**SHOREA ROBUSTA GAERTN. F: A MULTI-THERAPEUTIC POTENTIAL INDIGENOUS DRUG**

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Running Title: Multi-therapeutic potential of *Shorea robusta*

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**Abstract**

Shorea robusta Gaertn. f. is an Indigenous plant, commonly known as Sal, Shala, Indian Dammer, Holy tree. In ayurveda, bark and leaves of *S. robusta* were used to cure itching, leprosy, gonorrhea, wounds and stomach ulcers, disease of vagina, cough, pain in ear and head. It is used as anthelmintic, alexeteric, enrich the blood, prevent sweating, improve the complexion, etc. whereas, in Unani system of medicines *S. robusta* has been traditionally used to treat menorrhagia, eye irritation and in enlargement of spleen. It is a good blend of primary and secondary metabolites. Some pharmacological significant molecules isolated from *S. robusta* are bergenin, ursolic acid, caryophyllene oxide, calarene epoxide, Lupeol, β-humulene, α-amyrin, α-amyrin, β-Caryophyllene, etc. *S. robusta* has scientifically evaluated on experimental animals and reported to possess analgesic, anticancer, anticonvulsant, anti-diabetic, anti-hyperlipidemic, anti-inflammatory, antimicrobial, antioxidant, antipyretic, antiulcer, immunomodulatory, wound healing activity, etc. *S. robusta* is a plant drug having multi-therapeutic potential to cure a variety of health problems. It is worth to update the ethnopharmacological, phytochemical and pharmacological reports which might be a good source of information to the researchers working in these domains.

**Keywords**: *Shorea robusta*; Sal; Holy tree; Ayurveda; Unani System of Medicine.

**Introduction**

In the human health care, herbal medicinal plants play a vital role. A large proportion of populations of growing countries have faith on herbal practitioners who are reliant on medicinal plants to fulfill the major healthcare needs (WHO, 1993). Generally, in villages (rural and tribal) of India about 7500 plants are utilized in local health. The traditional system of medicines for example Unani, Siddha, Ayurveda, Tibetan and Homeopathy use about 1200 plants. These traditional systems merged ancient beliefs and were passed on by oral tradition and/or guarded literature from one generation to another (Pushpangadan, 1995). The present effort is to review and compile updated information on various aspects of *Shorea robusta Gaertn. f.* (Figure 1), an herbal medicinal plant used in Indian traditional system of medicines for variety of purposes. *S. robusta* (Sal) belongs to family Dipterocarpacea, which is usually well-known as Shal, Sal in Hindi and Indian Dammer and Sal tree in English. It is a deciduous tree generally found in India, from Himachal to Orissa Eastern districts spreading to the Eastern Ghats of Andhra Pradesh (Kritikar and Basu, 1999).

Species of Sal indigenous to Western Ghats countries, South Asia, ranging South of Himalaya, from Myanmar in the east to India, Bangladesh, Bhutan and Nepal (Murugesan, 1988). In India, the species found from Himachal Pradesh to Assam, West Bengal, Tripura, Bihar, Orissa and Eastern districts of Madhya Pradesh and Andhra Pradesh (Murthy, 2011). The present critical review is centralized to traditional uses, scientific reports based on phytoconstituents as well as
pharmacological activities along with standardization studies and some miscellaneous scientific reports on *S. robusta* (Figure 2).

**Fig. 2 : Centralized focus area on Shorea robusta Gaertn**

**Traditional reports**

*S. robusta* has been traditionally used in a variety of health problems. According to in ayurveda, bark and leaves of *S. robusta* used in the cure of itching, leprosy, gonorrhea, wounds and ulcers, enrich the blood, prevent sweating, improve the complexion, in cough, disease of vagina, pain in ear and head. These are used as anthelmintic and alexeretic. Resin of this plant has been used as tonic to brain, blood purifier, lessens sweating and body temperature, effective for wounds, fractures, pains, burns, itching and ulcers, useful in dysentery and also good for vaginal discharges. Unani system of medicine reported use of resin in menorrhagia, ascites, obesity, ulcers, enlargement of spleen, wounds, in toothache, beneficial for eye burning and eyesores. All kinds of wounds, skin diseases and scabies treated with oil of *S. robusta* (Kritikar and Basu, 1999). The resin also used in dysentery, gonorrhoea (Kritikar and Basu, 1999, Verma et al., 1993, Anonymous, 1972) astringent and in skin and ear troubles (Anonymous, 1972). It is also act as aphrodisiac and commonly given in weak digestion (Kritikar and Basu, 1999). Oleoresin gum used as ointment base with beeswax to heal foot crack, ulcers, wounds, burns, ear and eye troubles, skin disease (Pullaiilah and Rani 1999, Patra et al., 1992, Misra and Ahmad 1997, Upadhyay et al., 1998). For the control of Hemorrhoids, swelling and pain, it also offers with cow ghee (Kaur et al., 2001). Seeds has been given in pus forming wounds (Singh, 1986), whereas oil of seeds used as good medication for scabies and skin disease. Flowers were also effective in Diarrhea, gonorrhoea and leprosy (Chopra et al., 1956, The wealth of India, 1950).

**Scientific Reports**

**Phytoconstituents reports**

The chemical constituents present in plant are α-Amyrenone, Hopeaphenol, Asiatic acid, Benthamic acid and Uvaol (Soni et al., 2013; Merish et al., 2014), leucoanthocyanidin, and a terpene alcohol, furfural, monomethylether, dimethylether of homocatechol, alkylbenzene derivatives, pentosans, lignan, amino acids, fatty acids, tannin triterpenoids, ellagic, chebulinic, gallic, phenolic and shorbic acids (Adlakha et al., 2014). Phytoconstituents reported from different parts of *S. robusta* listed in Table 1 and 2.

**Table 1 : List of phytoconstituents reported from different parts of S. robusta**

<table>
<thead>
<tr>
<th>Phytoconstituents</th>
<th>Part of Plant</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>9,10-Dihydroxystearic; Stearic acid; Palmitic acid; Arachidic acids</td>
<td>Sal fat</td>
<td>(Reddy and Prabhakar 1987)</td>
</tr>
<tr>
<td>1,2,4-Benzene triol; Ethyl(trimethyl) silane; D-Mannitol</td>
<td>Bark</td>
<td>(Marandi et al., 2016)</td>
</tr>
<tr>
<td>1,3,5,7-Tetraethyl-1-butoxy cyclotetrasiloxane</td>
<td></td>
<td>(Patra et al., 1992)</td>
</tr>
<tr>
<td>Shoreaphenol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Methyl oct-5-yn-4-yl 2,2,2-trichloroacetate; Cyclooctene, 5, 6-dimethylene; Propyl octane-2-yl carbonate; n-Hexadecanoic acid (Palmitic acid); Phytol; Cyclohexane-1,3-dione; 2-allylaminomethylene-5,5-dimethyI; Trimethylsilyl 3-methyl-4-[(trimethylsilyl)oxy] benzoaI; β-amyrin, friedelin; β-sitosterol; α-carotene; β-carotene; Lutein; Phenophytin; 7-methoxy-4′,5- dihydroxyisoflavone</td>
<td>Leaf</td>
<td>(Marandi et al., 2016, Chauhan et al., 2002)</td>
</tr>
<tr>
<td>Hexadecyltrichloroacetate; Cyclooctane, methyl-2-Decanol; Searic acid; Hexamethylcyclotrisiloxane</td>
<td>Seed</td>
<td>(Marandi et al., 2016)</td>
</tr>
<tr>
<td>2α,3β,23-trihydroxy-11β-methoxy-urs-12-en-28-oic acid; Coumarin; β-aminor; α-aminor; Taraxasterol; Amino-glutethimide; Neoisolongifolene, 8-bromo-4-azapyrine; Cyloisolongifolene; Cyclotrisiloxane; Caryophyllene; (-)-Spathulenol; Cyloisolongifolene; Isolongifolene; Alloaromadendrene oxide-(1); (-)-Neoclovene-(I); dihydroisoroamadendrene epoxide; Longifolentaldehyde; Spirooctane; Epiglobulol; β-Humulene; Tetrasiloxane, decamethyl-Silane; 3,25-epoxy-1,2,3,11 tetrahydroxurs-12-en-28-oic acid; Ursolic acid; 2α,3β-dihydroxy-urs-12-en-28-oic acid; 2α,3α-dihydroxy-urs-12-en-28-oic acid; 3β,23-dihydroxyolean-12-en-28-oic acid; 2α,3β,23-trihydroxy-urs-12-en-28-oic acid; Nitro-L-arginine; Hexanoic acid; Caryophyllene; Caryophyllene oxide; Ledene oxide-(II); Calarene epoxide; Alloaromadendrene oxide-(1); Gamma-Gurjunepoxide (2); Isocaryophillene; Anthracene; Culmorin; Butanoic acid; Corticosterone; 2-ethylacridine; Ursa-9(11), 12-</td>
<td>Resin</td>
<td>(Misra and Ahmad 1997, Rai and Bapuji, 1993, Vashisht et al., 2017)</td>
</tr>
</tbody>
</table>
dien-3-one
β-Guaiene; Lanosterol; Ursa-9(11),12-dien-3-one; Ursa-9(11),12-dien-3-ol; β-amyrin; α-amyrin; Humulane-1, 6-dien-3-ol; Taraxasterol; Fluoranthene; Lupeol; 9-anthracene carbonitrile; Cytisine; 2,3-dimethylamphetamine; 3,25-epoxy1,2,3-trihydroxyurs-12-en-28-oic acid

<table>
<thead>
<tr>
<th>Chemical constituents</th>
<th>Chemical structure</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asiatic acid; 3,25-epoxy-1,2,3,11-tetrahydroxyurs-12-en-28-oic acid; Phayomphenol; 7-O-α-L-rhamnopyranosyl-(1→4)-α-L-rhamnopyranosyl-(1→6)-β-D-glucopyranoside, 3,25-epoxy-1,2,3-trihydroxyurs-12-en-28-oic Acid; 3,7-dihydroxy-8-methoxyflavone</td>
<td>Root bark</td>
<td>(Sharma et al., 2015)</td>
</tr>
<tr>
<td>Phenol; 3-(prop-2-en-1-yl) cyclohexene; Pentanoic acid, 4-oxo-, ethyl ester; 3-Octenoic acid, methyl(tetramethylene) silan; Butanedioic acid; diethyl ester; 3β-acetoxy-4,4,8,10,14-pentamethyl-17; 3β-acetoxy-4,4,8,10,14-pentamethyl-17; Naphthalene, hexahydro-1,6-dimethyl-4-(11H-Cycloprop[e]azulen-7-ol; 1R,4S,7S,11R-2,2,4,8-Tetramethyltricyclo Ledene alcohol; 2-(4a,8-Dimethyl-1,2,3,4,4a,5,6,7-octahy - Benzene, 1,3-bis(1,1-dimethylethyl)-2-me Ledene alcohol; 1-Fluoroforskolin; 5,9-Methano-benzocycloocten-1(2H)-one, 3, ClocortolonePivalate; Tris(2,6-dimethylphenyl)borane; 2,5-Bis(1-methyl-1-silacyclobutyl)-p-xy! Bis(2-ethylhexyl) phthalate; Methylprednisolone; Ursa-9(11),12-dien-3-ol; Tetracosanoic acid; tert-butyldimethlys, Ursa-9(11),12-dien-3-one</td>
<td>Oleo resin Oil</td>
<td>(Yusuf and Srinivasan, 2015)</td>
</tr>
</tbody>
</table>

Table 2: Bioactive phytoconstituents isolated from *S. robusta*

<table>
<thead>
<tr>
<th>Part of Plant</th>
<th>Chemical constituents</th>
<th>Chemical structure</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaves</td>
<td>Bergenin</td>
<td><img src="image" alt="Bergenin" /></td>
<td>(Mukherjee et al., 2013)</td>
</tr>
<tr>
<td></td>
<td>Urosolic acid</td>
<td><img src="image" alt="Urosolic acid" /></td>
<td>(Mukherjee et al., 2013)</td>
</tr>
<tr>
<td></td>
<td>Trimethylsilyl 3-methyl-4 [[(trimethylsilyl)oxy]benzoate]</td>
<td><img src="image" alt="Trimethylsilyl 3-methyl-4 ((trimethylsilyl)oxy)benzoate" /></td>
<td>(Marandi et al., 2016)</td>
</tr>
<tr>
<td>Resin</td>
<td>Caryophyllene oxide</td>
<td><img src="image" alt="Caryophyllene oxide" /></td>
<td>(Vashisht et al., 2017)</td>
</tr>
<tr>
<td></td>
<td>Calarene epoxide</td>
<td><img src="image" alt="Calarene epoxide" /></td>
<td>(Vashisht et al., 2017)</td>
</tr>
<tr>
<td></td>
<td>Lupeol</td>
<td><img src="image" alt="Lupeol" /></td>
<td>(Vashisht et al., 2017)</td>
</tr>
<tr>
<td></td>
<td>(-)-Spathulenol</td>
<td><img src="image" alt="(-)-Spathulenol" /></td>
<td>(Vashisht et al., 2017)</td>
</tr>
</tbody>
</table>
Pharmacological reports

Various investigations have been carried out and published on the pharmacological activities of *S. robusta* plant. These biological activities are because of crude extract and its isolated phytocompounds which can be of great interest in future for the advancement or development of plant based integral medicines. Pharmacological properties of *S. robusta* have been depicted in Figure 3.

![Pharmacological properties of S. robusta](image-url)
Analgesic activity

*S. robusta* has been used since long time as analgesic agent. Pharmacologically the activity was reported in the 70% ethanolic extract of resin of *S. robusta*. The extract at doses 30, 100, 300 mg/kg intraperitoneally determined by different pain models like hot plate and tail flick. Significant central and peripheral analgesic effect produced by the extract in Wistar albino rats and Swiss mice. The analgesic properties were proved from hike in reaction time in both hot plate and tail flick method (Wani et al., 2012). The Aqueous and methanolic extract of *S. robusta* leaves were examined by tail flick method and writhing method induced by acetic acid. Intraperitoneal doses of extract 200 and 400 mg/kg were injected to animals showed decreasing writhing movements and peripheral analgesic activity. This study concluded the analgesic activity of leaves of *S. robusta* (Chattopadhyay et al., 2012). The alcoholic and aqueous extract of bark at dose 300 mg/kg was evaluated in Swiss albino rats making use of Immersion test, writhing induced by 4% NaCl solution and tail clip method showed significant analgesic activity (Mohod, 2014). A significant analgesic activity showed by ethyl acetate extract of stem bark of *S. robusta* at doses (100 and 300 mg/kg) evaluated by hot plate, formalin induced paw licking methods and tail flick. The phytochemical analysis revealed the presence of flavonoids abundantly which has credited to inhibit the pain perception (Singh et al., 2016).

Antipyretic activity

*S. robusta* has been found to offer antipyretic activity proved experimentally. The 70% ethanolic extract of resin of *S. robusta* possessed antipyretic activity at dose 30, 100, 300mg/kg. This activity was studied making use of Brewer’s method in which pyrexia is induced by yeast in wistar rats which results significantly dose-independent decrease in the body temperature. The standard drug etoricoxib (10mg/kg) were used (Wani et al., 2012)

Anti-inflammatory activity

*S. robusta* leaves have been inhibit the inflammation in rats. Methanolic extract of leaves were assessed for Anti-inflammatory activity against carrageenan inducing inflammation in paw at doses 200 and 400 mg/kg. At both doses level significance anti-inflammatory activity produced in Wistar rats (Jyothi et al., 2008). Experimentally acute inflammation test was conducted on male Wistar albino rats, in one group carrageenan was used to induce edema in paw and cotton pellet induced sub-acute inflammation in other group of animals. In rat’s pretreatment with 70% ethanolic extract at doses 100, 300mg/kg showed significantly decline in granulation tissue formation and edema volume (Wani et al., 2012). Chattopadhyay et al., has stated the anti-inflammatory activity of leaves of *S. robusta*. Inflammation was induced by carrageenan and dextran induced paw edema and cotton pellet induced granuloma in Swiss albino male mice and adult male Wistar rats. Aqueous and methanolic extract at 400 mg/kg p.o has shown dose dependent inhibition of paw edema compared to standard group (Diclofenac sodium). In cotton pellet induced inflammation both extract inhibited granuloma weight in dose dependent manner. The aqueous extract (400 mg/kg) has shown significantly (P <0.001) higher inhibition of granuloma weight compared to diclofenac sodium (Chattopadhyay et al., 2012). Ethyl acetate extract of *S. robusta* stem bark has found to provide relief to rats against carrageenan and formalin induced inflammation. These experiment rats were administered with stem bark leaves at two dose level 100 and 300 mg/kg. Both the doses shown significantly anti-inflammatory activity credited to flavonoids, tannins and phenols (Singh et al., 2016).

Antimicrobial activity

*S. robusta* is reported with antibacterial activity. The aqueous extract of floral part of *S. robusta* shown antibacterial activity against gram +ve bacteria *(Staphylococcus aureus, Bacillus subtilis)* and gram –ve *(Klebsiella pneumonia and Serratia marcescens)*. This study found that extract of gynoecia has good inhibitory property compared to petal extract. The antibacterial effects of extract at concentration of 4 mg/well were compared with standard antibiotic Penicillin. Phytochemical analysis indicates the presence of tannins, flavonoid, cardiac glycosides and steroids may involve killing Bacteria (Duddukarni et al., 2011). The crude benzene, petroleum, methanol and aqueous extract of oleoresin of *S. robusta* were tested for antibacterial and antifungal activity by disc diffusion method against various gram –ve and gram +ve bacteria and some fungi such as *Proteus vulgaris, Escherichia coli, Pseudomonas fluorescenc, Bacillus licheniformis, Bacillus subtilis, Bacillus coagulans, Baccilus cereus, Staphylococcus griseus, Staphylococcus epidermidis, Staphylococcus aureus, Penicillium chrysogenum, Aspergillus flavus, Candida albicans, Aspergillus niger*. The aqueous extract shown activities against bacteria whereas methanol, petroleum and benzene extract possesses antibacterial and antifungal properties were compared with standard antibiotics (Murthy 2011). Antimicrobial activity of ethanolic and methanolic extract of *S. robusta* resin evaluated against some bacterial strain. A parallel study was conducted again to compared antimicrobial activity with five standard antibiotics such as Ciprofloxacin, Gentamycin, Kanamycin, Ofloxacin, Penicillin. The ethanolic extract found more effective against *S. aureus* and *Pseudomonas sp* whereas methanolic extract potent against *E. coli* and *S. typhi* strains. Preliminary phytochemical study ensures the presence of secondary metabolites likes terpenoids, saponins and alkaloids in the resin of plant may be responsible for antimicrobial activity against resistant microbial strains. Current research found *S. robusta* as a potent antimicrobial agent can be used in Pharmaceutical formulations and medicines to cure infectious diseases (Banerjee et al., 2014). The ethanol extract of bark, leaf, flower and seed were tested by standard disc diffusion method against 4 grams +ve bacterial strain viz. *Bacillus cereus, Streptococcus pneumonia, Bacillus subtilis, Staphylococcus aureus* and 8 grams –ve strains include *Enterobacter aerogenes, Pseudomonas aeruginosa, Salmonella paratyphi, Proteus mirabilis, Escherichia coli, Vibrio cholera and Klebsiella pneumonia, Proteus vulgaris*. Minimum zones of inhibition were found against *P. aeruginosa* and *B. Subtilis*. The seeds and bark shown higher antibacterial activities followed by leaf and flower. However, leaves possess considerable size of zones against *S. faecalis* and *S. aureus*. Seeds exhibited higher antibacterial activities validates its ethnic utilization against gastritis, dysentery and diarrhea (Marandi et al., 2016). Resin of *S. robusta* evaluated against gram +ve and gram –ve bacterial strain by paper disc diffusion method. The resin methanolic extract inhibits the growth of gram +ve and gram –ve pathogens similar to...
**Antibacterial and Antifungal Activity**

The methanolic and aqueous extract of *S. robusta* showed significant antibacterial and antifungal activity against various bacterial and fungal strains. The extracts were effective against *Escherichia coli*, *Proteus vulgaris*, *Bacillus cereus*, *Staphylococcus aureus*, *Methanococcus luteus*, *Aspergillus niger*, and *Candida albicans*. The minimal inhibitory concentration (MIC) for the methanolic extract was found to be 6.25 µg/mL.

**Antioxidant Activity**

The methanolic extract of *S. robusta* bark showed strong antioxidant activity. It effectively scavenged DPPH radicals and reduced iron oxide, indicating its potential to combat oxidative stress. The extract also inhibited lipid peroxidation in rat liver microsomes and showed a protective effect against CCl4-induced liver damage.

**Anticancer Activity**

The methanolic and aqueous extract of *S. robusta* leaves were evaluated for their anticancer potential using the MTT assay. The extracts demonstrated significant cytotoxic activity against human cancer cell lines, indicating their potential as anticancer agents.

**Antihyperlipidemic Activity**

The ethanolic extract of *S. robusta* was effective in maintaining normal serum lipid levels in diabetic rats. It significantly reduced plasma cholesterol, triglycerides, and LDL levels, while the HDL level was unaffected. The extract also improved the ratio of total cholesterol to HDL cholesterol, indicating a beneficial effect on lipid metabolism.

**Antidiabetic Activity**

The ethanolic extract of *S. robusta* bark significantly reduced blood glucose levels in streptozotocin-induced diabetic rats. It demonstrated a dose-dependent hypoglycemic effect, with the highest dose (300 mg/kg) showing the most significant reduction. The extract also improved the lipid profile, indicating a potential role in the treatment of diabetes mellitus.

**Anticonvulsant Activity**

The extract of *S. robusta* leaves showed anticonvulsant activity in a mouse model. It was effective in reducing the number of seizures induced by pentylenetetrazol (PTZ) and maximal electroshock. The extract also showed a dose-dependent protection against strychnine-induced seizures.

**Antimicrobial Activity**

The methanolic extract of *S. robusta* exhibited broad-spectrum antimicrobial activity, inhibiting the growth of both Gram-positive and Gram-negative bacteria as well as yeasts. It was effective against *Escherichia coli*, *Staphylococcus aureus*, *Micrococcus luteus*, and *Aspergillus niger*, among others. The extract was also active against fungal strains such as *Candida albicans* and *Cryptococcus neoformans*.
and Rethinam, 2018). Different extracts such as methanol, petroleum ether, acetone, chloroform, and water of oleoresin of *S. robusta* assessed for free radical scavenging activity by Hydrogen peroxide method. All methanolic extract has shown significant 64.7% scavenging (Thampi and Kumar, 2015). The methanolic extract of *S. robusta* leaves showed antioxidant activity against DPPH and α-Amylase Inhibition assay. The extract has 30.24% radical scavenging effect (Archana and Jeyamanikandan 2015). Antioxidant activity of *S. robusta* methanolic extract of oleoresin was reported by using DPPH and iron chelating method. This extract revealed a significant dose dependent inhibition of DPPH (Yusuf and Srinivasan, 2015).

### Antiulcer activity

Gastro protective effects of resin of *S. robusta* at two different doses 150 and 300 mg/kg were evaluated againststaineth and pyloric ligation (PL) induced gastric ulcers in rats. The antiulcer effect of aqueous extract was claimed with stabilization of various antioxidant markers like Superoxide dismutase (SOD), Glutathione peroxidase (GPx), Glutathione –S-transferase, (GST), catalase (CAT) and lipid peroxidation (LPO) in ethanol induced group of animals. In another PL group of animal’s plant extract shown destruction in gastric juice volume (65.44%), pepsin (44.39%), total acidity (26.98%) and protein (23.82%) while carbohydrate (22.67%) and mucin (41.46%) increase in gastric juice. Moreover, pH of gastric juice also increases from 1.25 to 4.54. This current study clearly proved that Sal extract decrease gastric acid and pepsin secretion indicating plant have both gastric cytoprotective and gastric anti-secretory effects (Muthu et al., 2013).

### Butyrylcholinesterase Inhibitory activity

The ethanolic extract of de oil cake of *S. robusta* evaluated for Butyrylcholinesterase Inhibitory activity by using Ellman’s method at concentration ranging from 12.5 to 200 µg/mL. The inhibition was found to be concentration dependent and maximum at 200 µg/ml. This study concluded that *S. robusta* used for symptomatic treatment of Alzheimer’s disease (Shekhar and Kumar, 2014).

### Immunomodulatory activity

The bark of *S. robusta* consumed with traditional claim that it boosts immunity. The hydroalcoholic extract of bark of *S. robusta* evaluated by various immunological models. Mice treated orally with 100 and 300 mg/kg doses of hydroalcoholic extract for 14 days when challenged with Sheep red blood cells (5 x 109 cells/ml). Among two doses 300 mg/kg altered the total and differential WBCs count, potentiated the effect on cellular and humoral response and phagocytosis. This study revealed significant stimulating immunomodulatory response of plant due to presence of flavonoids, polyphenols and terpenoids. Hence, this data supports the use of *S. robusta* bark as a potent natural health product for enhancing immunity (Kalaiselvan and Gokulakrishnan, 2012).

### Wound healing activity

Dutta *et al.* reported that *S. robusta* resin in combination with flax seed oil, Yashada bhasma useful in wound contraction, increased the hydroxyproline and collagen content also improved tensile strength. These effects together make this combination a vital usable for anti-aging activities especially for better skin health (Datta *et al.*, 2011). The wound healing activity of ethanolic extract of *S. robusta* resin evaluated in incision and excision wound models of rats. The ethanolic extract at doses 10 and 30 % applied locally on wounds and shown dose-dependent effects in healing process i.e. rise in hydroxyproline content and tensile strength, acceleration in wound contraction of rats. This results revealed wound healing activity of resins of Sal (Wani *et al.*, 2012). *S. robusta* has been used from ages for the treatment of wounds. The wound healing effects of leaves of *S. robusta* and its two fractions was studied on incision, excision, and dead space wound models. In rats some parameters evaluating such as the wound closure rate, tensile strength, hydroxyproline content, period of epithelization, granulation tissue weight and histopathology. Three types of topical formulations were prepared a) aqueous and methanol extract (2.5 and 5.0 g) mixed with 100g ointment base b) fraction 1 and 2 (5.0g) and 100 g ointment base, c) 0.025 g of isolated compound (bergenin and urosoic acid) with 10 g ointment base. Animals treated with 5 g fractions and extract showed significant reduction in wound area 96.55% and 96.41% with faster epithelization (17.50 and 17.86), whereas the isolated compound heal the wound faster. This data confirmed the traditional use of *S. robusta* leaves in wound healing (Mukherjee *et al.*, 2013). Methanolic extract, Petroleum ether, benzene insoluble fraction of methanolic extract (F1) and Essential oil of *S. robusta* resin possessed significant wound healing activity. Fraction, extract and essential oil were assimilated with yellow paraffin wax (10% w/w) and these prepared ointments applied to incisions and excision wounds of Wistar rats. Wounds heal faster with the application of F1 and Essential oil compared to plain base and framycent (standard). Tensile strength, wound contraction of F1 found to be 53%, 99% respectively which is higher than that of control group of animals. Protein and hydroxyproline content greater in F1 (20.8 and 3.5% w/w) and Essential oils (17.4 and 2.8% w/w) group than control group (9.95 and 1.48%) of rats. Histopathology examination showed complete epithelization and formation of new blood vessels in F1 group. This study indicates that essential oil and triterpene-rich fraction of *S. robusta* have maximum wound healing activity and confirm the traditional statements on this plant of healing of wounds (Khan *et al.*, 2015). The formulation of ethanolic extract of *S. robusta* resin was prepared in two different concentrations 10% w/w and 30% w/w and studied for wound healing activity. Dose dependent effect of resin extract was found in wound contraction and epithelization period. Phytochemical studies revealed the presence of anthraquinone glycosides, tannins, triterpenoids, carbohydrates, saponins and flavonoids (Shakya and Bashyal, 2018).

### Miscellaneous Scientific Reports

Singh *et al.* reported biochemical Analysis and isolation of leaf protein concentrates from the Leaves of *S. robusta*. It has good potential to use in production of leaves protein contents (LPC). Newly fresh and matured leaves yield high amount of LPC (5.96 g) per 100 g leaves. It was additionally found to contain exceptionally high measure of ash (9.24%), which comprised of calcium, Phosphorus, Potassium, Iron, Sulfur micronutrients. Looking at all the biochemical examination, LPC’s recovered from Sal shows genuinely great amount of protein-37.25%, fat-7.41%, nitrogen free concentrate 37.85%, total carbohydrates 45.5%, total soluble sugar-1.94% along with low amount of anti-nutritional...
factors such as total phenolics and total saponins (Singh et al., 2014). Another study reported comparison of different extract of S. robusta on the basis of Pharmacognostic evaluation. Microscopic characters, Ash value, extractive value, Thin layer chromatography and identification test has performed. Methanol, ethanol and Chloroform soluble extractive value reported to 44.85%, 48.57% and 4.48% respectively. The presence of phytoconstituents like amino acids, triterpenoids, alkaloids and flavonoids were confirmed by identification test followed by TLC (Vashisht et al., 2017). Standardization of oleo resin of includes organoleptic study, Physico-chemical constants, fluorescence analysis of extracts and powder, TLC profiling and heavy metal determination. All these evaluated parameters widely accepted and helpful in quality assessment of herbal drugs (Rasheed et al., 2012).

Conclusion and Prospects

S. robusta is a medicinal plant of vital importance owing to its diverse traditional uses Phyto-chemical constituents and therapeutic profile. The anticancer, anticonvulsant anti-diabetic and antimicrobial activity of S. robusta is a ray of light in treating the death causing diseases throughout the world. This review exposes that this plant is a strongest source of new potential phyto-constituents with various pharmacological properties. Identification of more compounds and their activities claimed traditionally suggests a promising future of this plant.

Conflict of Interest

No conflict of interest.

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