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MESQUITE (*PROSOPIS JULIFLORA*): LIVESTOCK GRAZING, ITS TOXICITY AND MANAGEMENT

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ABSTRACT

Prospis juliflora is an invasive tree native to Northern South America, Central America, and the Caribbean. It has been used as a folk remedy for catarrh, cold, diarrhea, dysentery, excrescences, flu, hoarseness, inflammation, measles, sore throat, and in the healing of wounds. Its antibacterial, antioxidant, antifungal, antitumor, and anthelminitic activities are also reported and it contain phytochemicals such as flavonols, alkaloids, tannins, ellagic acid, glycosides, steroids, and various phenolic compounds. It is reported to be used as feed for cattle worldwide. Low intake of this plant doesn't affect the health of cattle but excessive intake is harmful and can cause nervous breakdown, weight loss, imbalance in nutrient levels, etc. and in severe cases it can be fatal. Therefore, it should be used as feed in limited amounts.

Keywords: *Prosopis* sp., Mesquite, biological activities, neuronal damage, invasive plant species of Pakistan.

INTRODUCTION

From early ages, man has been using natural herbs and plants as folk medicines, but it is only since the mid-nineteenth century that serious efforts were made to isolate and purify the active principles for the treatment of various ailments. Since then, a large variety of biologically active compounds have been obtained and their structures determined, e.g. morphine from *opium*, cocaine from coca leaves, and quinine from the bark of the *cinchona* tree (Graham *et al.,* 1995). Owing to growing demand for herbals, the current need is to intensify research in the field of medicinal herbs and to get authentic information on the subject. Herbal products are often questioned for quality control and assurance. Toxicity and other biological tests carried out on tissue samples, animals, and sometimes organ cultures to determine whether it is safe to test the drug on humans. The animal tests investigate the effect of the drug on various body systems such as the respiratory, nervous, and cardiovascular systems. They are carried out under both *in vivo* and *in vitro* conditions. These preliminary tests provide information concerning the drug's pharmacokinetic properties and its interaction with other drugs and over-the counter medicines (Wamburu *et al.,* 2013).

The genus *Prosopis* is highly adapted to drylands. There are about 44 species in the genus *Prosopis* that have been identified (Pasiecznick *et al.,* 2001). *Prosopis juliflora,* commonly known as mesquite, is known in Pakistan as its local name, Kabul kikar, or Valayati jand (Qureshi *et al.,* 2014). It is an evergreen tree native to northern South America, Central America, and the Caribbean (Pasiecznik *et al.,* 2004). It can cope up with wide range of fluctuations in temperature, i.e. -12 to 50^{o}C. It can also tolerate drought conditions, i.e. regions where rainfall is less than 500 mm

(Silva *et al.,* 2013). It is also reported as an invasive plant in IUCN's list of 100 invasive species (Mwangi and Swallow, 2005). It has high nutritional values, as well as high productivity of pods, due to which it is also used as food for animals and humans in its native regions (Mendes, 1988). Mostly it is used as feed for cattle (Silva *et al.,* 1981; Silva *et al.,* 2013). In Pakistan, this shrub grows abundantly in the Sind and Punjab (Nasir and Ali, 1972). Due to their palatability and nutritional value, pods of *P. juliflora* or its bran are largely used for feeding dairy and beef cattle with good nutritional and economic results (Silva, 1981). Products from this plant have also been used for human consumption in bread, biscuits, sweets, syrup, and liquors (Van Den Eynden *et al.,* 2003). It has been used as a folk remedy for catarrh, cold, diarrhea, dysentery, excrescences, flu, hoarseness, inflammation, measles, sore throat, and in the healing of wounds (Hartwell, 1971).

Distribution

It is a shrub which is locally found in regions of Colombia, Peru, Mexico, Ecuador, and Venezuela. *P. juliflora* is an evergreen shrub which has extensive root system which can reach up to 40 cm in just eight weeks. It also grows quickly after germination (Pasiecznik, 2002). This characteristic of *P. juliflora* helps it to invade new regions. It is found as an invasive weed in Sudan, Eritrea, Ethiopia, Kenya, Iraq, Pakistan, India, Australia, South Africa, the Caribbean, the Atlantic Islands, Bolivia, Brazil, the Dominican Republic, El Salvador, Nicaragua, the United States (USA), and Uruguay (Iqbal and Shafiq 1997; Pasiecznik *et al*., 2001; Bokrezion, 2008). It has become established as a weed in Asia, Australia, and elsewhere. It is fast-growing, nitrogen-fixing, and tolerant to arid conditions and saline soils (Anonymous 2003, Pasiecznik *et al.*, 2004).

In Pakistan, *P. juliflora* was first introduced in Sindh at the time when Pakistan and India were not separate. It was introduced either from Jamaica or Mexico (Luna, 1996). It is found in the arid and semi-arid regions of Pakistan (Mwangi and Swallow, 2005). It is one of the dominant, invasive plants in Karachi (Rashid and Abbas, 2011). It is also reported in Punjab and the coastal areas of Balochistan (Khan *et al.,* 1986). In northern areas of Pakistan up to Kashmir, it is commonly found and used as weed (Iqbal and Shafiq, 1997). It is one of the abundantly found invasive species in Pakistan (Qureshi *et al.,* 2014).

Phytochemistry

Several alkaloids have been isolated from leaf extracts having pharmacological properties (Ahmad *et al.,* 1988, 1989; Aqeel *et al.,* 1989). Apart from alkaloids, other important compounds isolated from *P. juliflora* include flavone glycoside Patulitrin, Prosogerin D, Procyanidin, ellagic acid, tannins, and polystyrenes (Rastogi and Mehrotra, 1993). Phenolic compounds and flavonoids are present in most parts of the plant, as mentioned in earlier reports (Khan *et al.,* 2003). The phytochemical screening of the plant parts of *P. juliflora* showed that the leaves, pod, flower, stem, and root contain most of the secondary metabolites analyzed. They were shown to possess alkaloids, phenolic compounds, flavonoids glycosides, steroids, tannins, and triterpenoids. Leaf extract was found to be the richest source of secondary metabolites, followed by the pod and flower (Shachi, 2012).

Biological Activities of *Prosopis juliflora*

Antioxidant Activity

A study was carried out on pollen extracts of *P. juliflora*. It was evaluated in *in-vitro* and *in-vivo* conditions. Results showed high antioxidant activity, which was found due to the presence of flavonols present in its pollen extract (Almaraz-Abarca *et al.,* 2007). Similarly, another study also concluded antioxidant activity of *P. juliflora* due to the presence of flavonols. This study was analyzed by using wood extract. However, the bark extract showed less antioxidant activity (Simrah et al., 2011).

Antibacterial Activity

Singh and Verma, 2011; conducted a study on the antibacterial activity of *P. juliflora*. They studied its activity against *E. coli*, *S. aureus*, *B. cereus*, *P. putida*, *Klebsiella*, *Salmonella*, *Acinetobacter*, and *Alcalige*. The extracts of pods, leaf, and flower were tested. As a result, leaves showed highest activity; *Klebsiella* was found to be the most susceptible bacteria, whereas *Acinetobacter* and *Alcaligen* were the least susceptible.

Antifungal Activity

Satish and his fellows conducted a study to determine the antifungal activity of *P. juliflora* against *Aspergillus* sp. The solvents for extracts used were petroleum ether, benzene, chloroform, methanol, and ethanol. Results were highly significant, and the methanolic extract gave the most effective results (Satish *et al.,* 2007). Similarly, in another study, it was tested against *Candida albican* and results showed an inhibition zone against this fungi (Rechab *et al.,* 2011).

Further, the antifungal activity of aqueous, petroleum ether, benzene, chloroform, methanol, and ethanol extracts and the alkaloid extract of *Prosopis juliflora* (Sw.) DC. leaves (Mimosaceae) was evaluated for antifungal activity by poisoned food techniques against *Alternaria alternata*, a causal organism of brown spot on tobacco. Aqueous extract recorded highly significant antifungal activity at 24% concentration. Among different solvent extracts tested, methanol and ethanol extract recorded highly significant antifungal activity.

Antitumor Activity

The alkaloid extract of *P. juliflora* from its leaves was obtained using an acid base modified extraction method and *in-vitro* study was conducted to check its antitumor properties of MTT on MOLT-4 cells. Results showed that extracts have higher toxicity toward cancer cells as compared to normal cells. Therefore, this plant can be an antitumor as well (Sathiya and Muthuchelian, 2011).

Anthelmintic Activity

P. juliflora also showed significant results against gastroinstestinal nematodes. It was due to the presence of tannins, saponins, and alkaloids, and some other chemical constituents, which make this plant eligible to be used as a drug (Odhiambo *et al.,* 2014).

Toxicological Effect

Prosopis juliflora is largely used for feeding cattle and humans. Prosopis pods contain cytotoxic alkaloids that may cause intoxication to cattle, horses, sheep, and goats in diets containing high levels of pods (>50%). Problems have been reported in the

USA, Peru, and Brazil (Vilar da Silva *et al.*, 2002; Tabosa *et al.*, 2006; Camara *et al.*, 2009). Poisoning was also recorded from pods eaten after exposure to rain (Gohl, 1981). Goats and cattle fed with diets containing 60-60 and 50-75% prosopis pods, respectively, suffered mandibular tremors during chewing due to toxicity to neurons of certain nerve nuclei (Tabosa et al., 2000, 2006). Neurola lesions results in difficulties prehending and chewing it, which subsequently causes feed wastes and animal death (Tabosa *et al.*, 2006). In India, goats offered dry prosopis pods as sole feed during 4 days suffered from partial anorexia, depression, salivation, twitching, dehydration, and bloody diarrhoea, histological lesions in the liver, degenerative changes in renal tubules and rarefaction of lymphoid tissue (Misri *et al.*, 2003).

Alkaloidal fraction (AF) obtained from *P. juliflora* pods was tested on astrocyte primary cultures and it was observed that the astrocyte membrane were damaged after alkaloid fraction of *P. juliflora* exposure, suggesting that these alkaloids may have the ability to permeate the plasma membrane, changing its conformation and promoting the vacuolation (Hughes *et al.*, 2006). Previously similar effects were reported on erythrocytes subjected to alkaloids from *P. juliflora*, showing significant hemolysis due to membrane injury (Kandasamy *et al.*, 1989).

The disease also occurs spontaneously in goats in Peru and was produced experimentally in this species by feeding pods of *P. juliflora* as the main source of food. Clinical signs were characterized by twitching of the lips, head tremors, salivation, and emaciation (Baca et al., 1966). In Brazil, intoxication was produced in goats after ingestion of food containing either 60 or 90% of *P. juliflora* pods for 270 days. The first clinical signs were observed after 210 days of ingestion. Histologic lesions were characterized by diffuse vacuolation of neurons in the trigeminal motor nuclei, Wallerian-like degeneration of the trigeminal and mandibular nerves, and denervation atrophy of the masseter, temporal, hyoglossal, genioglossal, styloglossal, medial pterygoid, lateral pterygoid, and mylohyoid muscles (Tabosa, 2000). Trigeminal motor neuron vacuolation was also observed in a goat ingesting leaves, pods, or beans of the related plant *Prosopis glandulosa* (honey mesquite) (Washburn *et al.*, 2002).

In Kenya, the problems associated with the *Prosopis* invasion vary considerably between regions. However, in the Ngambo area of the Marigat District, the community noted the most severe problems are the reduction of pastures for livestock grazing, reduced farm lands and associated opportunities for cultivation, disfiguration of livestock gums (especially goats) and tooth decay, both of which result in deterioration of livestock health and sometimes death (Mwangi and Swallow, 2005). Clinical signs, which are more prominent during eating and rumination, are characterized by masseter muscle atrophy, involuntary movements and protrusion of the tongue, a dropped (slack) mandible, tilting of the head during chewing, profuse salivation, yawning, and dysphagia. Continuous chewing, nervousness, ruminal, anemia, submandibular edema, and gradual emaciation are also observed. If the plant is removed from the diet at the first stages of the disease, clinical recovery can be observed, but in most cattle, recovery does not occur, and the clinical signs persist (Tabosa *et al.*, 2003).

Cellular Damage Caused by *P. juliflora*

P. juliflora is also known for causing disease in animals (Baca *et al.,* 1967; Dollahite and Anthony, 1957). It causes a disease known as "cara torta," which is caused in cattle and calves. Its symptoms are neuromuscular alterations, the formation of lesions such as gliosis, spongiosis, and the loss of nissl substances. It also effects the neurons and their function by targeting its motor nuclei (Figueiredo *et al.,* 1995; Tabosa *et al.,* 2000). This neural damage was studied and observed in cattle and goats who were fed with high concentrations of *P. juliflora* pods. It was also observed in cattle and goats foraging in the area where *P. juliflora* was abundantly found (Camara *et al.,* 2009). According to another study, the same neural damage and degeneration of nerves of the mandibular and trigeminal was reported (Tabosa *et al.,* 2006). Alkaloids present in pods of this plant are reported to be the main cause of neural damage. It also induces the cytotoxic effect and reaction in glial cells (Hughes *et al.,* 2006; Silva *et al.,* 2007). However, neuronal vacuolization is also reported in other plants besides *P. juliflora* i.e. *Ipomea* (Van der Lugt, 2002), *Astragalus* (Summers *et al.,* 1995), etc.

The intoxication caused by *P. juliflora* is reported worldwide. In Brazil, it was reported in Paraiba for the first time in 1981. Now, 50% of the cattle is reported to be effected from neural breakdown due to pods of *P. juliflora* (Dantas *et al.,* 1996; Tabosa *et al.,* 2003). However, the intoxication was induced slowly, i.e., after ingestion of pods for 210-270 days in the trial study (Tabosa *et al.,* 2003). It is also reported in the USA and Peru (Dollahite, 1964; Baca *et al.,* 1996).

Prosopis juliflora As Feed Resource

Prosopis juliflora have high nutritive value, its pods have high crude protein, and they are source of high energy production (Chopra and Hooda, 2001). However, in cattle, excessive feeding of *Prosopis juliflora* showed harmful effects (Felker and Waines, 1977). Its consumption as green and immature pods caused weight loss and appetite loss, and it also caused weakness in cattle, as well as nervous breakdown. In severe cases, it was also reported as fatal (Garbar, 1986). Therefore, mature pods can be fed to cattle. Cyanide poisoning was also reported in those cattle which were feeding on *Prosopis juliflora* (Seifert and Beller, 1969). According to another study, there was no toxic effect of pods when 3.2 kg *Prosopis juliflora* was fed to each cattle along with sugarcane (Shukla, 1982). Cyanogenic glycosides are absent in pods, and thus, they can be used as feed (Mahadevan, 1954). However, phenols and tannins in condensed form are reported in the pods of this plant which can show harmful effects on cattle (Makkar *et al.,* 1990). The pods of the plant do not affect the digestibility when it's taken up to 30% in feed (Silva *et al.,* 1990). Similarly, at low levels, i.e., almost 30%, the intake of pods didn't affect the growth and production of cattle (Sharma, 1997) but it started showing symptoms such as weight loss, drop in carcass percentage, etc., when intake was ≥85% (Ibrahim and Gaili, 1985). Nitrogen, calcium, and phosphorus levels in cattle were also maintained at 30% (Talpada *et al.,* 2002). At 40% intake of pods, the negative effect was reported on the phosphorus balance in cattle (Talpada *et al.,* 1979). However, at 75 %, the levels of nitrogen, calcium, and phosphorus were affected and there was a remarkable decrease (Sharma, 1997).

CONCLUSION

Prosopis juliflora (Sw.) DC. Belongs to the Leguminosae family, commonly

known as mesquite, and is an evergreen tree native to northern South America, Central America, and the Caribbean. It has been used as a folk remedy for catarrh, cold, diarrhea, dysentery, excrescences, flu, hoarseness, inflammation, measles, sore throat, and in the healing of wounds. Its antibacterial, antioxidant, antifungal, antitumor, and anthelminitic activities are also reported and it contains phytochemicals such as flavonols, alkaloids, tannins, ellagic acid, glycosides, steroids, and various phenolic compounds. However, its toxicological effects are highly reported in cattle feeding on it. It causes many diseases such as partial anorexia, depression, salivation, twitching, dehydration, bloody diarrhea, histological lesions in the liver, degenerative changes in renal tubules, rarefaction of lymphoid tissue, etc. It can also lead to death. Therefore, this review recommends that cattle should not be fed by *P. juliflora* as it has more toxic effects as compared to benefits.

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