Pharmacological and Biological Activities

Pollen extract preparation of the plant gave positive clinical allergic reactions (Laserna *et al*., 1960). Injection of *Amaranthis spinosus* pollen extract induced production of blood antibodies in rabbits, demonstrated by agglutination of the specific antigens, and a rise in body temperature (Baruah and Chetia, 1965-1966). The plant is an important aeroallergen in India. Singh and Dahiya (2002) investigated antigenic and allergenic properties of 5 pollen samples of *Amaranthus spinosus* collected from the Delhi area at fortnightly intervals. The protein content did not exhibit statistically significant variability. However, samples collected during the peak flowering season showed higher protein content. Biochemical characterization of samples showed multiple protein fractions. Samples collected during peak season showed a slightly higher number of bands (22) in the molecular weight range of 14-70 kDa. Seven protein fractions of 70, 66, 60, 50, 40, 30 and 14 kDa were observed to have IgE binding capabilities and 9 were treated as allergenic. The observations are reported helpful in standardizing pollen antigens for diagnosis and immunotherapy in India (Singh and Dahiya, 2002). Prasad (2009) reported the plant as one of the common allergens. Patients of bronchial asthma has associated allergic rhinitis in 80 % cases (Singh and Dahiya, 2002).

Extract of *Amaranthus spinosus* had a high phagocytic index (Broker and Bhatt, 1953). The hepatoprotective activity of *Amaranthus spinosus* extracts and/or its constituents has been proved (Zeashan *et al*., 2008, 2009b, 2010; Ilango *et al*., 2010; Kanchana *et al*., 2010). The study of Kanchana *et al*. (2010) scientifically validated and concluded the traditional use of rutin (found in the plant) for liver disorders. The 50 % methanolic extract of the aerial parts of *Amaranthus spinosus* exhibited a significant hepatoprotective effect in paracetamol induced liver damaged rats by lowering serum levels of glutamic oxaloacetic transaminase (SGOT), glutamic pyruvic transaminase, (SGPT), alkaline phosphatase (ALP), total bilirubin (TBL), and increase in serum total protein levels (TPL) (Ilango *et al*., 2010). The results obtained by Gul *et al.* (2011) showed significant increase for both acute as well as chronic studies in protein and glycogen contents of liver at 250 mg of methanol extract/kg dose level. The extract possesses significant hepatoprotective activity which might be due to antioxidant defense factors and phenolics might be the main constituents responsible for activity (Zeashan *et al*., 2009b). Both chemoprotective and antioxidant activities of methanolic extract of *Amaranthus spinosus* leaves on paracetamol induced-liver damage were also reported by Kumar *et al*. (2010a). There are several articles on the antioxidant activity of the plant (e.g. Boni *et al*., 2010; Kumar *et al*., 2010a-d; Priya and Kalpana, 2010; Yashin *et al*., 2010; Katerere *et al.*, 2012). The plant has also antipyretic activity (Mishra *et al*., 2007;

Kumar *et al*., 2010b; 2011f).

The antidiabetic activity of the plant has been proved (Sangameswaran and Jaykar, 2008; Kumar *et al*., 2010d; Girija *et al*., 2011a,b). The methanolic extract of the plant significantly exhibited control of blood glucose level in streptozotocin (STZ)-induced diabetic rats on a 15 day model. Further, the methanolic extract also showed significant anti-hyperlipidemic and anticholesterolemic activities (Sangameswaran and Jaykar, 2008; Girija and Lakshman, 2011; Girija *et al.*, 2011c) 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. These findings of the plant established some pharmacological evidence to support the folklore claim that it is used as an anti-diabetic (Sangameswaran and Jaykar, 2008). Oral administration of methanolic extract of *Amaranthus spinosus* leaves at 200 and 400 mg/kg body weight per day, 21 days to diabetic rats was found to possess dose dependent antidiabetic and hypolipidemic activity in type-2 diabetic rats. Histological focal necrosis was observed in diabetic rat pancreas, but was less obvious in treated groups (Girija *et al*., 2011a).

The plant has effect in inhibiting urease activities and used for preventing and treating gastritis, gastric ulcer and duodenal ulcer with high safety (Shibata *et al.*, 2003). Aqueous extract of the leaves showed gastrointestinal motility at 100 mg/kg dose (Kumar *et al.*, 2008b). The extracts of the whole plant possess antiulcer (Zeashan *et al.*, 2009c) and antidiarrheal activities (Sawangjaroen and Sawangajaroen, 2005; Zeashan *et al.*, 2009c). It also has antimicrobial effect, and can replace conventional chemotherapeutics (Shibata *et al*., 2003). *Amaranthus spinosus* extracts possessed antifungal activity against isolates of four agriculturally important fungi, *i.e*. *Fusarium verticillioides*, *Fusarium proliferatum*, *Aspergillus flavus* and *Aspergillus parasiticus* (Thembo *et al*., 2010). The antibacterial activity of the plant extraets has been reported (Bulbul *et al.*, 2011; Harsha Vardhana, 2011; Chursi *et al.*, 2012). Amaramangin, isolated from the plant may be used as antitumor, antiviral and anti-AIDS agents and may be used as RNAN-glycoside in molecular biology and immunology research (Chen *et al*., 2004). The plant showed significant antimalarial activity (Hilou *et al*., 2006). It also possesses anti-inflammatory (Olajide *et al.*, 2004; Zeashan *et al.*, 2009a; Baral *et al.*, 2010), analgesic (Zeashan *et al.*, 2009a; Jamaluddin *et al.*, 2011), anthelmintic (Baral *et al.*, 2010; Kumar *et al.*, 2010h), diuretic (Amuthan *et al.*, 2012), antifertility (Jhade *et al.*, 2011b) and anti-anemic (Koné *et al.*, 2012) activities. The plant may has a potential use in the prophylaxis and management of anaphylactic reactions (Patil *et al.*, 2012).

The plant extracts possess potent cytotoxic activity (Bulbul *et al.*, 2011). The plant is reported among natural product based apoptosis inducers (Subbiah, 2005). Wild *Amaranthus spinosus* water extract directly stimulates proliferation of B lymphocytes *in vitro* (Lin *et al*., 2005b).