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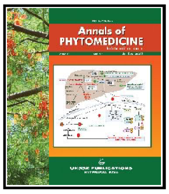

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A pharmacognostic and phytopharmacological study of *Salacia reticulata* (W.) root

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Abstract

Plants are considered the base for curing illnesses in Ayurvedic medicine. Ancient sages recorded many of them in treating various illnesses. Many medications are mentioned in Ayurvedic treatises and Ayurveda lexicons (Nighantus), *Salacia reticulata* (W.), being one of them. It was well known as "Ekanayagam" in Kerala's traditional medical system, and texts like Yogamritam, Shasrayogam, Cikitsamangari, *etc*., have extensively referenced it in the treatment of diabetes. The *S. reticulata*, *S. oblonga*, and *S. chinensis* species are collectively referred to as "Saptacakra" in Ayurveda. *S. reticulata* lacks a comprehensive pharmacological profile; hence its root was studied. Macroscopic characters have been recorded. Microscopically, the root bark contains reddish and yellowish materials, as well as starch granules, which give the root bark its yellowish hue. Additionally, it revealed a few stone cells in the root bark as well as prismatic calcium oxalate crystals. The primary identifying characteristic is the way phloem cells are arranged. Carbohydrates, phytosterols, phenolic compounds, flavonoids, and terpenoids are all present, according to the phytochemical analysis. The salacinol, kotalanol, mangiferin, and 13-MRT are the most common active components in Salacia. The individual component mangiferin has received the most research attention. Various recent studies have reported that it has an antihyperglycemic, alpha-glucosidase inhibitory effect, hypolipidemic, hepatoprotective, antimicrobial, antiproliferative, and antioxidant activity. A drawback is that because there are numerous active elements present, standardization is challenging.

1. Introduction

Herbal medicines are considerably popular as a source of primary healthcare in both developed and developing countries due to their qualities possessing a broad spectrum of biological and therapeutic activity, high safety margins, and lower prices (Priyanka *et al*., 2013). The Indian medical science, Ayurveda, which is currently enjoying a renaissance, is arguably the most comprehensive and sophisticated system of healthcare ever established. The World Health Organization expert committee advised more investigation of all the existing traditional methods of disease management, due to the high mortality and morbidity caused by the use of conventional medicines. Adulteration and substitution is the main problem faced by the traditional system of medicine, so standardization of different plant parts is more important. As per the recommendation of WHO, taxonomic, macroscopic, and microscopic morphological analysis (pharmacognostic techniques), palynological, anatomical, and phytochemical screening (both quantitative and qualitative), physicochemical analysis and fluorescence studies are important for the standardization of plant drugs (Geeta and Geeta, 2015).

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The drug *S. reticulata* is a traditional claim seen in Southern India, found abundantly in Kerala, which is used as a household remedy to control diabetes, skin disorders, and amenorrhoea. The mention of *S. reticulata* was not found in Vedas and ancient Ayurvedic literature, *viz*., *Brihattrayi*, *Laghutrayi*, and various Ayurveda lexicons expect *Nighantu Adarsh* (Vayida, 2018). *Sahasrayogam*, a book of compilation of Kerala folklore reclaims its importance and classical literature of Kerala has described *S. reticulata* in the treatment of *Prameha* (diabetes) in single or in combinations. It was well known as "*Ekanayagam*" in Kerala's traditional medical system, and texts like *Yogamritam, Shasrayogam, Cikitsamangari, etc*., have extensively referenced it in the management of diabetes. The primary component of formulations like *Niruyadigutika* (Nishteswar and Vidyanath, 2011a), *Nisakatakadikvatha,* and *Katakakhadiradi kvatha* is *Saptacakra* (*S. reticulata*) that are used in the treatment of diabetes (Nishteswar and Vidyanath, 2011b).

The vernacular names of *Saptacakra* (*S. reticulata*) are Saptarangi (Hindi), Ekanayakam (Malayalam), Pomkoradi (Tamil) and Ankudu chetu (Telugu). *Swarnamoola, Pitikamollam, Hemakorandakam, Mehari, Mehantaka,* and *Vairi* are synonyms of *S. reticulata* (Lucas, 2008).

The *S. reticulata*, *S. oblonga*, and S. *chinensis* species are collectively referred to as "*Saptacakra*" in Ayurveda (Prakash and Harini, 2021). There are 120 species in the Salacia genus, which is extensively spread in India, Sri Lanka, China, Indonesia, Vietnam, and other Asian nations. Botanically, *S. reticulata* belongs to the Hippocrataceae family (Hipprocratacae has been accepted as a distinct family of Celas-tracea). It is distributed throughout South India including the Andaman Islands; striving along riverbanks and seashores as well as in evergreen forests at altitudes up to 750 mts. A climbing perennial, woody shrub, the plant has dichotomous branching, the bark is smooth, greenish-grey, and thin and white internally. Leaves are opposite, coriaceous, ovate or obovate-oblong, reticulate, 6.5 - 9 cm x 4-5 cm. Flowers are bisexual and arranged as 2-8 clusters in the axils of the leaf. They are greenish white to greenish yellow. Calyx lobes are not fringed, lobes short entire. Petals are broad at the base, 0.4 cm long, thick. The ovary is enclosed in the disk. Anther cells dehiscing transversely. Fruits are large, tuberculate, bright pinkish orange, pulp mucilaginous and edible, and 1-4 seeds immersed in pulp (Varier, 1996).

Of all the *Salacia* species, *S. reticulata* is considered to be more potent and widely used in all countries like Sri Lanka, Japan, and the United States of America as an herbal supplement for type 2 diabetes. Considering the demand for *S. reticulata* a preliminary crude drug survey of the local market at Chennai and Kerala was also done. It is worth mentioning that, during survey it was found that *S. reticulata* is understood by drug dealers as *Kalinjar* and *Ekanayakam*. Large cut pieces of roots are sold in the market. These pieces were picked up from several places on the market and studied to identify the genuineness of the drug. During the survey, it was also found that the mixture of dried stems and root pieces of different plants which have yellow colour is sold in the market as *Saptacakra* (*S. reticulata*), hence its root was taken for study.

2. Material and Methods

2.1 Collection of plant material

The material drug *S. reticulata* roots picked for the study was acquired from the Chennai drug market (Shobhakanth & Co). Later examined for genuinity of drugs by identifying them with the original drugs available in the department and discussing with experts at the Department Post Graduate Studies in Dravyaguna, T.T.D's S.V. Ayurvedic College, Tirupati, and Department of Botany, S.V. University, Tirupati. After that, they were dried in the shade for one week cut into pieces and cleaned to remove any foreign material, and made into fine powder (Figures 3 and 4).

2.2 Pharmacognostical study

The pharmacognostical study of the trial drug *S. reticulata* was done at the Andhra Pradesh state level Drug Testing Laboratory, Hyderabad as per parameters for the identification process mentioned for macroscopic, microscopic, and standard physicochemical parameters in the Ayurvedic Pharmacopoeia of India (API).

2.3 Phytochemical study

S. reticulata roots were evaluated using various phytochemical tests as per API at the College of Pharmacy, Sree Vidhyanikethan, Tirupati. A review of chemical constituents isolated from *S. reticulata* was done.

2.4 Pharmacological activities

A review of pharmacological experiments in, animals, *in vitro,* and human studies of *S. reticulata* was done in PubMed.

Figure 1: *S. reticulata* plant.

Figure 2: Roots of *S. reticulata*.

Figure 3: Pulverizing the coarse powder in a pulverizer and sieving the powder.

Figure 4: Fine *S. reticulata* powder.

3. Results

3.1 Macroscopic and organoleptic parameters

The organoleptic study is the most common and simplest method for identification. Macroscopic and organoleptic parameters like shape, size, odour, colour, and taste were scientifically studied and results were presented in Table 1 (Anonymous 3, 1999).

3.2 Physicochemical analysis

Physicochemical parameters of like, foreign matter, moisture content, total ash, alcoholsoluble extractive (ASE) (Anonymous 2, 1999), and water-soluble extractive (WSE) (Anonymous 1, 1999) were determined. The results are presented in Table 2.

Table 1: Macroscopic and organoleptic properties of *S. reticulata*

Character	Root	Root powder
Shape	Cylindrical	Fine powder
Size	L-32-34 cmW- 6.5-7.5 cm	Fine powder
Colour	Externally yellowish bark; internally bark is dark brown	Light brown colour powder
Odour	Not specific	Not specific
Taste	Astringent	Astringent
Fracture	Root very hard and woody; Bark brittle	Fine powder

Table 2: Physicochemical parameters of *S. reticulata*

S. No.	parameters	Results	Units of measurement
1	Foreign matter	Nil	%
2	Moisture content	9.13	%
3	Total ash	4.45	%
4	Alcohol soluble extractive (ASE)	9.74	%
5	Water soluble extractive (WSE)	7.57	%

3.3 Microscopic characters of the *S. reticulata*

The transverse section of root bark shows 3 regions; namely, 1. Periderm, 2. Cortex, and 3. Phloem (Figure 5). Periderm is divided into 3 regions; namely, a. Cork, b. Phellogen, and c. Phelloderm.

Cork consists of externally 6-8 exfoliating layers of cork cells that are filled with dark green colour matter and highly suberised are present in this region. Phellogen is not specific and highly compressed and phelloderm shows thin walled parenchymatous cells (5-6 layers) filled with reddish and content are present in this region.

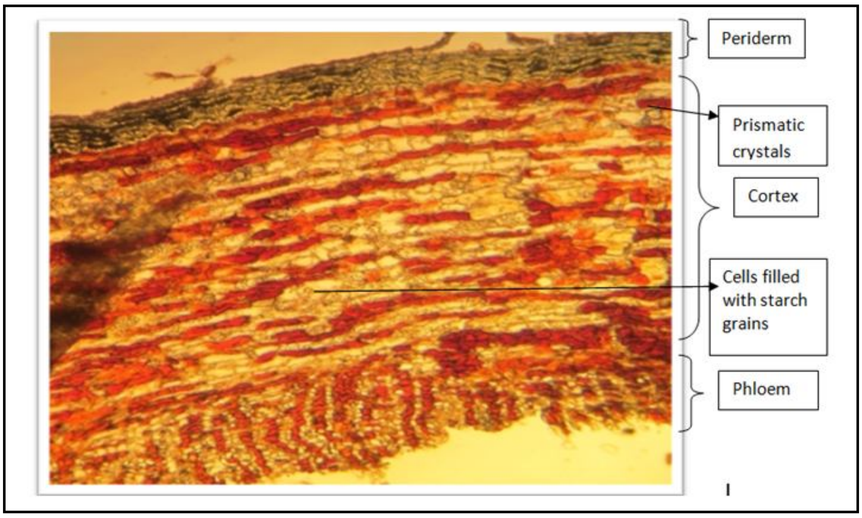


Figure 5: Transverse section of root bark of *S. reticulata*.

The cortex is composed of a wide area of thin-walled parenchymatous cells. Reddish or yellowish content is filled in most of the cells. Compound and simple starch grains are observed; some of the cells in this region have prismatic crystals of calcium oxalate; few stone cells with pitted walls are also observed in this region and phloem composed of thin-walled parenchymatous cells that are arranged loosely. Some of the cells are filled with reddish or yellowish matter and some are filled with starch grains; few cells have prismatic crystals of calcium oxalate.

3.4 Powder microscopy of the *S. reticulata* root

The powder microscopy of *S. reticulata* shows the presence of simple and compound starch grains (Figure 6). Simple starch grains are round, oval, and elliptical and parenchymatous cells are filled with starch grains. It also contains fragments of vessels with simple pitted, bordered pitted and scalariform thickenings (Figure 7); prismatic crystals of calcium oxalate; lignified fibers with oblique slit-like pits; thin-walled parenchymatous cells filled with yellowish and reddish colouring matter (Figure 8); thick-walled rectangular cells of cork filled with reddish content; few stone cells.

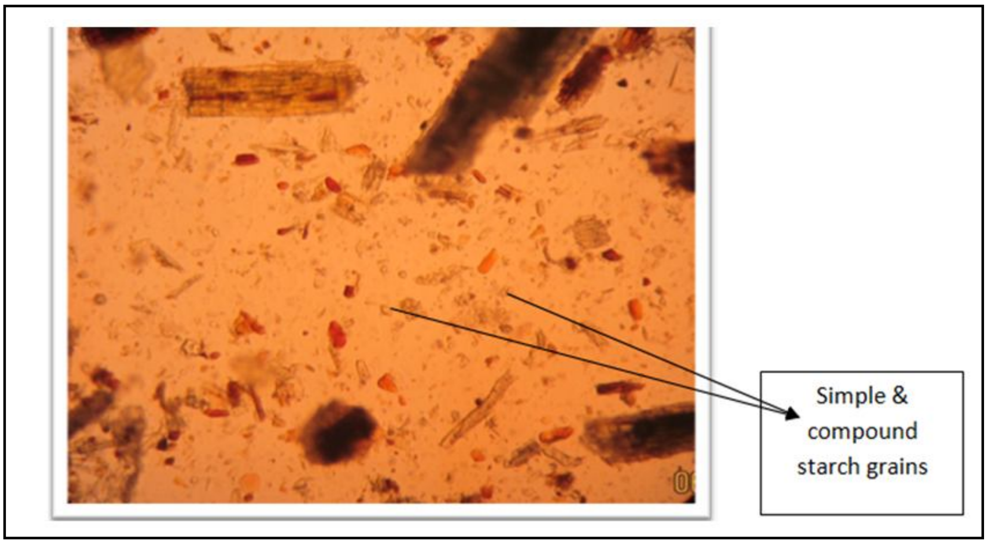


Figure 6: Powder microscopy of S. *reticulata* root showing starch grains.

Figure 7: Powder microscopy of *S. reticulata* root showing xylem vessels with pitted thickening.

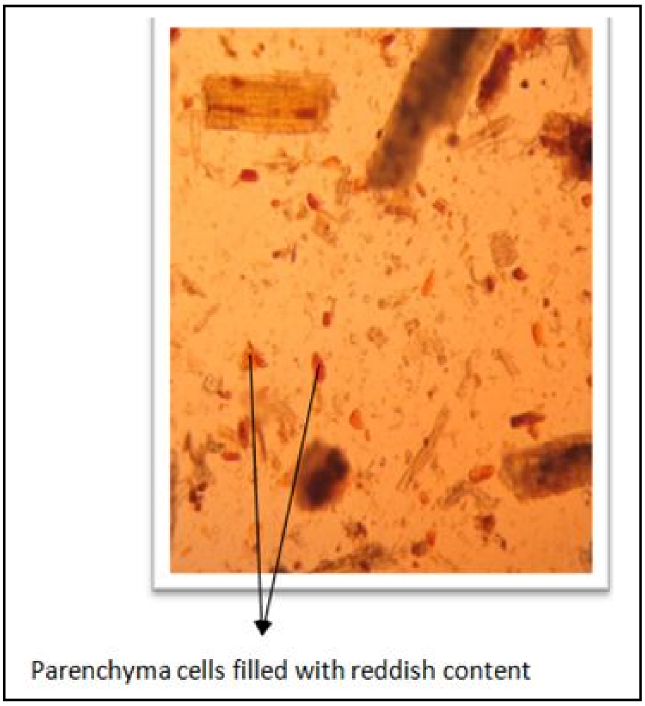


Figure 8: Powder microscopy of *S. reticulata* root showing parenchyma cells with reddish content.

3.5 Preliminary phytochemical analysis of the *S. reticulata*

Carbohydrates, phytosterols, phenolic compounds, flavonoids, and terpenoids are all present, according to the preliminary phytochemical analysis. The results of phytoconstituent analyses of *S. reticulata* are listed in Table 3.

Salacia contains a wide range of chemical compounds that can differ based on the species and region of origin (Yuhao *et al*., 2008). From roots and stem barks, many triterpenes, hydrocarbons, and sitosterol have been isolated (Mastuda *et al*., 2005). The major chemical constituents that present in the *S. reticulata are* present in Table 4.

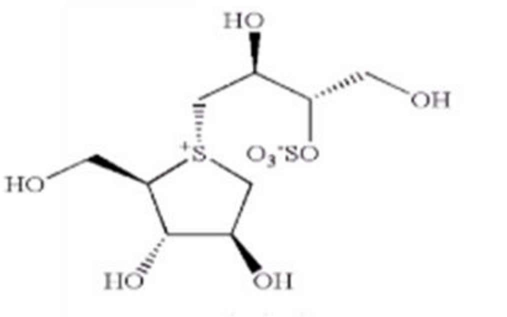
Table 3: Phytoconstituents of *S. reticulata*

S. No.	Name of test	Phytoconstituents	Result
1.	Dragendroff's test	Alkaloid	-
2.	Molisch's test	Carbohydrates	+
3.	Salkowaski test	Phytosterols	+
4.	Foam test	Saponins	-
5.	Braymer's test	Tannins and phenolic compounds	+
6.	Millon's test	Proteins and free amino acids	-
7.	NaOH test	Flavonoids	+
8.	Liebermann's test	Terpenoids	+
9.	Killer-Killiani test	Glycosides	-

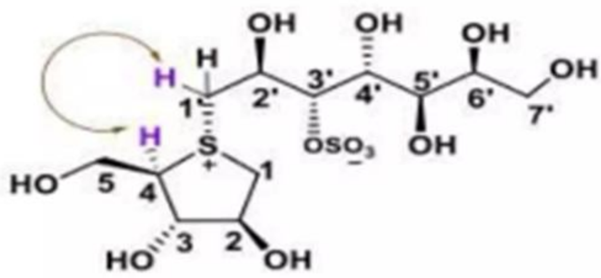
(+) indicate present (-) indicate absent

Table 4: The chemical constituents of *S. reticulata*

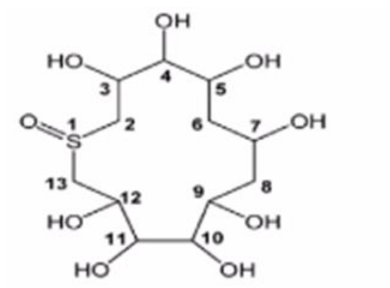
Chemical responsible for the hypoglycemic effect	Mangiferin ($C_{19}H_{18}O_{11}$) was isolated from from roots Kotalanol ($C_{12}H_{24}O_{12}S_2^+$) and salacinol ($C_9H_{18}O_9S_2^+$) were isolated from the stem and roots 13-membred ring thiocyclitol (13-MRT) isolated from aqueous extract	Yoshikawa *et al*., 2001 Yoshikawa *et al.* 1997, 1998 Hiromi, 2008 Oe and Ozaki, 2008
Other chemicals from roots	Triterpenes, 1,3-diketones, dulcitol, leucopelargonidin, epicatechin, 30-hydroxy-20 (30) dihydroisoiguesterin, hydroxyferruginol, lambertic acid, kotalagenin 16-acetate, 26-hydroxy-1,3-friedelanedione, and maytenfolic acid	Premakumara *et al.,* 1992; Tissera and Thabrew 2001; Yoshikawa *et al*., 1997, 1998



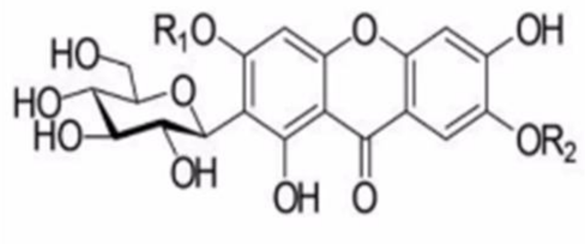
Salacinol



Kotalanol



13-MRT



Mangiferin

Figure 9: Chemical structure of the four important antidiabetic chemical constituents isolated from *S. reticulata*.

Table 5: Pharmacological activities of *S. reticulata*

References	Parameters examined	Plant species	Compound used	Model
Shivaprasad *et al.,* 2013	Glucose lowering, LDL	*S. reticulata*	Root extract	Human
Radha and Amrithaveni, 2009	Glucose lowering, LDL, HDL, HBA1c, Triglyceride, Cholesrol	*S. reticulata*	Bark	Human
Oe and Ozaki, 2008	Glucose lowering	*S. reticulata*	Extract	Human
Jayawardena *et al.*, 2005	Glucose lowering	*S. reticulata*	Extract	Human
Ruvin Kumara *et al.,* 2005	Hypoglycemic effect	*S. reticulata*	Extract of root bark	Rats
Giron *et al.*, 2009	Lowering blood glucose levels	*S. oblonga*	Various extracts of root and bark	Rats
Yoshino *et al.,* 2009	Anti diabetic activity	*S. reticulata*	Aqueous extract of the leaves	Mice
Shimada *et al.,* 2010; 2014	Anti obesity effects and safety	*S. reticulata*	Aqueous extract	Mice
Karunanayake *et al.,*1984	Lipid metabolism	*S. reticulata*	Extract	Rat and mice
Yoshikawa *et al.*, 2002a	lipase inhibitory	*S. reticulata*	Aqueous extract	Rats
Yokotani *et al.*, 2013	Hepatic cytochrome P450 activity *in vivo* in mice and in liver microsomes *in vitro*	*S. reticulata*	Aqueous extract	Mice
Yoshikawa *et al.,* 2002b	Antioxidant, chemoprotective and antiproliferative effects	*S. reticulata*	Extracts and mangiferin	Rats
Suwannalert *et al.*, 2014	Inhibition of melanin synthesis and antioxidant activity	*S. reticulata*	Root extract	*In vivo* studies UV irradiated or MSH induced B16 melanoma cells
Chandrashekar *et al.,* 2009	Free radical scavenging activity	*S. reticulata*	Various extracts	Rats
Muruganandan *et al.*, 2005b	Immunoprotective role	*S. reticulata*	Mangiferin	Rats

3.6 Pharmacological activities

A review of pharmacological experiments both in humans, and animals and *in vitro* studies of *S. reticulata* was done in PubMed. Some important observations are presented in Table 5.

3.6.1 Alpha-glucosidase inhibitory effect

The primary mechanism underlying its hypoglycaemic activity has been found to inhibit of postprandial glucose alpha-glucosidase inhibitory effect (Mastuda *et al*., 2005). Within the small intestine, the intestinal enzymes alpha-glucosidase and alpha-amylase convert starches, dextrins, maltose, and sucrose into easily absorbed monosaccharides. The inhibition of these enzymes would slow down the absorption of glucose and assist diabetics in avoiding postprandial glucose spikes. Alpha-glucosidase inhibitors like acarbose are currently being used in clinical settings using this method (Derosa, 2012). Therefore, it would be expected that *S. reticulata* extracts would inhibit the digestion of poly and oligosaccharides, thereby reducing postprandial hyperglycemia and hyperinsulinemia. It has been demonstrated that the maltose and sucrose-loaded rats' glucose levels are inhibited by the aqueous and methanolic extracts from *S. reticulata* by 80%. However, rats given glucose did not exhibit this inhibition, supporting *S. reticulata's* inhibitory impact on the brush boundary enzymes (Mastuda *et al*., 2005).

3.6.2 Antidiabetic activity

The aqueous decoction of 40 Sri Lankan medicinal herbs that are known to reduce blood sugar levels was studied by Karunanayake *et al*. (1984). The blood glucose levels of Sprague Dawley rats fed *S. reticulata* decoction were reduced by as much as 30%. The effects of the aqueous extract of *S. reticulata* on plasma glucose levels were examined in rats with diabetes induced by streptozotocin by Serasinghe *et al.* (1990). Plasma glucose levels were decreased by 42.8%, 45.4%, and 87.5%, respectively, in the experimental rats when they were given oral doses of 0.5, 1, and 5 g/kg body weight. From the aqueous stem extracts of *S. reticulata*, Oe and Ozaki (2008) recovered a new 13-membered thiocyclitol ring. Wistar rats that had been given a diet of maltose and sucrose were used in the activity's testing, and the extract considerably reduced postprandial glucose levels. Additionally, the *in vivo* activity of thiocyclitol as an alpha-glucosidase inhibitor was tested.

When healthy human volunteers were given 50 g of sucrose, 200 mg of the aqueous extract from the roots of *S. reticulata* considerably reduced the postprandial hyperglycemia. Kotalanol was isolated from the roots of *S. reticulata* by Yoshikawa *et al.* (1998) using bioassay-guided separation. When hydroalcoholic extract of *S. reticulata*, 500 mg/kg body weight, was fed to hyperglycemic rats induced by hydrocortisone, there was a significant decrease in serum glucose levels. The effectiveness and safety of the leaves and root bark of *S. reticulata* were assessed by Shivaprasad *et al*. (2013) using a randomized, double-blind, placebo-controlled procedure. Patients with mild to severe hyperlipidemia and prediabetes participated in the trial for six weeks. Twenty-nine patients received either a placebo or 500 mg of *S. reticulata* twice daily. *S. reticulata* leaves to 11, roots to 9, and placebo to 9 patients. The outcomes showed no adverse effects and a statistically significant reduction in low-density lipoprotein cholesterol and fasting blood sugar levels in a randomized single-center, double-blind technique,

Jayawardena *et al.* (2005) examined the impact of herbal tea extracts of *S. reticulata* on patients with type II diabetes. He concluded that *S. reticulata* herbal tea is both safe and beneficial after the extract demonstrated a considerable reduction in HbA1C. A substantial decrease in fasting plasma glucose levels, HbA1C, and BMI was observed in the placebo group administered aqueous stem extracts of *S. reticulata* by Kajimoto *et al.* (2000).

3.6.3 Hepatoprotective activities and antioxidant effect

Aqueous and methanolic extracts of the roots and stems of *S. reticulata* were shown to protect against carbon tetrachloride-induced hepatotoxicity in rats and to prevent the formation of thiobarbituric acid reactive substances, a marker of oxidative stress-mediated lipid peroxidation in the liver. Several catechins, including isolated mangiferin, have also been demonstrated to be effective free radical scavengers (Yoshikawa *et al.,* 2002b).

In vitro and *in vivo* hepatic cytochrome P450 activity in liver microsomes was examined in response to an aqueous extract of *S. reticulata* (Yokotani *et al*., 2013). Oral dosages of the extract of 0%, 0.5%, 1.5%, and 4.5% were administered. At the maximum dose, the Salacia lowered hepatic cytochrome P450 content while increasing the activities of CYP1A1, CYP2B, and CYP2C. It also suppressed body weight. The most prominent drug-metabolizing enzyme system, CYP3A, showed negligible effects in comparison to the control group. The liver enzymes alanine aminotransferase, aspartate aminotransferase, and alkaline phosphatase were unaffected by the extract at any dose, ruling out any hepatotoxicity. At the highest concentration, a dose that is over 125 times the comparable average human dose was needed to suppress CYP1A2 activity in mouse and human liver microsomes. Because effects were only observed at the highest dose, it is unlikely that the *S. reticulata* extract would have a major impact on the cytochrome P450 drug-metabolizing enzyme system at concentrations typically eaten.

3.6.4 Antioxidant activity

The antioxidant properties of hot aqueous and methanolic extracts of *S. reticulata* were investigated by Yoshikawa *et al.* (2002a). For antioxidative action, they employed mangiferin, (-)-4'-omethylepigallocatechin, and (-)- epicatechin-(4, β-8)-(-)-42-O methylepigallocatechin. They noticed that those two compounds showed DPPH radical scavenging action.

3.6.5 Antiobese study

The effects of Salacia species on preventing obesity have also received substantial research. A crucial enzyme for the breakdown of dietary fat, pancreatic lipase activity is thought to aid in weight loss. There have been claims that *S. oblonga*, a different species, has lipid-lowering properties. *S. oblonga* root extract was shown by Huang *et al.* (2006), to prevent rat hypertriglyceridemia caused by olive oil. Similar to hot water extracts, pancreatic lipase activity was reduced by *S. reticulata*. Thus, it is thought that the Salacia root's primary mechanism for reducing postprandial hyperlipidemia is the suppression of pancreatic lipase activity in the small intestine.

An open-label randomized research by Ofner *et al.* (2013) investigated the combined effects of *S. reticulata* and vitamin D on weight, body fat, and body mass index (BMI) in 40 healthy overweight or obese individuals. The participants, who ranged in age from 30 to 60, were split into Group A and Group B. For four weeks, each group received instructions on how to live a healthy lifestyle and exercise. For four weeks, the treatment group (Group B) additionally got a pill containing *S. reticulata* 200 mg and 64 IU of vitamin D3. The controls (group A) only got instruction on healthy living and fitness. In comparison to controls, those who received *S. reticulata* plus vitamin D showed weight loss of 6.1% (p = 0.03) and a decrease in body fat of 4.5% (p = 0.01). In group B, the BMI decreased p from 31.2 to 29.3 kg/m^2 (p = 0.02) as well.

3.6.6 Antiproliferative activities

In interleukin-1-activated cells, Sekiguchi *et al.* (2012) investigated the antiproliferative properties of *S. reticulata* leaves. The extract (850 g/ml) inhibited matrix metalloproteinase genes and synoviocyte-like cell lines (inflammatory synovial tissues) by 50%.

3.6.7 Safety studies

As already mentioned, herbal remedies made from *S. reticulata* and other Salacia species have been used for many years in traditional folk medicine to treat a variety of illnesses without any reported side effects. Even though numerous toxicological studies using rodents have demonstrated that *S. reticulata* has negligible to no side effects, clinical trials are essential to further substantiate the safety of using Salacia extracts. Additionally, oral treatment of the *S. reticulata* root extract during the early or middle stages of pregnancy showed no impact on fertility in terms of uterine implants, implantation index, or gestation index (Ratnasooriya *et al*., 2003). However, women whose pregnancies are impaired by diabetes should avoid using the *S. reticulata* extract since it may pose a significant threat to a healthy pregnancy (Ratnasooriya *et al*., 2003).

4. Discussion

The desire to cure disease and preserve health is as old as life itself. All indigenous remedies have originated directly or indirectly from folklore or traditional practices. Many single-drug therapies have been in use in folklore medicine, which are not mentioned in Ayurveda classics. It's a moral responsibility to identify such drugs and add them to our literature. The drug *S. reticulata* is one of such folklore claims seen in Southern India, found abundantly in Kerala, which is used as a household remedy to control various diseases. It is not delineated in any Ayurvedic classics like *Brihattrayi* and *Laghuttrai* and *nighantus* (Ayurveda lexicons) expects *Nighantu Adarsh*. But *Sahasrayogam*, a book of compilation of Kerala folklore reclaims its importance and classical literature of Kerala has described *S. reticulata* in the treatment of *madhumeha* (diabetes) in single or in combinations.

It seems that the use of this drug started in the medieval period, and it became famous in the modern era. Study shows that various synonyms were added by Ayurvedic scholars in different period giving us an idea about its habitat, morphological characters, and properties. The synonyms like *Saptacakra* (the cross-section of the root shows seven rings), *Swarnamoola, Pitikamollam, Hemakorandakam* (the colour of the root bark is golden yellow) help for the identification of drugs, and synonyms like Mehari*, Mehantaka, Vairi* (It destroys diabetes as an enemy) represents its action (Sharma, 1998).

By analyzing the description of different books, it may be concluded that *S. reticulata* has pharmacodynamic properties like *kasaya, tikta rasa* (astringent and bitter), *usna virya* (hot potency), *katu vipaka* (pungent biotransformation) and *kaphapittahara* property (pacifies *kapha* and *pitta* morbidities). It is mainly indicated in *madhumeha* (diabetes) and other conditions like sothahara (anti-inflammatory), vedanasthapana (analgesic), dipana (appetizer), anulomana (laxative), yakritauttejaka (hepatic stimulant), rakta sodhaka (blood purifier), mutrasangrahaniya (antidiuretic), arthavagamana (useful for menstrual cycle), garbhasayottejaka (uterine stimulant), svedopanayana (sweating) are also mentioned in Ayurveda literature (Shastry, 2004). It is also used in amenorrhea and dysmenorrhea and if used in large quantities it acts as abortificient. Various recent studies have reported that it has antihyperglycemic (Deepak *et al*., 2015), alpha-glucosidase inhibitory effect, hypolipidemic, hepatoprotective, antimicrobial, antiproliferative, and antioxidant activity (Table 5).

Considering the demand for *S. reticulata* a preliminary crude drug survey of the local market at Chennai and Kerala was also done. It is worth mentioning that, during the survey, it was found that *S. reticulata* is understood by drug dealers as *Kalinjar* and *Ekanayakam*. Large cut pieces of roots are sold in the market. These pieces were picked up from several places on the market and studied to identify the genuineness of the drug. During the survey, it was also found that the mixture of dried stems and root pieces of different plants which have yellow colour is sold in the market as *Saptacakra* (*S. reticulata*).

Adulteration and substitution is the main problem faced by the traditional system of medicine, so standardization of different plant parts is more important. As per the recommendation of WHO, taxonomic, macroscopic, and microscopic morphological analysis (pharmacognostic techniques), palynological, anatomical, and phytochemical screening (both quantitative and qualitative), physicochemical analysis and fluorescence studies are important for the standardization of plant drugs (Geeta *et al*., 2015).

Plant drugs have distinguishing qualities that have been used to determine purity, identity, and quality; this can be done utilizing a variety of pharmacognostic research and phytochemical screening techniques (Chenthurpandy *et al., 2*009). To standardize and authenticate the plant drug macro, micro, and physiochemical standards are taken into consideration. The protective characteristics of plants are caused by secondary metabolites like tannins, polyphenols, alkaloids, *etc*., which are common in them (Arora *et al*., 2017). Microscopy is an important tool that helps in separating genuine drugs from their contaminants.

Pharmacognostical studies of the *S. reticulata*, show that the root bark contains reddish and yellowish materials, as well as starch granules, which give the root bark its yellowish colour. It also showed prismatic crystals of calcium oxalate and a few stone cells in the root bark. The primary identifying characteristic is the way of arranging phloem cells (Figure 5). Powdered microscopy shows the presence of simple and compound starch grains (Figure 6), fragments of vessels with simple pitted, bordered pitted, and scalariform thickenings (Figure 7), and thin-walled parenchymatous cells filled with yellowish and reddish colouring matter (Figure 8). The physicochemical analysis of *S. reticulata* may confirm the presence of some water-soluble inorganic matter based on high values of water-extractive (WSE) and total ash in *S. reticulate* (Table 2). The alcohol-soluble extractive (ASV) value of *S. reticulata* root is higher, which represents the presence of the higher content of phytoconstituents (Table 2). Carbohydrates, phytosterols, phenolic compounds, flavonoids, and terpenoids are all present, according to the preliminary phytochemical analysis (Table 3). The high biological activity of *S. reticulata* roots proved that it contains high secondary metabolites like tannins, polyphenols, alkaloids, *etc*., and hence authenticates its utility as a drug.

Several animal studies have looked at the effects of *S. reticulata*, *S. oblonga*, and *S. chinensis* extracts on a range of metabolic, biochemical, and histopathological parameters. The extracts have been established to moderate increases in body weight gain, provide cardiac and hepatic protection, exhibit anti-inflammatory and antioxidant effects, and modulate changes in blood glucose and cholesterol levels through a variety of reliable methods. Aqueous extracts have been the most often utilized extracts, while other solvents have been used as well. Leaf, root, stem, and root bark are examples of plant parts that have been employed. The roots of *S. reticulata* were shown to have the highest level of activity in terms of lowering postprandial blood glucose levels when compared to other species and plant components.

With Salacia extracts, a lot of clinical studies have been carried out. These investigations have shown that aqueous extracts, when given to type II diabetic individuals, successfully controlled blood glucose levels without side effects. Numerous toxicity investigations on rats and mice have been carried out. The findings suggest that extract doses up to 2000-2500 mg/kg per day are safe without any adverse effects.

A major problem and cause for concern is the lack of standardization of extracts and the general knowledge of the composition of the extracts used

5. Conclusion

In the current study, the phytopharmacological analysis, pharmacognostic characteristics, and physicochemicals of *S. reticulata* root were carried out, which are most important for better assessment of purity and identification of the drug. Pharmacognostical studies of *S. reticulata*, show that the root bark contains reddish and yellowish materials, as well as starch granules, which give the root bark its yellowish colour and the primary identifying characteristic is was the way of arrangement of phloem cells. The alcohol-soluble extractive (ASE) value of the plant is more than the water-soluble extractive (WSE) value, which represents the presence of more alcohol-soluble phytoconstituents in the plant. The phytochemical analysis of plants showed the presence of different phytoconstituents which authenticate the use of *S. reticulata* as herbal medicine for treating various diseases. During the market survey, it was also found that the mixture of dried stems and root pieces of different plants which have yellow colour is sold in the market as *S. reticulata*, in such cases microscopy and preliminary phytochemical analysis are inadequate to authenticate the plant material. The details of the deterioration of plant material can not be found by microscopic and preliminary phytochemical analysis, therefore other recent advancements like TLC, HPLC, GCMS, X-ray diffraction, *etc.,* are included by WHO and Ayurveda Pharmacopeia of India.

Numerous researchers have looked into the hypoglycemic and hypolipidemic mechanisms of action of Salacia extracts, and it is clear that there are numerous pathways involving numerous ingredients. For instance, Salacia root extracts influence a variety of targets, such as alpha-glucosidase, aldose reductase, and pancreatic lipase, as well as PPAR-mediated lipogenic gene transcription, the GLUT4 transporter, and the angiotensin II type 1 receptor. The salacinol, kotalanol, mangiferin, and 13-MRT are the most common active components in Salacia. The individual component mangiferin has received the most research attention. The pharmacological action of numerous minor components also happens to be present. The existence of numerous pathways involving multiple components makes utilizing a plant extract extremely advantageous. A drawback is that because there are numerous active elements present, standardization is challenging.

There is a need for longer human trials to evaluate safety and to understand the weight loss mechanism. More detailed exploration of the chemical constituents in *S. reticulata* may contribute to the production of new drugs for the benefit of human life.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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