a study examining its impact on obesity induced by a high-carbohydrate-high-fat (HCHF) diet in female rats, supplementation with *A. spinosus* powder, methanol extract, and aqueous extract resulted in a notable reduction in body weight gain, organ weight, and abdominal fat accumulation. Rats fed with an HCHF diet exhibited substantial weight gain and increased liver weight due to fat accumulation, indicative of obesity-induced hepatic steatosis. However, administration of *A. spinosus* effectively mitigated these effects, bringing liver weight back to normal levels (Prince *et al.*, 2021). Further analysis revealed improved glucose tolerance and lipid metabolism, as indicated by enhanced lipid profiles, reduced serum cholesterol, triglyceride levels, and low-density lipoprotein concentrations, along with an increase in high-density lipoprotein. Moreover, *A. spinosus* supplementation normalized hepatic and renal biomarkers, including alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, and creatine kinase, all of which were elevated in the HCHF-fed obese rats. In addition, hepatic antioxidant markers such as reduced glutathione, superoxide dismutase, catalase, and glutathione peroxidase showed significant improvement following *A. spinosus* treatment, highlighting its protective effects against oxidative stress-induced metabolic disorders. Histopathological examination further confirmed a reduction in hepatic fat infiltration and a lower steatosis score, supporting the hepatoprotective potential of *A. spinosus*. The anti-obesity and anti-hyperlipidemic effects of *A. spinosus* can be attributed to its rich polyphenol content, which plays a crucial role in lipid metabolism regulation. Additionally, its high dietary fiber content contributes to fat excretion and prevents excessive fat accumulation. In another study involving triton WR-1339-induced hyperlipidemic rats, *A. spinosus* at doses of 200, 300, and 400 mg/kg significantly improved lipid parameters. The highest dose (400 mg/kg) exhibited the most pronounced lipid-lowering effects ($P < 0.01$), indicating its efficacy in managing hyperlipidaemia. These findings suggest that *A. spinosus* could be a promising natural intervention for obesity and lipid metabolism disorders, supporting its potential therapeutic application in metabolic health management (Kumar *et al.*, 2012; Girija *et al.*, 2011; Dzinyela *et al.*, 2021).

2.8 Hepatoprotective Activity

The hepatoprotective properties of *A. spinosus* has been extensively evaluated in various experimental models of liver injury. *In vivo* studies demonstrated that *A. spinosus* seed extracts effectively counteracted deltamethrin-induced liver toxicity in rats. Treatment with the extract significantly restored liver function by normalizing serum biomarkers such as alkaline phosphatase, lactate dehydrogenase, and aminotransferases. Additionally, hepatic oxidative stress markers, including malondialdehyde, superoxide dismutase, catalase, reduced glutathione, and glutathione peroxidase, were brought back to normal levels. Histopathological examinations further confirmed the hepatoprotective effects, showing improved liver architecture and reduced tissue damage. Further protective effects were observed in an experimental model of d-galactosamine/lipopolysaccharide (d-GalN/LPS)-induced hepatic injury. Administration of *A. spinosus* extract significantly reversed liver damage by restoring serum enzyme levels, as well as reducing elevated bilirubin, cholesterol, triglycerides, and free fatty acids. Histological analysis revealed reduced liver damage, further supporting its hepatoprotective role. The *A. spinosus* extract exhibited strong antioxidant activity, containing high levels of polyphenols and demonstrating superior reducing capacity compared to standard antioxidants. Additionally, studies using isolated rat hepatocytes and HepG2 cells exposed to carbon tetrachloride (CCl_4)-induced toxicity showed that *A. spinosus* extract significantly restored biochemical parameters and improved cell viability in a dose-dependent manner. The highest tested concentration exhibited hepatoprotection comparable to untreated control cells, further validating its role in mitigating oxidative stress and liver damage (Zeashan *et al.*, 2009-2010; Kumar *et al.*, 2011; Rjeibi *et al.*, 2016).

2.9 Analgesic activity

The analgesic activity of *A. spinosus* has been investigated by both peripheral and central anti-nociceptive effects through standard models, including the acetic acid-induced writhing test, hot plate test, and tail immersion test in Swiss albino mice. The peripheral analgesic activity *A. spinosus* evaluated by acetic acid induced writhing test, ethanolic extract of the root reduced writhing by 48.83% and 67.44% at the respective doses, while the methanolic extract of the leaf demonstrated inhibition rates of 58.02% and 63.2%. These results suggest a strong peripheral analgesic effect, likely attributed to the inhibition of prostaglandin synthesis.

The central analgesic activity was evaluated by using the hot plate and tail immersion tests. In the hot plate test, the *A. spinosus* ethanol extract of the root showed maximum nociception inhibition of 61.50% and 62.80% at the tested doses, while the methanolic extract of the *A. spinosus* leaf exhibited 55.09% and 66.22% inhibition. In the tail immersion test, which assesses centrally acting analgesics, the ethanol extract of the root exhibited 67.81% and 75.93% inhibition of nociception, while the methanolic extract of the leaf demonstrated 68.19% and 73.91% inhibition. The analgesic effects were primarily mediated through mu opioid receptors rather than kappa and delta receptors, indicating a mechanism similar to opioid analgesics. These findings support the traditional use of *A. spinosus* in pain management and highlight its potential as a natural analgesic agent (Kumar *et al.*, 2010; Dash *et al.*, 2019).

2.10 Antipyretic activity

Fever, a natural defense mechanism, is triggered by proinflammatory cytokines such as interleukin-1 and tumour necrosis factor- α , which stimulate prostaglandin E₂ synthesis in the hypothalamus. While fever helps eliminate pathogens, prolonged high temperatures can lead to dehydration, tissue damage, and worsened disease progression, as seen in HIV. Conventional antipyretic drugs like paracetamol and nimesulide reduce fever by inhibiting cyclooxygenase-2 (COX-2) and blocking PGE₂ synthesis. However, their prolonged use can cause hepatotoxicity, nephrotoxicity, and cardiovascular risks, increasing the demand for safer, plant-derived alternatives.

The antipyretic activity of methanol extracts of three *A. spinosus* was evaluated by using a yeast-induced pyrexia model in rats. After the extracts were administered, rectal temperatures were recorded at 19 h before methanol extracts of three *A. spinosus* administered and after administration at 1 h intervals up to 24 h. The ethanol extract of *A. spinosus* at 200 mg/kg significantly reduced fever after 1 h, with more pronounced effects at 3 and 4 h. *A. spinosus* at 400 mg/kg, showed moderate effects at 1 hr and stronger reductions at later time points. The methanol extract at low dose had non-significant effects in the first 2 h but showed significant activity after 3 and 4 h and at 400 mg/kg, exhibited moderate antipyretic activity after 2 h and a more significant effect thereafter. Diclofenac sodium (10 mg/kg) demonstrated the strongest antipyretic effect (Kumar *et al.*, 2009; Ashok Kumar *et al.*, 2011).

2.11 Anti-inflammatory activity

The anti-inflammatory action of *A. spinosus* was assessed through the carrageenan-induced paw oedema, acetic acid-induced vascular permeability and the formation of cotton pellet granulomas models. The extracts of *A. spinosus* significantly reduced paw oedema, with the ethanolic extract showing a higher level of activity compared to the petroleum ether extract. At doses of 500 mg/kg and 750 mg/kg, the ethanolic extract reduced oedema by 29% and 44%, respectively, after four hours, which is comparable to ibuprofen, which showed a 69% reduction in oedema. The petroleum ether extract demonstrated a 26% and 38% reduction in oedema at similar doses. Additionally, the methanol extract of *A. spinosus* has been found to suppress acetic acid-induced vascular permeability and the formation of cotton pellet granulomas, both of which are indicators of inflammation. The extract also exhibited analgesic properties, as indicated by its ability to reduce the number of writhing induced by acetic acid and inhibit formalin-induced paw licking (Jin *et al.*, 2013; Olajide *et al.*, 2004; Baral *et al.*, 2010; Paswan *et al.*, 2020). Overall, the findings suggest that *A. spinosus* exhibits potent anti-inflammatory activity, likely through inhibition of prostaglandin biosynthesis, making it a promising candidate for the development of natural anti-inflammatory therapies.

2.12 Antidiarrheal activity

The 50% ethanol extract of *A. spinosus* exhibits significant antidiarrheal properties, as demonstrated by its ability to inhibit gastrointestinal propulsion and fluid accumulation in various animal models. *A. spinosus* produced an inhibition of gastrointestinal transit, with the highest dose (400 mg/kg) showing a 54.17% reduction in transit, though it was slightly less effective than the standard drug, morphine, which produced a 64.70% inhibition. The effect of

A. spinosus on gastrointestinal motility was mediated via α 2-adrenergic receptors, as evidenced by the reduction of *A. spinosus* induced transit delay when treated with yohimbine (a α 2-adrenoceptor antagonist), which significantly decreased the transit inhibition by *A. spinosus*. Additionally, *A. spinosus* exhibited a potent antidiarrheal effect in the castor oil-induced diarrhoea model by reducing several parameters of diarrhoea, including the onset of diarrhoea, the total number of stools, the frequency of wet stools, and the severity of diarrhoea. The highest dose of *A. spinosus* (400 mg/kg) showed a 76.53% inhibition in the antidiarrheal index, though morphine showed greater inhibition. *A. spinosus* effectively blocked the intraluminal fluid accumulation induced by castor oil without affecting the weight of the intestinal contents, but it did increase the viscosity of the intestinal contents. The role of α 2-adrenoceptors in the antidiarrheal effect was further confirmed by the antagonistic action of yohimbine in the enteropooling test, indicating that the effects of *A. spinosus* on fluid secretion and motility are mediated by these receptors (Hussain *et al.*, 2009).

2.13 Antioxidant properties

Various extracts (petroleum ether, methanol, and ethyl acetate) *A. spinosus*, were tested for antioxidant activity using assays such as DPPH and Ferric Reducing Antioxidant Power (FRAP). The ethyl acetate extract exhibited the strongest antioxidant activity, surpassing the methanol and petroleum ether extracts, which showed moderate activity. The total phenolic content in the methanol, ethyl acetate, and petroleum ether extracts was found to be 48.01, 135.22, and 46.01 mg/g, respectively. Additionally, the 50% ethanol extract exhibited a total polyphenolic content of 336 mg/g and a reducing capacity 2.26 times higher than that of BHA (butylated hydroxyanisole). The extract demonstrated potent antioxidant activity in various assays, with IC₅₀ values of 29 μ g/ml for DPPH, 66-70 μ g/ml for superoxide scavenging, and 120-125 μ g/ml for hydrogen peroxide scavenging. Additionally, it exhibited effective scavenging activity for hydroxyl radicals and nitric oxide, with IC₅₀ values around 140 μ g/ml. The leaf tissue extract of *A. spinosus* was also studied for its metal chelating properties, anti-lipid peroxidation effects, and antioxidant capacity, highlighting the role of ecological variation in enhancing antioxidant traits. Key polyphenolic compounds, including protocatechuic acid, chlorogenic acid, quercetin, and rutin, were identified as major contributors to the plant's antioxidant activity, supporting its potential to mitigate oxidative damage. Overall, *A. spinosus* demonstrates potent antioxidant activity, offering therapeutic promise for preventing degenerative diseases (Bulbul *et al.*, 2011; Paswan *et al.*, 2020; Sarker *et al.*, 2024; Kar and Bhattacharjee, 2022).

2.14 Antivenom activity

The aqueous extract of *A. spinosus* was evaluated for antivenom activity against the toxic effects of *Naja kaouthia* venom, both *in vivo* and *in vitro*. When administered at doses of 300 mg/kg and 600 mg/kg, *A. spinosus* effectively neutralized the lethality induced by the venom, demonstrating up to three-fold protection. This was confirmed through both *in vivo* and *in vitro* methods, which revealed that aqueous extract significantly inhibited the release of creatine phosphokinase induced by the venom, suggesting a protective effect against tissue damage. In an indirect haemolysis assay, aqueous extract demonstrated the ability to neutralize the toxic enzyme phospholipase A₂ from *N. kaouthia* venom, particularly at lower

doses. The 300 mg/kg dose was also found to neutralize venom-induced inflammatory response in rats, providing additional evidence of its protective effects. Furthermore, aqueous extract exhibited the ability to counteract the anticoagulant activity of *N. kaouthia* venom, highlighting its potential as a therapeutic agent in snakebite management. The extract also reduced the bleeding time induced by the venom, further supporting its antivenom properties. The findings from these studies suggest that *A. spinosus* possesses potent venom-neutralizing properties, making it a promising candidate for further investigation. Given the limitations of conventional anti-venom treatments, such as high costs and hypersensitivity reactions, *A. spinosus* offers a potential alternative for managing snakebites (Yego *et al.*, 2022; Deshmukh, 2010).

2.15 Antiferility activity

The antifertility effects of *A. spinosus*, aqueous and ethanolic extracts, have been studied through various reproductive outcome assessments in mice and rats. The aqueous extract of the *A. spinosus* root showed a decrease in the number of implants and litters when compared to the ethanolic extract, with a significant increase in implantation failure. The extracts also led to a non-significant increase in uterine weight in immature ovariectomized rats. When the extracts were administered simultaneously with ethinyl estradiol, a significant antiestrogenic activity was observed, suggesting that the plant extracts could interfere with estrogenic activity. Despite these antifertility effects, the treatment did not cause any physical abnormalities in the litters, indicating that the plant is neither abortifacient nor teratogenic in albino mice. Additionally, the absence of toxicity and lethality at the administered doses supports the safe nature of the root extracts. The ethanolic extract of *A. spinosus* demonstrated a decrease in reproductive organ weights and the number of implantation sites, suggesting its potential as an anti-implantation agent. This extract also caused a dose-dependent alteration in the estrous cycle, including a decrease in the diestrous phase and an increase in the proestrous phase. Overall, these findings suggest that the ethanolic extract of *A. spinosus* possesses antifertility, antiestrogenic, and anti-implantation effects, with potential as a contraceptive and abortifacient agent. However, further studies are required to understand the underlying mechanisms and to identify the active compounds responsible for these effects (Jhade *et al.*, 2011; Gurumani and Balamurugan, 2013).

3. Conclusion

A. spinosus exhibits a broad spectrum of pharmacological activities, including antidiabetic, anticancer, antiobesity, hepatoprotective, analgesic, antipyretic, and antidiarrheal effects. Its therapeutic potential is attributed to its rich bioactive composition, including alkaloids, flavonoids, and essential minerals. The plant's role in cognitive enhancement, metabolic regulation, and inflammation control highlights its medicinal significance. Additionally, its antifertility properties suggest potential contraceptive applications. Given its diverse benefits, further research is warranted to explore its clinical applications and underlying mechanisms.

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Conflict of interest

The author declares no conflicts of interest relevant to this article.

References

- Abbasi, A.M.; Shah, M.H and Khan, M.A. (2015). Ethnobotanical aspects of wild edible vegetables. Wild Edible Vegetables of Lesser Himalayas: Ethnobotanical and Nutraceutical Aspects, **1**;67-140.
- Abid, M.; Vaseem, M.; Hidayatullah, M.; Nayeem, A.; Khan, A.; Ahmad, S.; Ansari, N.; Husain, I and Ansari, M.S. (2024). Combined and comparative biochemical and behavioural assessment of *Delphinium denudatum* and *Amaranthus spinosus* for antistress, nootropic and antioxidant activities. Journal of Advanced Zoology, **45**(2);1164-1177.
- Ashok Kumar, B.S.; Lakshman, K and Jayaveera, K.N. (2011). A comparative antipyretic activity of methanolic extracts of some species of *Amaranthus*. Asian Pac. J. Trop. Biomed., **47**;S50.
- Atchou, K.; Lawson-Evi, P and Eklü-Gadegbeku, K. (2024). Pharmacological study of *Amaranthus spinosus* L. root extract on high-fat diet and low-dose streptozocin-induced type 2 diabetes complications in Rats, Review, pp:1-18
- Baral, M.; Datta, A.; Chakraborty, S and Chakraborty, P. (2011). Pharmacognostic studies on stem and leaves of *Amaranthus spinosus* Linn. IJABPT, **2**(1):41-47.
- Baral, M.A.; Chakraborty, S and Chakraborty, P. (2010). Evaluation of anthelmintic and anti-inflammatory activity of *Amaranthus spinosus* Linn. Int. J. Curr. Pharm., **2**(4):44-47.
- Boro, S.; Bharadwaj, B.; Unni, B.; Rai, A.K and Bhattacharjee, M. (2023). Phytochemical analysis and identification of bio-active compounds in ethanolic leaf extract of *Amaranthus spinosus*. RJPT, **16**(8):3685-3690.
- Bulbul, I.; Jahan, I; Laizuman Nahar, N.; Alam Ripa, F and Haque, O. (2011). Antibacterial, cytotoxic and antioxidant activity of chloroform, n-hexane and ethyl acetate extract of plant *Amaranthus spinosus*. Int. J. Pharmtech Res., **3**(3):1675-1680.
- Dajas, F.; Rivera-Megret, F.; Blasina, F.; Arredondo, F.; Abin-Carriquiry, J.A.; Costa, G.; Echeverry, C.; Lafon, L.; Heizen, H.; Ferreira, M. and Morquio A. (2003). Neuroprotection by flavonoids. Braz. J. Med. Biol. Res., **36**(12): 1613-1620.
- Dash, P.R.; Chowdhury, F.A.; Sultana, Z and Jahan, N. (2019). Investigation of analgesic activity of *Amaranthus spinosus* Linn. (Leaves) from Bangladesh in Swiss Albino Mice. IJP., **6**(5):187-192.
- Deshmukh, M.G (2010). Antivenom activity of *Amaranthus spinosus* root extracts against *Naja kaouthia* snake venom (Master's thesis, Rajiv Gandhi University of Health Sciences, India).
- Dubey, P.; Jayant, S.K. and Srivastava, N. (2020). Preliminary phytochemical screening, FTIR and GC-MS analyses of aqueous, ethanolic and methanolic extracts of stem of *Tinospora cordifolia* (Willd.) Miers for search of antidiabetic compounds. Ann. Phytomed., **9**(2):183-197.
- Dzinyela, R.; Asomaning, E.K.; Abdul-Baasit, A.N.; Alhassan, A.R and Movahedi, A. (2021). An *In vivo* evaluation of antihyperlipidaemic activity of ethanolic extract of *Amaranthus spinosus* leaves on dexamethasone induced hyperlipidaemic rats. Biochem. Mol. Biol., **6**(25):10-1648.
- Faribaa, M.H. (2016). An observation of an unusual therapeutic use of *Amaranthus spinosus* L. (Amaranthaceae) by the Garo tribe of Bangladesh. Asian J. Pharmacogn., **1**(1):19-21.
- Faruq, M.O.; Rahim, A.; Arifuzzaman, M and Ghosh, G.P. (2024). Phytochemicals screening, nutritional assessment, and antioxidant activities of *A. viridis* L. and *A. spinosus* L. leaves: A comparative study J. Agric. Res., **18**:101341.

- Gandhi, P.; Samarth, R.M and Peter, K. (2020). Bioactive compounds of amaranth (Genus *Amaranthus*). Bioactive compounds in underutilized vegetables and legumes. Review, pp:1:37.
- Ganjare, A and Raut, N. (2019). Nutritional and medicinal potential of *Amaranthus spinosus*. JPP., 8(3):3149-3156.
- Gautam, A.; Gupta, A.; Pal, L.C.; Azmi, L and Rao, C. (2022). An evidence based phytochemical analysis and *in vivo* pharmacological evaluation of *Amaranthus spinosus* whole plant extract for the enhancement of memory and cognitive behaviour. J. Pharm. Negat. Results., 13:5046-5053.
- Ghosh, S. (2019). Phytochemical screening and antioxidant activity of the stem of *Amaranthus spinosus* Linn. (Family-Amaranthaceae).
- Girija, K and Lakshman, K. (2011). Anti-hyperlipidemic activity of methanol extracts of three plants of *Amaranthus* in triton-WR 1339 induced hyperlipidemic rats. Asian Pac. J. Trop. Biomed., 1(1):S62-S65.
- Girija, K.; Lakshman, K and Chandrika, P.U. (2011). Antidiabetic and hypolipidemic potential of *Amaranthus spinosus* Linn, in streptozotocin-induced diabetic rats. J. Pharm. Chem., 5:16-21.
- Girija, K.; Lakshman, K.; Udaya, C.; Sachi, GS and Divya, T. (2011). Anti-diabetic and anti-cholesterolemic activity of methanol extracts of three species of *Amaranthus*. Asian Pac. J. Trop. Biomed., 1(2):133-138.
- Goyal, D.M.; Hiremath, S.K and Sarangi, M.S. (2016). A review of *Amaranthus spinosus* Linn: A potential medicinal plant. IJAMY., 9(1):13.
- Gurumani, M. and Balamurugan, K. (2013). Evaluation of antifertility potential of ethanolic extract of whole plant of *Amaranthus spinosus* in female albino rats. WJPPS., 3:2162-2167.
- Houe, N.C.; Puthenparampil, D.; Malayil, D and Narayanankutty, A. (2020). Variation in the polyphenol composition, antioxidant, and anticancer activity among different *Amaranthus* species. S. Afr. J. Bot., 135:408-412.
- Hussain, E.A.; Sadiq, Z and Zia-Ul-Haq, M. (2018). Betalains: biomolecular aspects. Springer International Publishing.
- Hussain, Z.; Amresh, G.; Singh, S. and Rao, C.V. (2009). Antidiarrheal and antiulcer activity of *Amaranthus spinosus* in experimental animals. Pharm. Biol., 47(10):932-939.
- Ijeoma, A.; Egbulefu, A.; Ishmael, V.; Chibuzo, A and Ogechukwu, U. (2023). Structural elucidation and antimicrobial analysis of bioactive compounds from *Amaranthus spinosus*. Asian J. Appl. Chem., 13(4):31-39.
- Jabborova, D.; Dustova, M.; Barot, M.; Matchanov, A.; Maulyanov, S. and Azimov, A. (2024). Biochar and NPK fertilizer effects on flavonoids and vitamins composition of okra *Abelmoschus esculentus* (L.) Moench grown in Tashkent region of Uzbekistan. Ann. Phytomed., 13(2):1039-1047.
- Jhade, D.; Ahirwar, D.; Sharma, N.K.; Hatwar, B.; Gupta, S. and Jain, V.K. (2011). Antifertility activity of ethanolic and aqueous root extract of *Amaranthus spinosus* Linn. in rats. J. Nat. Med., pp:959-967.
- Jin, Y.S.; Xuan, Y.; Chen, M.; Chen, J.; Jin, Y.; Piao, J and Tao, J. (2013). Antioxidant, anti-inflammatory and anticancer activities of *Amaranthus viridis* L. extracts. Asian J. Chem., 25(16):8901.
- Joshua, L.S.; Pal, V.C.; Kumar, K.S.; Sahu, R.K and Roy, A. (2010). Antitumor activity of the ethanol extract of *Amaranthus spinosus* leaves against EAC bearing swiss albino mice. Der Pharmacia Lettre, 2(2):10-15.
- Kar, A and Bhattacharjee, S. (2022). Exploring polyphenol based bioactive antioxidants of underutilized herb *Amaranthus spinosus* L. for medicinal purposes. JERP., 7(3):151-163.
- Kulkarni, K.S.; Kasture, S.B and Mengi, S.A. (2010). Efficacy study of *Prunus amygdalus* (almond) nuts in scopolamine-induced amnesia in rats. Indian J. Pharmacol., 42(3):168-173.
- Kumar, B.A.; Lakshman, K.; Jayaveera, K.N.; Murgan, C.V.; Kumar, P.A.; Kumar, R.V.; Meghda, H and Sridhar, S.M. (2010). Pain management in mice using methanol extracts of three plants belonging to family Amaranthaceae. Asian Pac. J. Trop. Med., 3(7):527-530.
- Kumar, B.A.; Lakshman, K.; Nandeesh, R.; Kumar, P.A.; Manoj, B.; Kumar, V and Shekar, D.S. (2011). *In vitro* alpha-amylase inhibition and *in vivo* antioxidant potential of *Amaranthus spinosus* in alloxan-induced oxidative stress in diabetic rats. Saudi J. Biol. Sci., 18(1):1-5.
- Kumar, B.S.; Lakshman, K.; Jayaveera, K.K.; Shekar, D.S.; Muragan, C.S and Manoj, B. (2009). Antinociceptive and antipyretic activities of *Amaranthus viridis* Linn. in different experimental models. AJMB., 1(3):167.
- Kumar, B.S.A.; Lakshman, K.; Narayan Swamy, V.B.; Arun Kumar, P.A.; Sheshadri Shekar, D.; Manoj, B and Vishwantha, G.L. (2011). Hepatoprotective and antioxidant activities of *Amaranthus viridis* Linn. Maced. J. Med. Sci., 4(2):125-130.
- Mondal, A.; Guria, T.; Maity, T.K and Bishayee, A. (2016). A novel tetraenoic fatty acid isolated from *Amaranthus spinosus* inhibits proliferation and induces apoptosis of human liver cancer cells. Int. J. Mol. Sci., 17(10):1604.
- Olajide, O.A.; Ogunleye, B.R and Erinle, T.O. (2004). Anti-inflammatory properties of *Amaranthus spinosus* leaf extract. Pharm. Biol., 42(7):521-525.
- Paswan, S.K.; Srivastava, S and Rao, C.V. (2020). Incision wound healing, anti-inflammatory and analgesic activity of *Amaranthus spinosus* in wistar rats. RJPT., 13(5):2439-2444.
- Paswan, S.K.; Srivastava, S. and Rao, C.V. (2020). Wound healing, antimicrobial and antioxidant efficacy of *Amaranthus spinosus* ethanolic extract on rats. Biocatalysis and Agricultural Biotechnology, 26:101624.
- Prajitha, V and Thoppil, J.E. (2017). Cytotoxic and apoptotic activities of extract of *Amaranthus spinosus* L. in *Allium cepa* and human erythrocytes. Cytotechnology, 69:123-133.
- Prince, M.R.; Zihad, S.N.; Ghosh, P.; Sifat, N.; Rouf, R.; Al Shajib, G.M.; Alam, M.A.; Shilpi, J.A and Uddin, S.J. (2021). *Amaranthus spinosus* attenuated obesity-induced metabolic disorders in high-carbohydrate-high-fat diet-fed obese rats. Front. Nutr., 8:653918.
- Rjeibi, I.; Saad, A.B and Hfaiedh, N. (2016). Oxidative damage and hepatotoxicity associated with deltamethrin in rats: The protective effects of *Amaranthus spinosus* seed extract. Biomed. Pharmacother., 84:853-860.
- Sarker, U and Oba, S. (2019). Nutraceuticals, antioxidant pigments, and phytochemicals in the leaves of *Amaranthus spinosus* and *Amaranthus viridis* weedy species. Sci. Rep., 9(1):20413.
- Sarker, U.; Oba, S.; Ullah, R.; Bari, A.; Ercisli, S.; Skrovankova, S.; Adamkova, A.; Zvonkova, M. and Mlcek, J. (2024). Nutritional and bioactive properties and antioxidant potential of *Amaranthus tricolor*, *A. lividus*, *A. viridis*, and *A. spinosus* leafy vegetables. Heliyon, 10:e30453.

Sharma, L.; Kasture, P.; Umrao, A.; Rao, J and Rao, G. (2020). A study to determine the anticancer and pro-apoptotic properties of *Amaranthus spinosus* Linn. Extract, AS20. JEI., 3:1-6.

Singhania, N.; Kumar, R.; Pramila; Bishnoi, S.; Ray, A.B and Diwan, A. (2023). Bioactive properties and health benefits of Amaranthus. Harvesting Food from Weeds, pp:351-383.

Thakur, A.; Thakur, N.S.; Hamid and Gautam, S. (2020). Effect of packaging on phenols, flavonoids and antioxidant activity of dried wild pomegranate (*Punica granatum* L.) arils prepared in solar tunnel drier. Ann. Phytomed., 9(2):198-206.

Yego, K.K.; Njagi, E.N.; Orinda, G.O.; Gikunju, J.K. (2022). Snake-antivenom activities of aqueous extracts of *Amaranthus spinosus* L. against *Naja* sub. Fulva Venom. IJISRT., 7(12):1487-1493.

Zeashan, H.; Amresh, G.; Singh, S and Rao, C.V. (2009). Hepatoprotective and antioxidant activity of *Amaranthus spinosus* against CCl₄ induced toxicity. J. Ethnopharmacol., 125(2):364-366.

Zeashan, H.; Amresh, G.; Singh, S and Rao, C.V. (2010). Protective effect of *Amaranthus spinosus* against D-galactosamine/lipopolysaccharide-induced hepatic failure. Pharm. Biol., 48(10):1157-1163.

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