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A COMPREHENSIVE REVIEW OF *ALBIZIA PROCERA* (ROXB.) BENTH.-AN UPDATE

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ABSTRACT: *Albizia procera* is a genus of albizia, the member of legume family (fabaceae) and subfamily Mimosoideae. *Albizia procera* is tree with open canopy, occurs naturally in a wide distribution from India and Myanmar through South-East Asia to Papua New Guinea and Northern Australia. On basis of our study, *Albizia procera* has the high economic potential to be applied in pharmaceuticals, pharmacognosy, traditional medicines, agricultures, tanning, dyeing, construction, ornamental markets, and so many researchers identified more pharmacological activities in *Albizia procera* were used in humans. This review presents phytochemical constituents, pharmacognostic characters, traditional uses, pharmacological and biological activities reported for the plant and it will be helpful to explore the knowledge about *Albizia procera* for the researchers.

INTRODUCTION: Albizia is a genus of more than 160 species of mostly fast-growing subtropical and tropical trees and shrubs in the subfamily Mimosoideae of the family Fabaceae. The genus is pantropical, occurring in Asia, Africa, Madagascar, America and Australia, but mostly in the Old World tropics. In some locations, some species are considered weeds. They are commonly called silk plants, silk trees, or irises. The obsolete spelling of the generic name - with double 'z' - is still common, so the plants may be called albizia. The generic name honors the Italian nobleman Filippodegli Albizzi, who introduced *Albizia julibrissin* to Europe in the mid-18th century [1]. Some species are commonly called mimosa, which more accurately refers to plants of genus Mimosa [2].

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Species from south-east Asia used for timber are sometimes termed East Indian walnut. Albizias are important forage, timber and medicinal plants [3, 4] and many are cultivated as ornamentals for their attractive flowers. *Albizia procera* is a genus of albizia, the member of legume family (Fabaceae) and subfamily Mimosoideae. It occurs naturally in a wide distribution from India and Myanmar through South-East Asia to Papua New Guinea and Northern Australia [5]. *Albizia procera* is a tree with an open canopy, up to 30 m tall and trunk of 35 (60 max.) cm in diameter; bole straight or crooked, Bark smooth, branches terete, glabrous.

Leaves bi-pinnate, flowers are sessile, uniform (central flowers usually larger than marginal ones), bisexual. Fruits rich red or reddish-brown, flattened pods are chartaceous, glabrous, with distinct marks over the seeds; mature pods each containing 6-12 seeds, usually remaining on the tree until the whole twig bearing the pods is shed; seeds small, greenish-brown, elliptical to round, flat, with a hard, smooth seed coat. *Albizia procera* is a useful tree for farm and amenity planting, light shade,

firebreaks and for the rehabilitation of seasonally dry, eroded and degraded soils, regarded as a soil improver and is used as a nurse tree in tea gardens, coffee, and cocoa plantings.

In India, the leaves of *Albizia procera* are considered good fodder for most ruminants (cattle, sheep, goats, elephants, and deer) and the tree is lopped for fodder in several states. *Albizia procera* makes a good cabinet and furniture timber and is also suitable for general construction, agricultural implements, household products, poles, house posts, truck and bus bodies, and packing cases. It is suitable source material for paper pulp, giving satisfactory yields of bleached pulp. All parts of the plant are reported to show anti-cancer activity. The roots contain alpha-spinasterol and saponin that has been reported to possess spermicidal activity at a dilution of 0.008%. *Albizia procera* is commonly used in traditional medicines. A decoction of the bark is given for rheumatism and haemorrhage and is considered useful in treating problems of pregnancy and for stomach-ache. The bark is given with salt to water buffalo as a medicine. In India, leaves are poulticed onto ulcers. Phytochemicals shows the presence of different types of secondary metabolites such as triterpenoids, carbohydrates, glycosides, phytosterols, phenolic compounds, saponins, tannins and flavonoids were presented Evaluation of pharmacological activities confirmed *Albizia procera* as antioxidant, analgesic, antibacterial, CNS depressant, *in-vitro* α-amylase, and α -glucosidase inhibitor, anti-HIV-1 integrase activity, antidiabetic, antidiarrheal and hepato-protective activities.

Plant Profiles and Literature Review of *Albizia procera:*

Plant Profile:

Plant	:	*Albizia procera* (Roxb.) Benth.
Synonyms	:	*Acacia procera* (Roxb.) Willd. *Mimosa elata* Roxb. *Mimosa procera* Roxb.
Family	:	Mimosaceae

Vernacular Names

Tamil	:	Konda Vagai, Velvagai
English	:	Acacia, Albizia, Brown Albizia, Forest Siris, Safed Siris, Tall Albizia, White Siris
Hindi	:	Gurar, Karak, Safed Siris
Bengali	:	Koroi
Burmese	:	Kokko-Sit, Sit, Sitpen
Indonesian	:	Wangkal, Weru
Javanese	:	Weru
Malay	:	Oriang
Malayalam	:	Chalavaka, Kottuvaga
Marathi	:	Kinnigurai
Telugu	:	Chigara, Tella chinta
Telugu	:	Dun Siris, Seto Siris
Spanish	:	Abizia, Acacia, Tall Albizia
Thai	:	Suan, Thingthon
Trade name	:	Forest Siris, Safed Siris, White Siris
Sanskrit	:	Katabhi, Kinhai

Botanical Description: *Albizia procera* is a tree with an open canopy, up to 30 m tall and trunk of 35 (60 max.) cm in diameter; bole straight or crooked, up to 9 m. The bark is smooth, pale grey-green, yellowish-green, yellowish-brown or brown with horizontal ridges, under bark green color, changes to orange just below the surface; inner bark is pink or straw-colored; branches are terete and glabrous. Leaves are bipinnate with 2-5 pairs of subopposite pinnae; rachis is 10-30 cm, glabrous with a gland 1-2.5 cm above the base; gland narrowly elliptical, 4-10 mm long, sessile, flat and disc-like or concave with raised margins; pinnae 12-20 cm long, glabrous; leaflets 5-11 pairs per pinna, opposite, rigidly chartaceous to sub-coriaceous, asymmetrically ovate to sub-rhomboid, 2-4.5 (6 max.) × 1-2.2 (3.2 max.) cm; base asymmetrical; apex rounded or sub truncate, often emarginate, mucronate; both surfaces sparsely appressed puberulous, rarely glabrous on top side.

Inflorescence composed of pedunculate glomerules collected in an axillary, sparsely puberulous panicle up to 30 cm long; peduncle (0.8 min.) 1.5-2.3 cm long, 2-5 together; flowers 15-30 per glomerule, sessile, uniform (central flowers usually larger than marginal ones), bisexual. Fruits rich red or reddish-brown in color, flattened pods 10-20 × 1.8-2.5 cm, chartaceous, glabrous, with distinct marks over the seeds; mature pods each containing 6-12 seeds, usually remaining on the tree until the whole twig bearing the pods is shed; seeds small, greenish-brown, elliptical to round, flat, with a hard, smooth seed coat, 7.5-8 × 4.5-6.5 × 1.5 mm. The genus is named after the 18th-century Florentine nobleman

and naturalist Filippo del Albizzi. The species name is derived from the Latin word 'procerus', meaning very tall or high, possibly alluding to the height the species can attain.

FIG. 1: *ALBIZIA PROCERA*(ROXB.) BENTH

History of Cultivation: *Albizia procera* was introduced to the Virgin Islands at least a century ago, became naturalized in Puerto Rico after its introduction in 1924 as an ornamental and farm forestry species, and has been introduced into Panama and a number of African countries.

Natural Habitat: *Albizia procera* is widely distributed in India and Myanmar through Southeast Asia to Papua New Guinea and northern Australia. The habitat ranges from monsoon forest, mixed deciduous forest, savannah woodlands, pyrogenic grassland, roadsides, dry gullies, to stunted and seasonal swamp forest. It is commonly found in open secondary forest and in areas with a pronounced dry season. It is susceptible to frost and has moderate light requirements.

Once established, it becomes drought tolerant. Best development occurs in areas with more than 2500 mm annual rainfall and means the annual temperature of 21-32 ºC. If the area is not burned, *Albizia procera* will colonize alang-alang (Imperata cylindrica) grassland. Good survival and rapid early growth have been reported in afforestation trials on both saline and alkaline soils, which are widely cultivated in agroforestry systems.

Geographic Distribution:

I. Native: Australia [6], Brunei, Cambodia, China, India [7, 8], Indonesia, Laos, Malaysia, Myanmar, Nepal [9], Papua New Guinea [10, 11], Philippines [12], Taiwan, Province of China, Thailand, Vietnam.

II. Exotic: Antigua and Barbuda, Bahamas, Barbados, Cuba [13], Dominica, Dominican Republic, Grenada, Guadeloupe, Haiti, Jamaica, Martinique, Netherlands Antilles, Panama, Puerto Rico [14-16], St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Sudan, Tanzania, Trinidad and Tobago, Virgin Islands (US) [17], Zimbabwe [18].

Biology: During the dry season the tree becomes almost leafless for a short time. Depending on the location, pods can take 8 months to ripen, as in India, or tree could flower and fruit throughout the year. Seeds may be released from the mature dehiscent pods still attached to the tree or from windblown pods that later dehisce or decompose. In Australia, flowering occurs about March to May and the fruits mature from July to October. In Sudan [19], it flowers from March to April and fruits in May. Flowers are bisexual.

Ecology: *Albizia procera* [20, 21] is widely distributed from India [22] and Myanmar through Southeast Asia [23] to Papua New Guinea and northern Australia [24]. The habitat ranges from monsoon forest, mixed deciduous forest, savannah woodlands, pyrogenic grassland, roadsides, and dry gullies, to stunted, seasonal swamp forest. It is commonly found in open secondary forest and in areas with a pronounced dry season. It is susceptible to frost and has moderate light requirements. Once established, it becomes drought tolerant. Best development occurs in areas with more than 2500 mm annual rainfall and means an annual temperature of 21-32 ºC. If the area is not burned, *Albizia procera* will colonize alang-alang (*Imperata cylindrica*) grassland. Good survival and rapid early growth have been reported in afforestation trials on both saline and alkaline soils, which are widely cultivated in agroforestry [25] systems.

Tree Management: *Albizia procera* is a large, fast-growing tree, with a mean annual increment in diameter of 1-4 cm; it attains a dbh of 40-60 cm in 30 years. The spacing of 2-3 × 0.5 m in pure stands results in canopy closure in about 3 years. Trees that are suppressed in dense stands will die from lack of light. Due to the light crown, regular weeding and control of the undergrowth are required. Therefore *Albizia procera* is often mixed with other species and planted at a spacing of 3 × 1 m. Mixed planting and pruning in open stands can improve stem form and give a bushy crown. Thinning is necessary after 9 years. Because of its

aggressive growth, *Albizia procera* is a potential weed. This is particularly true in the Caribbean, where it grows faster than many native species. *Albizia procera* seedlings, saplings, and larger trees all coppice vigorously when damaged.

The application of phosphorus fertilizer can improve nodulation and nitrogen fixation, particularly on infertile soils. Natural forests are managed for timber [26] production by coppicing on a 40-year rotation. Fuelwood [27] plantations are managed on a 20-year rotation. Plantations should be weeded twice in the 1st year and once during the 2nd. During weeding soil should not be unduly exposed; only weeds directly interfering with seedlings should be removed.

Germplasm Management: Seed storage [28] behavior is orthodox. Clean seed can be stored at room temperature for 10 months with minimal loss of viability. However, germination can drop to below 50% after storage. Seeds survive 10 years or more at room temperature.

Pests and Diseases: In India and Malaysia, *Albizia procera* trees have sometimes been defoliated by larvae of Lepidoptera species such as *Ascostis selenaria*, *Rhesala imperata*, *Rhesala inconcinnalis*, and *Rhesala moestalis*. In India, young shoots and saplings are attacked by *Oxyrhachis tarandus* and *Oxyrhachis mangiferana*. A caterpillar, *Indarbela quadrinotata*, eat the bark, and a red borer, *Zeuzera coffeae*, attacks the woody stems and branches of saplings. In India, a beetle, *Bruchus bilineatopygus*, causes up to 80% damage to seeds by boring into them. The termite *Coptoterme scurvignathus* is reported as a pest of the tree in India, while in Africa [29] the termite *Ancistrotermes amphidon* is a serious pest on young trees.

Another 50 insect pests of Coleoptera, Hemiptera, Homoptera, and Lepidoptera feed on young shoots, leaves, roots, sap, seeds, and dead wood in Southeast Asia [30]. The tree is also susceptible to diseases from stem cankers such as *Fusarium solani* and *Nectria haematococca*. Rusts include *Sphaerophragmium acaciae* and *Ravenelia sessilis*. Fusarium oxysporum ssp. Perniciosum invades the fine roots and causes gummosis of vessels, wilt and eventual death. Root and butt rot is also a problem.

Plant Characterization:

Macroscopical Characterization: The color of the bark of *Albizia procera* is brown, has characteristic odour and is slightly bitter in taste. The color of the leaf of *Albizia procera* is green, has characteristic odour and is slightly bitter in taste.

Microscopical Characterization:

Sectioning: The Transverse Section of the plant viz. leaf and bark were collected and trimmed. Selected samples were fixed in FAA solution containing formalin (5ml), acetic acid (5ml) and 70% v/v ethyl alcohol (90ml). After 24 hours of fixing, the specimens were dehydrated with a graded series of tertiary- butyl alcohol (TBA). Infiltration of the specimens was carried out by gradual addition of paraffin wax (50-60 ºC m.p.) until TBA solution attained supersaturation. The specimens were cast into paraffin blocks.

The paraffin-embedded specimens were sectioned with the help of Rotary Microtome, RMT-30 (Labcon Scientific Instruments, Mumbai). The thickness of the sections was kept between 10 and 12 µm. The dewaxing of the sections was carried out as per the procedure described by Johanson, 1940. The sections were stained with phloroglucinol: hydrochloric acid (1: 1) and mounted in glycerine.

Photomicrograph: Microscopic descriptions of selected tissues were supplemented with micro-graphs. Photographs of different magnifications were taken with Nikon Lab Phot 2 microscopic unit. For normal observation, the bright field was used. For the study of crystal, starch grains, and lignified cells, polarized light was employed.

Leaflet: The leaflet is uniform in thickness with even and smooth surfaces. The midrib does not project much beyond the surface of the lamina **Fig. 2**. The leaflet along the region of the midrib is 180µm thick. The vascular bundles of the midrib are circular and collateral. It consists of thick, circular sclerotic bundle sheath enclosing the xylem and Phloem strands. The xylem consists of three or four vertical rows of circular thick-walled cells. Phloem occurs thick beneath the xylem strand. The vascular bundle is 500 µm thick. Calcium oxalate prismatic crystals are located in the sclerenchyma sheath.

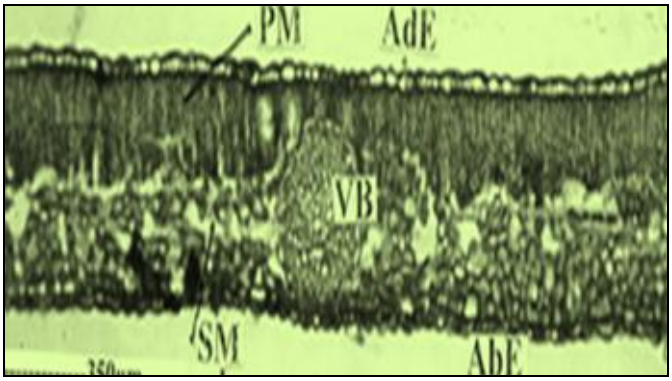

FIG. 2: TRANSVERSE SECTION OF LEAF THROUGH MIDRIB. (AbE: Abaxial epidermis; AdE: Adaxial Epidermis; Ph: Phloem; PM: Palisade Mesophyll; Sc: Selerenchyma; SM: Spongy Mesophyll; VB: Vascular Bundle; X: Xylem)

Lamina: The lamina is 160µm thick. The adaxial epidermis of the lamina is fairly thick, the cells being elliptical to circular with thin cuticle. The epidermis is 10µm thick. The abaxial epidermis is slightly thin and the cells are semi-circular with outer tangential walls being convex. The palisade zone includes very high, thin cylindrical cells which are 80µm in height. The spongy mesophyll consists of seven layers of spherical or lobed parenchyma cells forming wide air chambers.

Leaf Margin: The marginal part of the lamina is as thick as the middle part of the lamina, it is semi-circular and wide. The epidermal cells are squares thick-walled and have prominent cuticle. The palisade cells are reduced in height; the spongy parenchyma cells are compact and densely tanniniferous. A small vascular strand is located at the submarginal part.

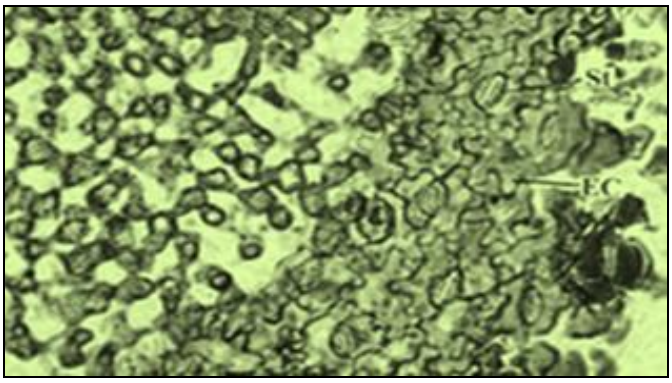

FIG. 3: PARADERMAL SECTION OF THE LAMINA SHOWING EPIDERMAL CELLS AND STOMATA TYPE. (EC-Epidermal cells; GC: Guard cells; SC: Subsidiary cells; St: Stoma)

Stomata: As viewed in paradermal sections, the epidermal cells of the lamina are fairly wide thick-walled and the anticlinal walls are wavy. The stomata paracytic types, the stoma has two subsidiary cells with wavy walls, lying parallel to the guard cells. The guard cells are elliptical and measure 10 × 15 µm in size **Fig. 3**.

Petiole (Main Rachis): The rachis is three angled with the thick bilobed adaxial axis. The rachis is 1.85mm thick (along the vertical axis) and 1.6mm wide along the abaxial part. The adaxial bilobed part is 700µm wide. The epidermal layer is thin and the cells are small, thick-walled and spindle-shaped. The outer ground tissue is parenchymatous; the cells are circular compact and thin-walled. The vascular system is multi-stranded. These are prominent circular collateral vascular bundles located with one in each adaxial wing. In the lower triangular part, there is a wide horizontal plate of vascular strand and abaxial three independent strands, one of them being the median, the other two are lateral in position **Fig. 4**. The wing bundles have an arrow of wide thick walled xylem elements; each row have three cells and there are six rows in each bundle the abaxial bundles are wide and thick. They are wedge-shaped and collateral. In each bundle, there are wide, thin-walled, elliptical or angular xylem elements which are in short parallel rows. Phloem occurs in the thick and wide segment on the outer metaxylem part of the xylem strand. The wing bundles and the abaxial bundles are all surrounded by thick sclerenchymatous.

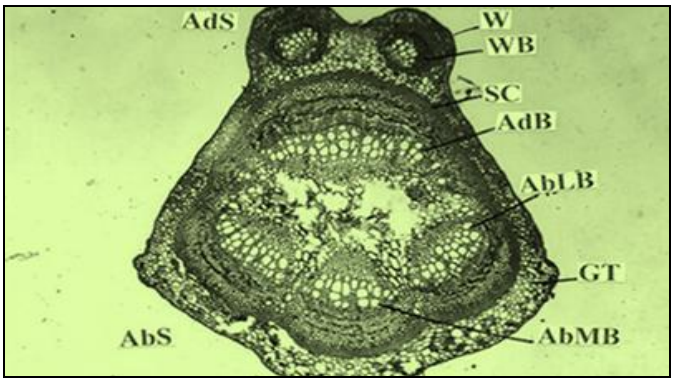

FIG. 4: TRANSVERSE SECTION OF STALK OF THE MAIN RACHIS. (AbLB: Abaxial Lateral Bundles; AbMB: Abaxial Median Bundle; Abs: Abaxial Side; AdB: Adaxial Bundle; AdE: Adaxial Epidermis; AdS: Adaxial Side; GT: Ground Tissue; Ph: Phloem; PM: Palisade Mesophyll; SC: Sclerenchyma; SM: Spongy Mesophyll; W: Wing; WB: Wing Bundles; X: Xylem)

Bark: The bark is more or less smooth with thin, less prominent flakes. The entire thickness of the bark is 3.3mm thick. The fissures are shallow,

irregular and wide **Fig. 5**. The bark consists of a continuous superficial periderm, wide cortex a thick cylinder of sclerenchyma boundary and wide secondary phloem. The major portion of the secondary phloem is composed of collapsed phloem and a narrow innermost portion includes non-collapsed phloem

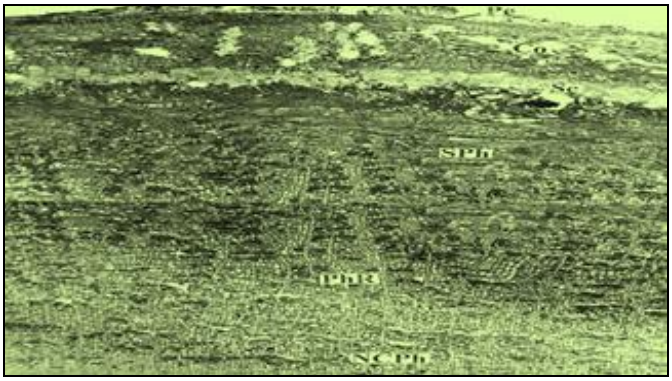

FIG. 5: TRANSVERSE SECTION OF BARK – ENTIRE VIEW. (Co: Cortex; NCPh: Non collapsed Phloem; PhR: Phloem Ray; SPh: Secondary phloem; Sc: Sclerenchyma)

Powder Microscopic Observation of *Albizia procera*: The bark powder, when examined under the microscope, exhibits the following inclusions:

(i) Fibers: Bast fibers are abundant in the powder **Fig. 6**. The fibres are all narrow typed. Occasionally wide fibers may also be seen. The fibres have thick lignified walls, wide lumen with Pits not evident. The ends of the fibres are tapering. The fibres are 500-880µm long and 20µm thick. Long, narrow, scale-like parenchyma cells are commonly seen in the powder. They have thin walls and a wide lumen. No inclusions are evident in the cells. Calcium oxalate crystals are seen associated with the fibers and axial parenchyma. The crystals are prismatic type. They occur in vertical strands isolated crystals are also seen. The crystals are 10 × 20 µm in size.

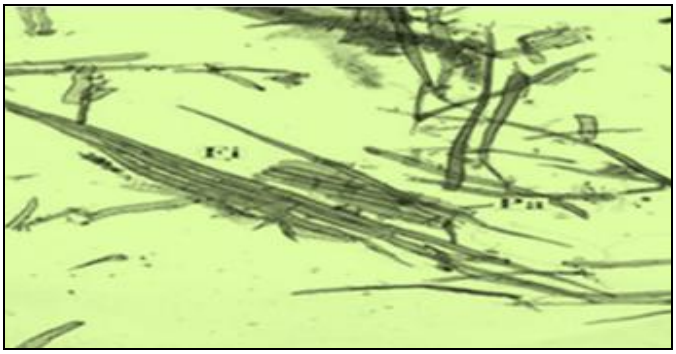

FIG. 6: FIBRES AND PARENCHYMAL CELLS OF *ALBIZIA PROCERA*

Physicochemical Standards of *Albizia procera*: The leaf and bark of *Albizia procera* were shadow dried at a temperature range of 20-30 ºC for about 2 weeks. The dried sample was then powdered in a grinding mill. The obtained powder was used for physicochemical analysis such as ash value, determination of total ash, water-soluble ash and acid insoluble ash, loss on drying, crude fiber content, solubility value, water-soluble extractive, ethanol-soluble extractive, extractive values, and fluorescence analysis and for extraction using solvents [31].

Physicochemical Analysis of *Albizia procera*: The present study on physicochemical characteristics and preliminary phytochemical [32] screening provide useful information which may help in authenticating the genuine plant along with nature of phytoconstituents present in it [33]. The results for physicochemical [34] parameters are shown in **Table 1**.

Ash value is an important quantitative tool used to determine the authenticity and purity of the drug. Percentage weight of loss on drying or moisture content was found to be 11.10% (Leaf) and 10.8% (Bark). The less value of moisture content could prevent bacterial, fungal or yeast. The crude fiber content of the plant material was found to be 8.6% (Leaf) and 5.8% (Bark). Determination of crude fiber is useful in distinguishing between similar drugs and also in the detection of adulteration.

TABLE 1: PHYSICOCHEMICAL ANALYSIS OF LEAF AND BARK OF *ALBIZIA PROCERA*

S. no.	Physiochemical parameters	Leaf (% w/w)	Bark (% w/w)
	Ash value		
	Total ash	10.93	11.12
1	Acid insoluble ash	1.65	1.24
	Water-soluble ash	5.87	2.85
	Extractive values		
	Water-soluble extractive	4.38	4.18
	Alcohol soluble extractive	3.14	3.80
2	Petroleum ether extract	1.93	1.36
	Chloroform extract	3.76	2.12
	Ethyl acetate extract	2.12	1.76
	Ethanol extract	3.39	4.50
	Hydro-alcohol extract	6.20	9.50
3	Loss on drying	11.10	10.80
4	Crude fibre content	8.60	5.80

Water-soluble values were found to be 4.38% (Leaf) and 4.18 (Bark). Alcohol soluble extractive was found to be 3.14% (Leaf) and 3.8% (Bark). The Percentage yield of different extracts was given in **Table 1**.

TABLE 2: FLUORESCENCE ANALYSIS OF LEAF OF *ALBIZIA PROCERA*

Treatment	Day Light	UV Light	
		365nm	265nm
Leaf + Ethanol	Green	Greenish-yellow	Dark brown
Leaf + Chloroform	Green	Greenish-yellow	Brownish green
Leaf + Petroleum ether	Pearl green	Dark green	Greenish brown
Leaf + Ethyl acetate	Yellow	Greenish-yellow	Purplish green
Leaf + Benzene	Yellowish-brown	Fluorescence green	Purplish green
Leaf + Water	Yellow	Yellowish green	Brownish-yellow
Leaf + 1N Hydrochloric acid	Brown	Light green	Bluish yellow
Leaf + 1N Sodium hydroxide	Brown	Fluorescence green	Light brown

TABLE 3: FLUORESCENCE ANALYSIS OF BARK OF *ALBIZIA PROCERA*

Treatment	Day Light	UV Light	
		365nm	265nm
Bark + Ethanol	Brown	Fluorescence green	Dark brown
Bark + Chloroform	Dark brown	Yellowish green	Light brown
Bark + Petroleum ether	Brown	Yellow	Light brown
Bark + Ethyl acetate	Dark brown	Fluorescence green	Brown
Bark + Benzene	Dark brown	Fluorescence green	Yellowish green
Bark + Water	Dark brown	Yellowish green	brown
Bark + 1N Hydrochloric acid	Dark brown	Yellowish green	Yellowish orange
Bark + 1N Sodium hydroxide	Brownish-yellow	Greenish-yellow	Light orange

The bark of *Albizia procera* showing yellowish-green and brownish-green may be due to the presence of Tannin. Bark showing yellowish-orange and light orange could be due to the presence of flavonoids. The leaf of *Albizia procera* showing purplish-green may be due to the presence of flavonoids as anthocyanins. Leaf showing dark brown is likely to be due to the presence of Tannins.

Uses and Services:

Erosion Control: *Albizia procera* is widely planted for its good soil-binding capacity [35]. In Bangladesh, *Albizia procera* is regarded as a soil improver and is used as a nurse tree in tea gardens, coffee and cocoa plantings [36].

Shade or Shelter: Occasionally cultivated as shade for tea and coffee plantations. Also acts as a wind and firebreak. In Cuba, it is used as a shade tree over coffee and in the Philippines, farmers conserve trees of *Albizia procera* in the landscape because they cast only light shade.

Reclamation: *Albizia procera* is Popular for the rehabilitation of seasonally dry, eroded and degraded soils. Its ability to grow on dry, sandy, stony and shallow soils makes it a useful species for afforestation of difficult sites [37].

Nitrogen Fixing: *Albizia procera* fixes atmospheric nitrogen. It readily forms an association with Rhizobium species, enabling it to thrive in nitrogen-deficient soils [38].

Ornamental: *Albizia procera* is a useful tree for farm and amenity planting. Trees are often planted along avenues and in gardens to beautify them [39].

Boundary or Barrier or Support: The branches (twigs) are used by tea planters as stakes for laying out tea gardens. These are found to split well. The species is popular along field borders.

Timber: *Albizia procera* has a large amount of non-durable, yellowish-white sapwood. The heartwood is hard and heavy, light or dark brown, with light and dark bands resembling walnut. It is straight-grained, splits readily, seasons well, works easily and is durable [40]. The timber is strong, elastic, tough and hard. *Albizia procera* wood is chiefly for makes a good cabinet, furniture, construction, agricultural implements, household products, poles, house posts, truck and bus bodies, packing cases, molding, carts, cane crushers, carvings, boats, oars, oil presses, and rice pounders. It is resistant to several species of termites, including *Bifiditermes beesoni*, *Cryptotermes cynocephalus* and *Coptotermes curvignathus*, although the last is reported in India as a pest [41] of the tree.

Gum or Resin: When injured, the stem exudes large amounts of a reddish-brown gum that is chemically similar to, and used as a substitute for, gum arabic.

Fuel: *Albizia procera* makes excellent charcoal and fuel wood [42]. The high rate of biomass production, high proportion of biomass in stem and branches (91%) and observed vigorous coppicing after felling led Lugo *et al.*, (1990) [43] to recommend the species for fuelwood [44] production in Puerto Rico. The calorific value of dried sapwood is 4870 kcal/kg, and that of heartwood 4865 kcal/kg. Excellent charcoal (39.6%) can be prepared from the wood, and it is widely used as a fuel. Pods and fallen leaves should be considered not as undesirable litter but as potential energy sources.

Fiber: The chemical analysis of the wood indicates that it is a suitable material for paper pulp. Bleached pulp in satisfactory yields (50.3%) can be prepared from *Albizia procera* wood by the sulfate process. The fibers of *Albizia procera* are short and blending with a long-fibred pulp may be necessary to improve strength properties for some end uses. It is suitable for writing and printing paper (mean fiber length is 0.9 mm, the mean fiber diameter is 0.021 mm).

Fodder: In the Philippines, cooked leaves are eaten as a vegetable. In times of scarcity, the bark can be ground with flour and eaten. In India, the leaves of *Albizia procera* are considered good fodder for most ruminants (cattle, sheep, goats, elephants, and deer) and the tree is lopped for fodder in several states.

In Australia, it appears that early settlers regarded *Albizia procera* as a good fodder tree [45-47]. According to Lowry and Seebeck (1997), the main natural feed source from *Albizia procera* when established at wide spacing's in a silvopastoral system would be the fallen leaves during the period of low-quality dry-season pasture. These leaves could be expected to have similar feed value to the leaves of A. lebbeck but would be available much later in the dry season. According to Valkenburg (1997), the mineral content of the leaves for sodium, potassium, calcium, and magnesium is adequate for animal production, but the sodium and potassium contents are inadequate, suggesting that this species should not be used alone for fodder but in mixtures with other fodder species. The leaf has a high crude fibre and lignin content, indicating poor digestibility and inadequate sodium and phosphorus content. This was confirmed by who found the predicted in vivo dry matter digestibility of *Albizia procera* foliage to be low (19.4%). In a study in West Africa, Larbi *et al.*, (1996) [48] found that *Albizia procera* was inferior in feed value to *Albizia lebbeck* and *Albizia saman.* Leaves contain 19.9% protein, 3.3% fat, 39.7% carbohydrates, 1.51% calcium, 0.3% phosphorus, 31.9% fibre and 6.2% ash (minerals).

Ethnomedical Review: All parts of the plant are reported to show anti-cancer activity. The roots contain alpha-spinasterol and a saponin that has been reported to possess spermicidal activity at a dilution of 0.008%. *Albizia procera* is commonly used in traditional medicines [49]. A decoction of the bark is given for rheumatism, haemorrhage and it is also useful in the treatment of problems occurring in pregnancy, stomach-ache, diabetes mellitus, sinus, etc. Seeds were powdered and used in amoebiasis. It cures urinary tract infection including glycosuria, hemorrhoids, fistula and worm infestation and also suppresses skin diseases. The bark is given with salt to water buffalo as a medicine. Fruits of *Albizia procera* acts as an astringent and diminishes Kapha and Sukra [50]. In India, leaves are poulticed on to ulcers [51].

Poison: The bark is a source of tannin, but yields are low [52]. The pounded bark is used as a fish poison, and the leaves are known to have insecticidal and piscicidal properties. The seeds contain proceranin A, which is toxic to mice and rats when administered parenterally and orally; the intraperitoneal LD_{50} for mice is 15 mg/kg body weight. Hydrocyanic acid has been identified as occurring in the tree.

Other Products: In the Philippines the wood functions as a cash reserve for farmers, who sell it to local woodcarvers.

Biological Activities: Traditionally a number of activities are reported from various parts of this plant. A few of them are scientifically proven. Some of the reported studies are the following:

***In-vivo* Antioxidant Activity:** S. Sivakrishnan *et al.,* studies show paracetamol induces the oxidative stress in the cell by producing reactive oxygen species. After administration of ethanolic extract of *Albizia procera* in paracetamol treated rats showed a significant increase in the levels of an antioxidant enzyme such as superoxide dismutase (SOD), catalase (CAT) and non-enzymatic antioxidant glutathione (GSH) when compared with paracetamol-induced rats (group II).

Based on the results, it was concluded that the ethanolic extract of *Albizia procera* has significant *in-vivo* antioxidant activity [53] and can be used to protect tissue from oxidative stress [54-57].

***In-vitro* Free Radical Scavenging Activity:** Kottaimuthu *et al.,* the study was undertaken to investigate and evaluate the *in-vitro* antioxidant activities of ethanolic extract of *Albizia procera*. The ethanolic extract of *Albizia procera* was examined for DPPH (α,α-diphenyl-β-picryl-hydrazyl) radical scavenging activity, superoxide anion, nitric oxide and hydroxyl radical scavenging activity with reference standard rutin, quercetin and ascorbate respectively through *in-vitro* models.

Albizia procera showed significant free radical scavenging activity than that of various standards. The radical scavenging activity was found to be concentration dependent manner. Ethanolic extract of *Albizia procera* showed strong scavenging activity against free radical compared to various standards [58]. These *in-vitro* assays indicate that this plant extract is a better source of natural antioxidant, which might be helpful in preventing the progress of various oxidative stresses [59-62].

Antioxidant Potential, Total Phenolic and Flavonoids Content: Sivakrishnan *et al.,* the study was clearly indicated that the ethanolic extract of *Albizia procera* can be used as an easily accessible source of natural antioxidants and as a possible food supplement in the pharmaceutical industry. *In-vitro* study indicates that these plant extracts is a significant source of natural antioxidant, which might be helpful in preventing the progress of various oxidative stresses [63-67]. Therefore, further investigations need to be carried out to isolate and identify the antioxidant compounds present in the plant extract.

Phytochemical Evaluation: Sivakrishnan *et al.,* shows the above-powdered materials were successively extracted with ethanol by hot continuous percolation method in Soxhlet apparatus for 24 h. Different types of secondary metabolites such as triterpenoids, carbohydrates, glycosides, phytosterols, phenolic compounds, saponins, tannins, and flavonoids were presented [68-75].

Current reports show that the Flavonoids, a group of polyphenolics, are free radical scavengers, super antioxidants which have anti-inflammatory, prevent oxidative cell damage through their water-soluble property and also possess anti-cancer activity have shown immense potential anti-oxidant properties. Flavonoids in intestinal tract lower the risk of heart disease Triterpenoids shows analgesic, hepatoprotective and anti-inflammatory properties. Tannins may have a potential value such as cytotoxic, anti-cancer agents and hasten the healing of the wound and inflamed mucous membranes.

Saponins are used in hypercholesterolemia, hyperglycemia, antioxidant, anticancer, anti-inflammatory and weight loss, *etc*. according to the medical field. It is a bioactive antibacterial agent of plants. Phytosterols have cardiotonic activity, possess insecticidal and antimicrobial properties. Phenolic compounds have antioxidative, antidiabetic, anticarcinogenic, antimutagenic and anti-inflammatory, inhibition of angiogenesis and cell proliferation as well as the improvement of endothelial function**.**

Phytochemical Review: Bark, leaf, and root contain saponin and sapogenin. Hydrolysis of the saponin yields machaerinic acid. The tree contains some HCN. Leaf and fruit have given positive tests for hemolysis. A new pentacyclic triterpenic acid, procera acid was isolated from the seed. The gum contains aldobiuronic acid and the disaccharide 3-O-D-galactopyranosyl –L –arabinose [76]. Degraded gum from *Albizia procera* contains D-galactose, D-mannose, D-glucuronic acid, and 4-O-mehtyl D-glucuronic acid [77].

Complete methylation and subsequent hydrolysis of the product afford 2,4-di-O-methyl-D-galactose (3 moles), 3,4,6-tri-O-methyl-L-arabinose. Percera-genin $C_{30}H_{46}O_4$ is reported from the seed [78].

Gas Chromatography-Mass Spectroscopy Analysis: S. Sivakrishnan and J. Kavitha *et al.*, Shows GC-MS chromatogram of ethanolic extract of aerial parts of *Albizia procera* (Roxb.) Benth. The analysis clearly showed the presence of twelve compounds [79]. Chromatogram GC-MS [80-87] analysis of the ethanolic extract of *Albizia procera* (Roxb.) Benth. showed the presence of 12 major peaks and the components corresponding to the peaks were determined as follows. 3-O-Methyl-d-glucose [55.38%], 1,10- Decanediol [2.31%], 3-Pentanol, 2,3-dimethyl- [0.26%], Decanoic acid, ethyl ester [1.54%], Phytol [3.33%], 1-Undecyne [0.77%], Didodecyl phthalate [2.56%], Squalene [6.15%], 9,12- Octadecadienoic acid (Z,Z)-,phenylmethyl ester [3.85%], 6,9,12 Octadecatrienoic acid, phenylmethylester, (Z,Z,Z)-[4.87%], Benzo [b]thiophene-2 carboxamide, 3-chloro-N-(4-methoxyphenyl)- [8.97%], 13-Tetradece-11-yn-1-ol [10.00%]. The presence of various chemical compounds confirms the application of *Albizia procera* (Roxb.) Benth. for various ailments by traditional practitioners.

Analgesic, Antibacterial, and CNS Depressant Activities: Mst. Mahfuza Khatoon *et al.*, results indicated that the extracts could significantly reduce the number of writhing, showing potential anti-nociceptive action and the mechanism by which they exert their analgesic effect probably by inhibiting synthesis or action of any of the above pathway [88]. In order to confirm whether the antinociceptive action was central or peripheral, the extracts were also examined using the formalin test method, which was generally considered a central action. The test consists of two different phases: early phase where the pain began due to the direct stimulation of the sensory nerve fibers by the direct action of formalin, and in the late phase, pain-induced due to different inflammatory mediators, such as histamine, prostaglandins, serotonin, and bradykinins. Central analgesic drugs like narcotics, inhibited equally both phases, while peripherally acting drugs, such as steroids (hydrocortisone and dexamethasone) and NSAIDs (indomethacin), suppresses mainly the late phase.

The results obtained here indicated that the extracts inhibited late phase mechanisms of pain, suggesting that the plant extract may act as steroids and NSAIDs. It is also reported that the inhibition of pain may also due to the presence of phenolic constituents [89] which may be due to the similar type of constituents present in the extracts of *Albizia procera* leaves. However, the exact mechanism of this action has not been investigated here.

Locomotor activity refers to an increase in alertness and decrease in a locomotor activity considered as the sedative effect. In this study, locomotor activity measured by hole cross and open field tests showed that the extract significantly decreased locomotor activity which indicates it has CNS depressant activity. Diazepam, which was used to induce sleep in this study, believed to act at specific binding sites that are closely linked to γ-aminobutyric acid (GABA) receptors, the binding of benzodiazepines enhancing GABA-ergic transmission. It has been reported that many flavonoids and neuroactive steroids were found to be ligands for the GABA receptors in the central nervous system; that can act as benzodiazepine-like molecules [90]. Preliminary phytochemical studies revealed the presence of glycosides, flavonoids, tannin, etc. in methanol extract of *Albizia procera* leaves. So, it is probable that flavonoids present in the extracts may responsible for its CNS depressant activity.

A number of studies have raised the necessity of developing alternative antimicrobial drugs [91]. Plant antimicrobials would appear to be an excellent choice. It has been shown previously that methanol extract of *Albizia procera* stem bark exhibit a potent antimicrobial activity against *Bacillus subtilis*, *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Enterococcus faecalis*. No previous report on the antibacterial activity of the leaves of *Albizia procera* could be found in the literature. Use of leaves extract in the current study demonstrated that the leaf also produces antibacterial compounds against Gram-positive and Gram-negative bacteria.

Antidiarrheal Activity: Hossan MF *et al.*, results suggest that methanolic extract of *Albizia procera* has an antidiarrheal activity in magnesium sulfate-induced diarrhea in mice partly via reducing the colonic water secretion induced by magnesium sulfate [92]. The antidiarrheal activity of the plant extract was comparable to the standard drug, loperamide; effectively antagonizes the diarrheal activity-induced either by castor oil, increased

biosynthesis of prostaglandins or cholera toxin. Loperamide, other than regulating the gastrointestinal tract, is also prominent in slowing down the transit time of intestinal content, reduces the flow rate through the colon, and consequently affect the colonic motility [93]. The significant inhibition of the castor oil and magnesium sulfate-induced enter pooling in mice suggests that *Albizia procera* leaf extract produces relief in diarrhea either by spasmolytic pathway or due to antisecretory activity in the diarrheal animal model. In conclusion, the present study revealed that *Albizia procera* contains pharmacologically active substances effective for the management of diarrhea. Further studies are required to fully investigate the mechanisms responsible for this observed antidiarrheal activity.

Anti-HIV-1 Integrase Activity: Pattarapan Panthong *et al.*, results showed that the ethanol extract had good anti-HIV-1 IN [94] activity with an IC_{50} value of 19.5 mg/mL, whereas ethyl acetate fraction exhibited the most potent with an IC_{50} value of 19.1 mg/mL, followed by water fraction (IC_{50} value ¼ 21.3 mg/mL), hexane and chloroform fractions (IC_{50} value 4100 mg/mL), respectively. From bioassay-guided isolation, the ethyl acetate fraction was further separated to give two compounds which are (+)-catechin (1) and protocatechuic acid (2), respectively. Of the tested samples, (+)-catechin (1) exhibited appreciable activity against HIV-1 IN with an IC_{50} value of 46.3 mM, whereas protocatechuic acid (2) showed mild activity with 46.0% inhibition at a concentration of 100 mM. (+)-Catechin (1) could interact with Thr 66, Gly148, and Glu152 in the core domain of IN enzyme, whereas protocatechuic acid (2) could bind with Thr66, His67, Glu152, Asn155, and Lys159. This is the first report on anti-HIV-1 IN activity of *Albizia procera* bark [95]. These results may suggest that *Albizia procera* bark has potential as anti-HIV-1 IN agent.

Antidiabetic Activity: Praveen Kumar Pasala *et al.*, Study was to identify more effective hypoglycemic fractions from chloroform extract of *Albizia procera* stem bark. Isolated fractions of *Albizia procera* stem bark chloroform extract were given individually to different batches of rats both normal (80 mg/kg of b.wt animals) and Streptozotocin-induced diabetic rats (160 mg/kg b.wt animals) after an overnight fast. The blood glucose levels were measured at 0, 1, 2, 3, 5 and 6 hours after the treatment. Fractions were also treated to Streptozotocin-induced diabetic rats by chronically (80mg/kg b.wt). The fractions E of *Albizia procera* stem bark chloroform extract was shown maximum blood glucose-lowering effect in both normal and Streptozotocin diabetic rats with acute and chronic treatment. The other fractions are also showing hypoglycemic and antihyperglycemic activity, but the effect is significantly less than that of fraction E. The antihyperglycemic activity of fractions of *Albizia procera* stem bark chloroform extract was compared with the treatment of glibenclamide. The present data confirm the antidiabetic activity of *Albizia procera* in Indian traditional medicine for Diabetes mellitus treatment. The antihyperglycemic action attributed to the presence of valuable flavonoids, terpenoids in the fraction E [96].

***In-vitro* α-Amylase and α-Glucosidase Inhibitor Activities:** Anand D and Sathish M study were carried out to determine the *in-vitro* α-amylase and α-glucosidase inhibitory activity of extract and fractions of *Albizia procera* [97]. The α-amylase and α-glucosidase inhibition assay were carried out at concentrations 50–2000 μg/ml and acarbose used as standard. The absorbance was measured at 540 nm and recorded by spectrophotometer. Percentage inhibition was calculated for both the assays. Preliminary phytochemical screening was also evaluated using standard procedures. There was a dose-dependent percentage inhibition of extracts (petroleum ether and ethanol) and fractions (chloroform, ethyl acetate, and n-butanol). The ethanol extract and n-butanol fraction show good inhibitory activity against both α-amylase and α-glucosidase with the percentage inhibition of 86.20% and 88.20% and 83.13% and 87.10%, respectively. The preliminary phytochemical screening shows that ethanol extract consists of active constituents such as flavonoids and phenolic compounds and tannins. This finding suggests that the ethanol extract and n-butanol fraction show good inhibitory activity against both α-amylase and α-glucosidase and show good antidiabetic activity.

Acute Toxicity Study: S. Sivakrishnan *et al.*, studies show the results of acute toxicity study revealed that LD50 values squalene isolated from

Albizia procera were high and apparently showed the safety of extract [98]. The treatment of rat with squalene isolated from *Albizia procera* did not change any autonomic or behavioral response in rats. The zero-percent mortality for squalene isolated from *Albizia procera* was found at the doses of 500 mg/kg. Overall results suggested the LD50 value of 500 mg/kg. Hence, the therapeutic dose was calculated as $1/10^{th}$ (50 mg/kg) of the lethal dose for hepatoprotective and *in-vivo* antioxidant activity.

Hepatoprotective Activity: Paracetamol induced hepatotoxicity on Wistar rats showed a significant increase ($p<0.001$) in AST, ALT, ALP, and GGT ($p<0.01$) in serum levels when compared with control. Elevated levels of serum enzymes leaking out from damaged liver cells into circulating blood represent the damage to hepatic cells. The effect of squalene isolated from *Albizia procera* treatments reversed the level of AST, ALT, ALP, and GGT when compared to paracetamol alone treated rats. Silymarin treated animals also showed a significant decrease in AST, ALT, ALP and GGT levels, which seem to offer the protection and maintain the functional integrity of hepatic cells. Administration of paracetamol significantly increased the levels of total bilirubin, urea, and creatinine when compared with the control group of rats. The serum total bilirubin, urea, and creatinine were significantly decrease in paracetamol with squalene isolated from *Albizia procera* treated rats (Group III) and as well as a standard drug (Group IV) compared with paracetamol-induced hepatotoxicity on Wistar rats (Group II). The effective control of total bilirubin levels indicating its protective effect over liver and improvement in its functional efficiency.

Based on the findings, the squalene isolated from *Albizia procera* may enhance the ability of the kidneys to remove these waste products from the blood as indicated by the reduction in serum urea and creatinine levels and confer a protective effect on the kidney [99].

The paracetamol administered rats were significantly increased the levels of total cholesterol and triglycerides when compared with the control group of rats. Increase in the level of total cholesterol and triglyceride is a risk factor for ischemic heart disease. The serum total cholesterol and triglycerides were significantly decrease in paracetamol with squalene isolated from *Albizia procera* treated rats (Group III) and as well as a standard drug (Group IV) compared with Paracetamol induced hepatotoxicity in Wistar rats (Group II). The decreased level of triglyceride and total cholesterol are responsible to remove cholesterol from within artery.

The paracetamol-induced hepatotoxicity on Wistar rats (Group II) were significantly decrease in the level of total protein and albumin when compared with the control group of rats (Group I). The decrease in the level of total protein observed in paracetamol-induced hepatotoxicity in Wistar rats may associate with a decrease in the number of hepatocytes, which in turn may result in the decreased hepatic capacity to synthesis protein. Albumin is a major protein generated by the liver and severe liver injury causes a decrease in the amount of albumin produced. Treatment of rats with squalene isolated from *Albizia procera* treated rats (Group III) and as well as a standard drug (silymarin (Group IV)) significantly increase the level of total protein and albumin compared with paracetamol-induced hepatotoxicity on Wistar rats (Group II). An increase in serum levels of total protein and albumin suggests the stabilization of endoplasmic reticulum, leading to protein synthesis. The hepatoprotective effect of squalene isolated from *Albizia procera* was confirmed by histopathological examination of the liver tissue of control and treated animals: Group I control shows normal cellular architecture with distinct hepatic cells, sinusoidal spaces and central vein and also shows normal hepatocyte cords, sinusoids, stroma, and hepatic parenchyma. Group II negative shows Hepatocytes show degenerative changes. There are seen epithelioid granulomas and aggregates of mononuclear inflammatory cells.

Some of the sinusoids show congestion, portal tract showed infiltration and marked periportal congestion. Group III squalene isolated from *Albizia procera* shows normal hepatocytes with sinusoids and portal tract showing recovery. There was no apparent sign of necrosis and periportal infiltration. Group IV standard shows normal hepatocytes, stroma, hepatic parenchyma, and their lobular architecture was normal.

CONCLUSION: The growth of the pharmaceutical industry and the unceasing development of new and more effective synthetic and biological medicinal products have not diminished the importance of medicinal plants in many societies. *Albizia procera* is a well known and commonly found tree. Traditionally it has a number of medicinal activities.

Although, its distribution is very common, yet very less research has been done on these plant parts as compared to other *Albizia* species. So, it is required to explore the knowledge about its identification, investigation of its phytochemicals and biological evaluation of various traditionally mentioned activities. This review is an effort to compile all available information and research data on this plant.

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