Leptadenia reticulata (Retz) Wight and Arn (Apocynaceae): AnInsight into its Overview on Botany, Phytochemistry, Pharmacology & Ethnopharmacological Properties, Marketed Formulation and Toxicity studies

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ABSTRACT

Since the dawn of time, people have used plants for medicinal purposes. This knowledge has been central to developing many traditional medical practices, including the Indian system of medicine like Ayurveda, Siddha, Unani, Homeopathy, Naturopathy, and other medicine systems, including Tibetan, Chinese, and Native American medicine. According to the WHO, 80% of the global population uses herbal medicines for basic medical requirements. The usage of herbal products has risen due to increased perception, health consciousness, the belief that prevention is preferable to cure, and natural approaches to healthy living. The science of Rasayana in Ayurveda is concerned with enhancing overall health, energy, and vitality. Due to its energizing, reviving, and lactogenic characteristics, *Leptadenia reticulata* (Jivanti) stands out among the other plants used in Rasayana. This herb's medicinal potential is due to various bioactive components, including phytosterols, terpenoids, pregnane glycosides, fatty acids, phenolic acid, flavonoids, and other chemical components. Several conditions, including hematopoiesis, diabetes, emaciation, cough, dyspnea, fever, burning sensation, night blindness, and dysentery, are treated with *L. reticulata*. This plant is one of the key components included in many herbal preparations. The current study aims to gather the knowledge currently accessible on the pharmacological, phytochemistry, botanical, Ethnopharmacology, Toxicity study, marketed products, and patents of *L. reticulata.*

KEYWORDS: *L. reticulata*, Ayurveda, Pharmacological, Phytochemistry

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1. INTRODUCTION

Since the dawn of time, people have used plants for medicinal purposes. This knowledge has been central to the development of many traditional medical practices, including the Indian system of medicine like Ayurveda, Siddha, Unani, Homeopathy, Naturopathy, and other systems of medicine which include Tibetan, Chinese and Native American medicine [1-4]. According to the WHO, 80% of the global population uses herbal medicines for basic medical requirements [5]. Natural plant-based materials and their components are the primary focus of drug discovery research. Most therapeutically effective medications were developed using information from numerous conventional illness treatment methods [6,7].

The usage of herbal products has risen due to increased perception, health consciousness, the belief that prevention is preferable to cure, and natural approaches to healthy living. The market for plant raw materials has grown due to the exponential rise in nutraceutical and cosmeceutical customers [8-10]. The science of Rasayana in Ayurveda is concerned with enhancing overall health, energy, and vitality. Due to its energizing, reviving, and lactogenic characteristics, *Leptadenia reticulata* (Jivanti) stands out among the other plants used in Rasayana [11]. As per Vedas, *Leptadenia reticulata* has been used as an immunity booster and galactagogue.

In contrast, in Charaka, the significant role of *Leptadenia reticulata* in rasayana has been explained, and vagbhata mentioned its vitalizing action [12-14]. Several conditions, including hematopoiesis, emaciation, cough, dyspnea, fever, burning sensation, night blindness, and dysentery, are treated with *L. reticulata*. This plant is one of the key components included in many herbal preparations.

This herb's medicinal potential is due to various bioactive components, including phytosterols, terpenoids, pregnane glycosides, fatty acids, phenolic acid, flavonoids, and other chemical components. The isolation, characterization, and comprehension of the therapeutic importance of specific lead molecules of *L. reticulata* have recently attracted the attention of phytochemists and biologists. Different plant sections have different phytochemical compositions and bioactive components. Moreover, several variables, including geographical conditions, meteorological conditions, growth patterns, and

harvesting time, affect how biochemical components accumulate in plants [15,16]. Moreover, different plant component compositions may emerge from applying different extraction techniques. A limited number of investigations have been done on identifying, isolating, and characterizing specific phytocompounds from *L. reticulata*. Numerous chemical component classes, including terpenoids, phenolics, flavonoids, steroids, and esters, have been found in *L. reticulata*.

Due to their limited distribution and cyclical availability, natural resources cannot satisfy the current demand for the medicinal plant. As a result, agriculture is still the only sustainable option. *L. reticulata* has also been designated as a threatened species due to overexploitation of its natural resources through various unethical practices [17]. Farmers and businesses are prepared to grow the herb; still, it is difficult to do so commercially due to its low germination rate, lack of authentic plant components, and ignorance of its growing procedures [18,19]. Farmers have now been obliged to think about producing *L. reticulata* due to its increasing market value and increased demand on a worldwide scale [20].

Various therapeutic plants are now commercially grown to address the rising worldwide demand for plant metabolites utilized by the pharmaceutical industry. Various crop improvement methods still need to be used to create better types of medicinal plants. Adopting micropropagation technology will benefit the large-scale production of improved genetically and chemically homogeneous planting material [19, 20]. Despite extensive agronomic practices and much traditional research work, the intended *L. reticulata* productivity objective still needs to be met. *L. reticulata* is frequently contaminated with a variety of different plants, including *Cimicifuga foetida*, *Holostemmaada-kodien*, *Ichnocarpus frutescens*, *Dendrobium ovatum*, *D. macraei*, and *Flickingeriamacraei* [21-24]. As a result, another significant difficulty confronting the herbal medicine sector is the validity of *L. reticulata.*

The current study aims to gather the knowledge currently accessible on the pharmacological, phytochemical, botanical, ethnopharmacology, toxicity study, marketed products, and patents of *L. reticulata*. Researchers can use these data to investigate new medicinal compounds from this multipurpose plant. This in-depth analysis covers scientific data found using a variety of search engines, including Google Scholar, Scopus, PubMed, and ScienceDirect.

2. BOTANICAL ASPECTS OF *L. RETICULATA*

2.1. Taxonomy

L. reticulata, often called Jivanti, is an Apocynaceae family member and an Ayurveda herb. Below is a description of its taxonomic position (Table 1):

Table 1: Taxonomical profile of *Leptadenia reticulata*

Kingdom	Plantae
Subkingdom	Tracheobionta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Asteridae
Order	Gentianales
Family	Apocynaceae
Genus	Leptadenia
Species	*Leptadenia reticulata*(Retz) Wight and Arn

Several names, including Jivaniya, Jivanti, Jivapushpa, Jivana, Hemavati, Payaswini, Shakashreshtha, Madhusrava, and Maangalya, are used to refer to *L. reticulata* in Ayurveda. Its name in Siddha medicine is Keerippaalai. As shown in **Table 2**, *L. reticulata* is also known by several other local names in India. [25,26]

Table 2: Vernacular names of *L. reticulata*

Language	Vernacular Name
Sanskrit	Jivaniya, Jivanti, Jivapushpa, Jivana, Hemavati, Payaswini, Shakashreshtha, Madhusrava and Maangalya
Hindi	Dori
Bengali	Bhadjivai
English	Jiwanti or Jeevanti
Tamil	Palaikkodi
Telegu	Kalasa
Kannada	Hiriyahalle
Marathi	Haranvel, Hiranvel

Gujarati	Dori, Methidodi, Dodi Saagi/Dodi Saka.

2.2. Origin and distribution

Although the natural origin of *L. reticulata* has not yet been discovered, its depiction in the Atharvaveda, the earliest Hindu text, suggests that it most likely came from India. At a maximum elevation of 2000 m, it is believed to be found chiefly in Rajasthan, Punjab, Gujarat, the Himalayan ranges, Sikkim, the Khasi Hills, the Deccan Plateau, the Konkan mountains, Kerala, and Karnataka in India[25,27]. The Subtropical and tropical regions of Africa, Nepal, Burma, Sri Lanka, the Malay Peninsula, Phillippines, Cambodia, Madagascar, and Mauritius are all claimed to have it in addition to India [28]. Locals in Kathiawar and Gujarat use This plant as a cooking herb [23]. In Tarafdar, Panwar [29] and 12 districts of Western Rajasthan (Indian Thar Desert) reported finding *L.reticulata* following an extensive field survey. Moreover, this species was discovered on hillsides, open woodlands, and hedges [30]. In some regions of India, it is commercially grown due to its great demand [27].

2.3. Morphology

The morphology of different parts of *L. reticulata* is reported in Table 3 [23,26,27,30].

Table 3: Morphology of different parts of *L. reticulata*

Plant Part	Description
Stem	Younger stems are greenish pubescent, whereas mature stems are light yellowish with severely fractured barks.
Leave	The leaves are simple, opposite, oval or ovate-oblong (3-9 cm 1.1 cm), cordate, large (4-7.5 cm long and 2-5 cm broad), and finely glabrous over.
Petioles	Petioles can reach a length of 2.5 cm.
Flower	The plant produces many blooms (up to 270 blossoms per plant), and it takes 25–28 days for all flower buds to emerge fully. With lateral or sub-auxiliary umbellate cymes, the flower is yellowish.
Anthesis	Flowers bloom for 4 to 5 days, and peak anthesis is noted between 9:00 and 9:30 in the morning. On the fourth day, when the blooms are almost at the point of withering, another dehiscence occurs between 11:00 and 1:00 p.m.

Flowering period	Flowers bloom between July and October, and fruits ripen between September and December.
Calyx	Sub-acute, five-lobed, ovated, silky lobes with tiny hairs over the surface.
Corolla	Small tubes with rotated pubescent tissue
Stamens	Five stamens unite with the stigmatic head to produce the gynostegium, a five-angled disc attached to the corolla tube's ground. There are no membrane appendages on the anthers. On the outer edge of the stigma, the pollen grains are organized.
Ovary	Bicarpellary ovary.
Fruit	Fruit is sub-woody, follicular, turgid, and green-colored, measuring 6.3 to 9 cm in length and tapering. Fruits might have up to 448 seeds and reach maturity in 102-158 days.
Seed	The seeds are ovate-oblong and taper to a diameter of around 6 mm.
Root	The roots have ridges and furrows along the length of them and are rough and white. The cylindrical, erratically twisted roots have longitudinal ridges. Root length might vary by up to one meter or more.

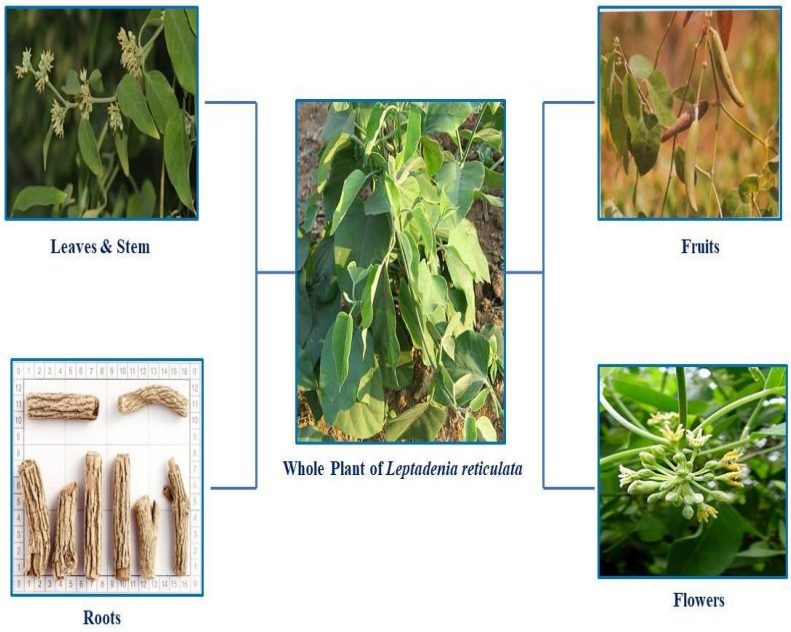

Figure. No.1: Parts of *L. reticulata*

2.4. Phytochemistry of *L. reticulata*

It is acknowledged that medicinal plants are suppliers of a diverse spectrum of bioactive chemical substances. The vast chemical variety inside each plant attracts the pharmaceutical industry's interest and has prompted the creation of several novel medications. According to our literature review, *L. reticulata* has a complex chemical profile with 46 chemical components, including phytosterols, terpenoids, pregnane glycosides, fatty acids, phenolic acid, flavonoids, and other chemical components. The main chemical components are depicted in the following tables.

Table 4: Main Phytochemical constituents of *L. reticulata* classified according to their chemical class

Phytosterols Found in *L. reticulata*
β-sitosterol
Stigmasterol
Terpenes & Terpenoids Found in *L. reticulata*
α-amyrin
β-amyrin
Lupeol
Simiarenol
Phytol
Pregnane Glycoside Found in *L. reticulata*
Reticulin
Deniculatin
Leptaculatin
Fatty Acids Found in *L. reticulata*
n-Hexadecanoic acid
3-Hydroxy-4 methoxybenzoic acid
Dodecanoic acid
6-Octadecanoic acid
Pentadecanoic acid
Tetradecanoic acid
Phenolic Acid & Flavonoids Found in *L. reticulata*
Apigenin
Diosmetin

Rutin
Luteolin
Quercetin
Iso-Quercetin
p-Coumaric acid
2H-Pyran, 6-heptyltetrahydro-2,2-dimethoxy
4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl.

The isolation, characterization, and comprehension of the therapeutic importance of certain lead molecules of *L. reticulata* have recently attracted the attention of phytochemists and biologists. Different plant sections have different phytochemical compositions and bioactive components. Moreover, several variables, including geographical conditions, meteorological conditions, growth patterns, and harvesting time, affect how biochemical components accumulate in plants [15,16]. Moreover, different plant component compositions may emerge from applying different extraction techniques. A limited number of investigations have been done on identifying, isolating, and characterizing specific phytocompounds from *L. reticulata*. Numerous chemical component classes, including terpenoids, phenolics, flavonoids, steroids, and esters, have been found in *L. reticulata*.

The aerial portions of *L. reticulata* include alkaloids, tannins, sterols, terpenoids, saponins, carbohydrates, glycosides, and flavonoids, according to preliminary qualitative tests [31-33]. Researchers have also documented glycosides, carbohydrates, flavonoids, phytosterols, tannins, saponins, free catechols, starches, and phenolic substances in various solvent extracts of *L. reticulata* stems. A flavone that occurs as a C-glycoside has also been discovered in this plant. It has also been demonstrated that *L. reticulata* cells produced in vitro contain reducing sugars, alkaloids, tannins, steroids, flavonoids, and glycosides. [34-40].

Many pharmacologically active substances, including triterpenoids, leptadenol, n-tricontane, cetyl alcohol, β-sitosterol, α-amyrin acetate, lupanol 3-O diglucoside, leptidin, luteolin, diosmetin, stigmasterol, and l α-tocopherol, have been discovered to be abundant in *L. reticulata*. This plant is one of the primary constituents in more than 23 commercially available medicines. [11,26,40]

2.5. Pharmacological usage of *L. reticulata*

In the context of the plant's significance in Ayurveda, research has been done to ascertain its pharmacological characteristics. It has been discovered that *Leptadenia reticulata* has the following pharmacological properties.

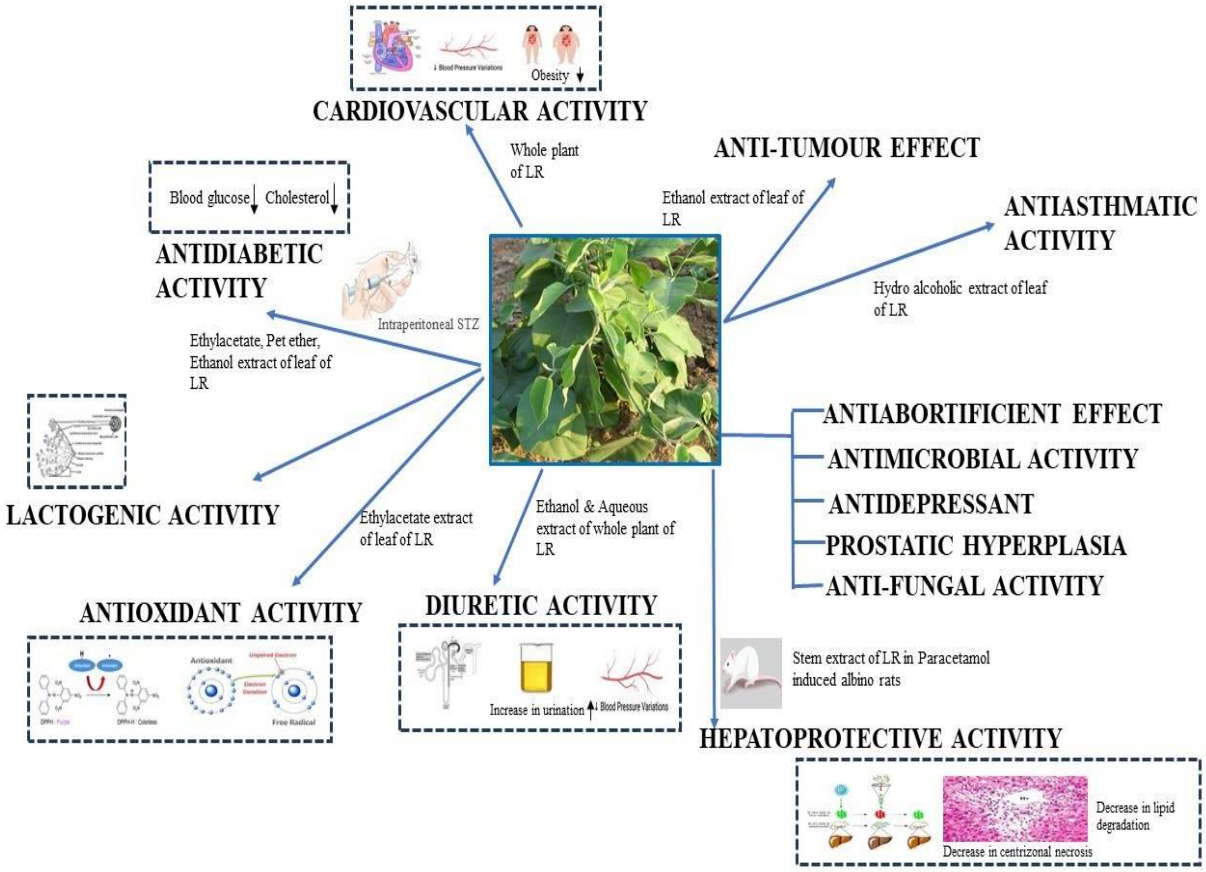

Figure. No. 2: Pharmacological Activities reported from different parts of *L. reticulata*

2.5.1. Anti-diabetic activity

Streptozotocin induced diabetes in Wistar rats. *Leptadenia reticulata* leaf extracts in ethyl acetate, petroleum ether, and ethanol were given orally at 200 mgkg(-1), po. Metformin (50 mg kg(-1), p.o.) was given as the conventional anti-diabetic medication. When the extract with the highest anti-diabetic activity was subjected to column chromatography, an active fraction with the facetious name Lr-1 was isolated. Lr-1 (100 mg kg(-1), p.o.) was investigated for its potential to lower blood sugar and cholesterol. In diabetic rats, it was discovered that the ethanol extract considerably ($P < 0.05$) reduced the FBG level [41].

2.5.2. Anti-abortificient effect

New moms who experience inadequate or absent breast milk might benefit from *L. reticulata* extract (Leptaden tablet). This medication helps treat recurrent abortions and has a

galactagogue effect. According to experimental studies employing radioimmunoassay on guinea pigs, Leptaden prevents the production of F2 alpha. As an increase in prostaglandins promotes abortion or preterm labor, this aids in preventing both. Leptaden therapy has a higher positive impact than a progesterone treatment combination. It has also been determined that Leptaden treatment alone effectively managed threatening abortion [42].

2.5.3. Anti-tumour effect

Swiss Albino mice were used to test the efficacy of the ethanolic extract of *Leptadenia reticulata* leaves (LELR) against Dalton's Ascitic Lymphoma (DAL). (106 cells) DAL cells were intraperitoneally administered to the animals. Animals were given 200 mg/kg of LELR daily for eight days, starting two days after cell injection. The reference medication was five-fluorouracil (20 mg/kg). On day 11, hematological parameters, packed cell volume, cancer cell number, the mice's tumor weight, and their increased lifespan were assessed and compared to the identical parameters in the control group. After therapy with LELR, the tumor-induced mice's lifespan significantly increased, and fewer cancer cells and tumor masses were found [43].

2.5.4. Anti-ulcer activity

Rats were used to assess the antiulcer efficacy of *L. reticulata*'s aqueous leaf extract (100 mg kg-1 and 200 mg kg-1). Compared to control animals, the results showed a substantial decrease in total acidity, ulcer index, and acid volume, indicating the potential of *L. reticulata* leaves to treat ulcers [44].

2.5.5. Diuretic activity

Water and ethanolic extracts of the entire plant of *Leptadenia reticulata* were tested on normal rats for their diuretic properties. Experimental rats were given oral dosages of 100 mg/kg p.o. of ethanolic and aqueous *Leptadenia reticulata* extracts in entire plants. The trial used furosemide (100 mg/kg) as a positive control. The amount of sodium, chloride, and potassium in the urine and its volume were all measured to assess the extract's diuretic properties. Both ethanolic and water extract considerably increased urine volume compared to the control group; however, this impact was less pronounced than furosemide. In both the treatment and control groups, there was a significant increase in the renal elimination of sodium, chloride, and potassium ions [45].

2.5.6. Hepatoprotective activity

On paracetamol-induced liver injury in albino rats, *Leptadenia reticulata* stem extracts were tested for their hepatoprotective properties.500 mg/kg, p.o. Paracetamol in 1% CMC caused liver injury. The experimental rats were given 100 mg/kg, and 200 mg/kg of ethanolic and aqueous extracts of *Leptadenia reticulata* stems orally each day for seven days. The reference medication was Liv-52 syrup (2mL/100g). Serum glutamic pyruvic transaminase (SGPT), alkaline phosphatase (ALP), and serum glutamic oxaloacetic transaminase (SGOT) were significantly reduced, demonstrating the ethanolic extract's hepatoprotective activity. Comparing animals receiving various dosages of *L. reticulata* and paracetamol to the control group in histopathological examinations revealed a significant decrease in lipid degradation and centrizonal necrosis. Significant hepatoprotective action was seen in the ethanolic extract, and the extract's effectiveness was virtually on par with that of a typical medication [46].

2.5.7. Anti-oxidant activity

A significant free radical scavenging activity towards diphenylpicrylhydrazyl (DPPH), hydroxyl, and nitric oxide radicals was discovered in an in vitro antioxidant investigation of *L. reticulata*'s methanolic extract. Rodents were used to study the leaf extract of *L. reticulata*'s antioxidant properties. They discovered a considerable rise in the antioxidant enzymes catalase and superoxide dismutase (SOD), indicating the substance's antioxidant potential. The ethyl acetate extract of *L. reticulata*, which had an IC50 value of 267.13 g/mL, was found to have the highest antioxidant potential, next to the methanolic extract of *L. reticulata*, which had an IC50 value of 510.15 g/mL. Similar to this, FeCl3 reduction and hydrogen peroxide scavenging methods both found that the extract of ethyl acetate of *L. reticulata* had the highest antioxidant capacity, with IC50 values of 234.1 and 406.4 g/mL, respectively [47,48].

2.5.8. Anti-fungal activity

The methanolic extract of aerial portions of *L. reticulata* contains flavonoids and tannins, which have potential antimicrobial properties against all chosen pathogens [49].

2.5.9. Anti-microbial activity

The antibacterial efficacy of several solvent-based extracts of *L. reticulata* leaves against 5 Gram-positive, and three fungal strains was investigated by Vaghasiya and Chanda. They noticed that none of the investigated Gram-positive bacterial strains were susceptible to acetone extract. However, it successfully suppressed two strains of Proteus mirabilis, Klebsiella pneumoniae and Citrobacter freundii, all of which are Gram-negative. While Klebsiella pneumoniae and Proteus mirabilis were Gram-negative strains, Staphylococcus aureus and S. epidermidis were Gram-positive strains, and the methanol extract was efficient against both types of bacteria [50,51].

2.5.10. Lactogenic activity

L. reticulata is additionally used in medications to help women produce more milk. Jivanti contains the active ingredient stigmasterol. As determined by the protein and glycogen content of the mammary glands, photomicrographic analysis, and secretory evaluation of lactating mammary glands, stigmasterol exhibited lactogenic capabilities. Without affecting the makeup of milk or blood, it caused a sizable galactopoietic reaction [52].

2.5.11. Anti-asthmatic activity

Leptadenia reticulata (Retz) Wight &Arn leaf hydroalcoholic extract (LRLHE) was tested for its ability to treat asthma. A rat ileum preparation, tracheal chain, Guinea pig ileum, compound 48/80-induced mast cell degranulation, passive cutaneous anaphylaxis, and HPTLC analysis of the extract's isolated sapogenin fraction against ß-sitosterol as a standard marker were all used in the evaluation. With dosages of 100, 200, and 300 mg/kg b.w. in rats, LRLHE displayed a considerable ($P<0.05$, $P<0.01$) anti-asthmatic effect, and it significantly inhibited the contractions of smooth muscle preparations caused by acetylcholine and histamine. ß-Sitosterol was present in the plant's separated sapogenin fraction. According to the study's findings, LRLHE may have anti-asthmatic efficacy in various animal models and indicate potential in the treatment of asthma [53].

2.5.12. Anti-depressant

One of the key ingredients in the composition of the antidepressant medicine Malkanguni is *Leptadenia reticulata*[Whole Plant]. Acorns calamus, *Celatsruspaniculata*, and *Nardostachysjatamansi* are also components of Malkanguni. The medication works well to

treat depression without causing any adverse effects and significantly improves bacterial growth [54].

2.5.13. Cardiovascular activity

Research was carried out to investigate the wide range of medicinal herbs utilized in Ayurveda to treat heart disorders, obesity, or inflammation. One plant used to treat heart disease and lower blood pressure is *Leptadenia reticulata*[Whole Plant]. According to Ayurveda principles, this herb was utilized for the care of CVS problems depending on the individual etiology of the patient [55].

2.5.14. Prostatic hyperplasia

In a randomized controlled study, the effectiveness of Speman, a locally produced Ayurvedic remedy, was examined. One of the ingredients of Speman is an Ayurvedic remedy that uses entire plants without roots of *Leptadenia reticulata*. The study comprised 10 controls, 40 trial cases, and a pool of 50 patients with benign prostate enlargement (BEP). Evaluation of symptom rating indicated a statistically significant advantage ($p<0.001$) for the Speman group compared to the placebo-treated controls. A statistically significant increase in corrected Qmax ($p<0.01$), void volume ($p<0.05$), and mean flow rate ($p<0.01$) was seen on the uroflowmetric examination. Substantially, the voiding time was not influenced. Although the prostate's size was reduced when it was evaluated subjectively (by digital inspection), an objective measurement (through ultrasound) did not reveal a statistically significant change in size. It was determined that Speman relieves symptoms by restoring the micturition dynamics altered in BEP [56].

3. ETHNOPHARMACOLOGY OF *L. RETICULATA*

In its native lands of Asia, the various organs of *L. reticulata* are historically used to treat human and animal illnesses. **Table 5** thoroughly displays the ailments that have been treated and the plant's used components and route administration.

Table 5: List of ethnopharmacological activities reported from different parts of *L. reticulata*

SL. No.	Activity	Part used	Route of Administration	References
1.	Diabetic	Leaf and stem	Oral	[57]

		extract		
2.	Analgesic	Roots and stem	Oral& Topical	[58]
3.	Anti-inflammatory	Roots and stem	Topical& Oral	[58]
4.	Wound healing	Roots	Topical	[59]
5.	Anticancer	Stem bark	Oral	[60]
6.	Immunomodulatory	Leaf	Oral	[61]
7.	Antioxidant	Leaf	Oral	[61]
8.	Hepatoprotective	Stem	Oral	[62]
9.	Antibacterial	Stem, leaves, and roots	Oral and parenteral	[63]
10.	Anti-asthmatic	Leaf	Oral	[64]

4. MARKETED PRODUCTS OF *L. RETICULATA*

The marketed products that use *L. reticulata* as a critical component in their formulation and preparations have been enlisted in **Table 6**.

Table 6: List of marketed formulations in which *L. reticulata* is used as the principal ingredient

SL. No:	Marketed Product	Manufactured by	Therapeutic class	Composition
1.	RattiJivantichurna Powder	SGAV LTD	Treat Blood pressure, bacterial infection, and fungal infection	Jivantichurna Powder
2.	Jivanti extract tablets	Yash Remedies	Help's the lactating mother, Treats eye disorders, and is used as a general tonic.	Each tablet contains extract derived from Jivanti 350 mg.
3.	Gauri herbal	Gauri	It is an organic	-

	Leptadenia reticulata extract tablets	Ayurvedic	multipurpose remedy extract product	
4.	Jivanti Capsules	Chakrapani Ayurveda	Used in colitis and used as cardiotonic	The capsule containing the powder of roots, leaves, fruit, flower, and whole plant of *Leptadenia reticulata*
5.	JivantiChurna	Planet Ayurveda	Used to Maintain a healthy eye, Balance all three dosha vata, pitta, and Kapha also help's the lactating mother.	Jivanti roots
6.	Jivanti *L. reticulata* extract powder cold and cough 5000 mg capsules	Amalth	Supplement	Jivanti extract, Brown rice flour, Capsule [HPMC]
7.	XetomosJivanti essential oil 30 ml	Xetomos	Aromatherapy	-
8.	Joyveda male infertility supplement	Joyveda	Male infertility	Viddhadaru (*Argyreia speciosa*); Gokshuru (*Tribulus terrestris*); Jeevanti (*Leptadenia reticulata*); Shailyeam(*Parmeliaperlata*); Ashwagandha (*Withaniasomnifera*); Kokilaksha (*Astercantha longifolia*); Vanya

				(*Lactucaserriola*); Kapikacchu (*Mucuna pruriens*); Salam Panja (*Eulophia campestris*); Bala (*Sida cordifolia*); Ginseng Extract; Maca Root Extract; Chopchini (*Smilax china*)
9.	Himalaya confide tablets	Himalaya	Immunomodulatory	Extracts of *Argyreia speciosa*; *Tribulus terrestris*; *Leptadenia reticulata*.

5. PATENTS OF *L. RETICULATA*

Several patents about their production, biological characteristics, etc., have recently been published. Here is a succinct summary of the patents and findings of *L. reticulata* (Table 6). In the year 2011, Hashimoto Hitoshi, Tani koji, Yamashita ritsuro, and Ayusawamasaru gave agents that promote melanin production as per their discovery that the substance that encourages the production of melanin contains, as an active ingredient, an extract of at least one plant chosen from the *Ficus benghalensis*, *Momordica charantia*, *Leptadenia reticulata*, *Mimusopselengi*, *Areca catechu*, *Santalum album*, *Acorus calamus*, *Myristica fragrans*, *Beriberisaristata*, and *Vetiveriazizanoides* groups. In contrast, in 2015, Jyotsna Singh, Vandana Bajpai, Ritu Saxena, and Bhupendra Singh gave the Process for preparing an extract from *Leptadenia reticulata* and its use for cancer treatment. In another study, the inventor discloses Methods for improving milk letting down in Milch Animals. This invention by Patil Prashanth Neminath relates to herbal compositions that increase lactation in farm animals by containing a sufficient quantity of an extract and a minimum of one bioactive fraction or powder from herbs like asparagus, gossypium, foeniculum, lepidium, chlorophytum, ipomoea, withania, and leptadenia, as well as optionally dicalcium phosphate, chelated minerals, and mineral mixtures. Recently one of the studies by Dinesh Sharma, Rakesh

Shukla, and Alok Kumar Tripathi discloses the Herbal composition for treating cardiovascular disorders containing *Leptadenia reticulata* and the preparation method.

Table 7: Patents of *L. reticulata*

SL.NO.	Title	Inventor	Patent Number	Year
1.	Melanin Producing-promoting agent	Hashimoto Hitoshi, Tani koji, Yamashita ritsuro, Ayusawamasaru	JP201157317A	2011
2.	Methods for improving milk letting down in Milch Animals	Patil Prashanth Neminath	US2015017268A1	2015
3.	Process for the preparation of an extract from *Leptadenia reticulata* and its use for the treatment of cancer	Singh, Jyotsna; Bajpai, Vandana; Saxena, Ritu; and Singh, Bhupendra	US20150267116A1	2015
4.	Composition and method for treating diabetes using *Leptadenia reticulata* extract and Gymnema sylvestre extract	Dharmalingam, Sivakumar; Suresh, Rangasamy; and Duraipandiyan, Veeramuthu	US20160351616A1	2016
5.	Anti-diabetic composition containing *Leptadenia reticulata* and	Anand, Reema; and Gupta, Anil Kumar	IN2019CH02493A	2019

	method for its preparation			
6.	Novel herbal composition for the treatment of liver diseases containing *Leptadenia reticulata*	Sahu, Dinesh Kumar; Sahu, Madhusmita; and Satapathy, Mridula	IN201911013621	2019
7.	Herbal composition for treating cardiovascular disorders containing *Leptadenia reticulata* and method of preparation thereof	Sharma, Dinesh; Shukla, Rakesh; and Tripathi, Alok Kumar	IN2022CH00349A	2022

6. ADULTERATION OF *L. RETICULATA*

The paucity of planting materials, the small culture base, and the rising demand for *L. reticulata* herbal products on a global scale have all recently grown significantly. As a result, dealers are undoubtedly motivated to produce numerous imposters and substitutes for *L. reticulata* dry herb in the marketplace. Quality materials must be authenticated to maintain the herbal businesses and ensure that patients receive the most benefits from the herbal products. No established techniques exist to recognize and distinguish *L. reticulata* from potential raw powdered herbal ingredients. As the Leptadenia genus shares similarities with other similar species, it is particularly challenging to distinguish between groups based on morphological or anatomical characteristics. As a result, it is frequently mistaken for different plant species and is hence vulnerable to adulteration in Indian marketplaces by other low-cost plant powdered materials. *L. reticulata* is frequently contaminated with a variety of different plants, including *Cimicifuga foetida*, *Holostemmaada-kodien*, *Ichnocarpus frutescens*, *Dendrobium ovatum*, *D. macraei*, and *Flickingeriamacraei***.** Rutin, dl-tocopherol acetate, and stigmasterol contents in *L. reticulata* leaves were estimated using a sensitive

HPTLC approach**.** Researchers have proposed that it can be a marker for accurately identifying *L. reticulata* for routine quality analysis [65,66].

7. TOXICITY STUDIES OF *L. RETICULATA*

Ayurvedic medicines are said to have fewer adverse effects than allopathic ones. Medicinal plants' toxicity must be assessed to ensure the safety of these plants and preparations [67]. A study examined the acute oral toxicity of several *Leptadenia reticulata* plant extracts. Swiss mice were used to test the acute toxicity of methanol, petroleum ether, and *Leptadenia reticulata* aqueous extracts. Studies on acute toxicity were conducted by OECD Directive 423. Each extract was given orally to the animals at 100, 250, 500, 750, 1000, and 2000 mg/kg body weight. Following dosing of the extract for fourteen days after 1, 4, and 24 hours, the indications of toxicity and death were observed. The test animals' overall behavior did not alter, or they died at the maximum dose (2000 mg/kg body weight) [68]. These findings demonstrate the beneficial effects of oral administration of *Leptadenia reticulata* aqueous, petroleum ether, and methanol extract. While in another investigation, the toxicity of isolated *Leptadenia reticulata* chemical substances was assessed by OECD recommendations. A 1/10th dosage was administered for pharmacological screening in an animal model (Abortifacient and anti-implantation action.), and the dose was defined as acute toxicity. By making the vaginal smears, the stages of the estrous cycle were tracked throughout the toxicity trial. As a result, it was found that in terms of hematology, *Leptadenia reticulata* isolated compounds were not toxic and Histopathological studies revealed that *Leptadenia reticulata* isolated compound did not cause any noticeable alterations to the uterus or the ovary [69]. A study revealed that the stems of *Leptadenia reticulata* (Retz.) Wight and Arn. have hepatoprotective effects against rats with liver toxicity from carbon tetrachloride (CCl4). 1.25 ml/kg of the toxin CCl4 was administered to cause hepatotoxicity in a 1:1 combination with olive oil. *L. reticulata* stem aqueous and ethanolic extracts were given orally for seven days at 250 and 500 mg/kg/day. Silymarin was used as the usual medication (50 mg/kg). These extracts' ability to preserve the liver was assessed using biochemical markers such as blood levels of the enzyme's glutamic pyruvic transaminase, glutamic oxaloacetic transaminase, total bilirubin, alkaline phosphatase, serum protein, and liver histological examinations. As a result, the architecture of the liver was restored, decreased levels of blood bilirubin and protein when compared to the standard and silymarin-treated groups were observed, and treatment of rats with ethanolic and aqueous extracts

considerably reduced liver toxicity and the signs of liver injury. The liver histology revealed regular hepatic cords, no necrosis, and no fatty infiltration, proving that the extracts avoided hepatic toxicity brought on by CCl4 [70].

8. CONCLUSION AND FUTURE SCOPE

The scientific information on the botanical, phytochemistry, Pharmacological, Ethnopharmacological, Marketed, and patent aspects of *L. reticulata* is documented in this review. This multipurpose herb can be employed in modern therapeutic procedures to treat a variety of human maladies since it has numerous potential medicinal properties. *L. reticulata* can be the primary ingredient in many herbal preparations attributed to its renewing, reviving, and lactogenic qualities. Due to overexploitation, unresearched harvesting, and habitat degradation, *L. reticulata* is an endangered, vulnerable plant. Future studies should thus concentrate on its conservation-related elements. The in vitro generation of bioactive chemicals from *L. reticulata* will be supplemented by cutting-edge methods such as genetic engineering, cell culture, and bioreactors. Although the biological characteristics of *L. reticulata* are well recognized, most research only used crude extracts and a small number of pure isolated components. Additionally, many physiologically active chemicals have yet to be discovered. The majority of the phytochemicals listed as components of the named plant are familiar to plants and are not incredibly unique to *L. reticulata*. Which of them are likely to be held accountable for the numerous biological processes outlined must be determined in additional, in-depth research. Significant research is needed in plant identification, isolation, extraction, and characterization of other physiologically active chemicals from this herb to translate its traditional applications into evidence-based human use. More toxicity studies and clinical investigations must be encouraged to ensure the efficacy of this herbal remedy for human usage. Quality control procedures must be established to prevent potential erroneous or adulteration of *L. reticulata* with other plant components. This review highlights the pharmacological, ethnopharmacology, toxicity study, botanical, and phytochemical aspects of *L. reticulata*.

DECLARATION OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

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