



## A Review on Ethnobotany, Phytochemistry and Pharmacology of *Boswellia ovalifoliolata*

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**Abstract:** *Boswellia* is also known as Indian frankincense, used mainly to treat various inflammatory disorders like osteoarthritis, rheumatoid arthritis, asthma and inflammatory diseases. It has been reported in reducing the risk of arthritis, cancer, inflammatory bowel diseases, cardiovascular disorders and neurodegeneration. Ten compounds and three new compounds were isolated and characterized from the oleo gum resin of *Boswellia ovalifoliolata*. Boswellic acid, one of the pentacyclic triterpenoid present in almost all the species of *Boswellia* as a role in inhibiting cancer growth. *Boswellia* has got significant anti-inflammatory activity, it is necessary to isolate new compounds from the plant. The pharmacological action of the crude extract need to be studied in detail. The present review provides an overview of Ethnobotany, phytochemistry and pharmacology of *Boswellia ovalifoliolata*.

**Key words:** *Boswellia ovalifoliolata*; Traditional uses; Ethnobotany; Pharmacology.

### Introduction

Natural products are an important source of chemical diversity of starting material over the past decades<sup>1</sup>. Biological and geographical diversity in nature leads to chemical diversity, so researchers are focusing on samples to analyze and evaluate in drug discovery or bioassays. Plants are rich sources for drug discovery, which comprise many fields of inquiry and different methods of analysis. The process involves various field specialists like botanist, ethnobotanist, ethnopharmacologist or a plant ecologist to collect and identify the plant of interest<sup>2</sup>. There are two types of metabolites: Primary metabolites are necessary for all the living organism. It is synthesized by the breakdown of molecules like proteins, fats, nucleic acids and carbohydrates. Secondary metabolites are synthesized by an organism through a mechanism which are not directly involved in the growth, development and reproduction<sup>3</sup>. Medicine and natural products have been closely linked with the use of traditional medicines and natural products<sup>4</sup>. In view of the importance of medicinal plants in drug discovery it is necessary to study the ethnopharmacology, phytochemistry, pharmacological activities of medicinal plants.

*Boswellia ovalifoliolata*, an endemic and endangered medicinal tree species belong to the Tirupati-Kadapa-Nallamali hotspot of India. It belongs to the family Burseraceae<sup>5</sup>. It is native to Seshachalam hill range of the Eastern Ghats of India<sup>6</sup>. This 11<sup>th</sup> hotspot harbors a huge number of regional, threatened, rare and keystone species due to its vivid geographical conditions. Climatic factors also make it more favorable for the unique distribution of endemic plant wealth<sup>5</sup>. The local tribes in the nearby villages make a deep cut on the trunk to extract the gum, which causes damage and depletion of plant species in the natural habitat<sup>7</sup>. It is commonly used by tribes like Nakkala, Sugali, Chenchu and indigenous communities to treat a number of

ailments<sup>8</sup>. There are about 18 species of *Boswellia*, which are shrubs or trees with outer bark often flaking. They include *B. sacra*, *B. frereana*, *B. neglecta*, *B. microphylla*, *B. papyrifera*, *B. ogadensis*, *B. pirottae*, *B. rivae*, *B. madagascariensis*, *B. socotrana*, *B. popoviana*, *B. nana*, *B. ameero*, *B. bullata*, *B. dioscoridis*, *B. elongata*, *B. serrata* and *B. ovalifoliolata*. Only the last two species have been reported to be distributed in India<sup>9</sup>.

Boswellic acids present in all the species of *Boswellia* make it more distinctive of this genus<sup>5</sup>. Gum contains mainly Amyrins together with resin acids and volatile acids<sup>7</sup>. Gum extract used to treat dysentery, inflammation, joint pains, ulcers, arthritis and amoebic dysentery. The stem used for stomach ulcers, diabetes. The leaf extract is used for mouth and throat ulcers. The main aim of this review is to study the Ethnopharmacology, phytochemistry and pharmacological activities of *Boswellia ovalifoliolata* for the future research and development.

Telugu names: Guggilam, Konda sambrani, Adavi sambrani, Sambrani.

## Medicinal parts

### Gum resin

Only few literature has been reported in the gum resin of *Boswellia ovalifoliolata* such as Antiadipogenesis and antihyperlipidemic activity.

### Stem bark

The stem bark of *Boswellia ovalifoliolata* exhibit antimicrobial and cardioprotective activity against water, ethanol, methanol, chloroform and hexane extract.

### Leaves

*In vivo* analgesis activity, anti-ulcer activity, anti-inflammatory activity, cytotoxic activity, anti-microbial activity and wound healing property have been studied in the leaf extract.

## Classification

Kingdom	: Plantae
Phylum	: Tracheophyta
Class	: Equisetopsida
Order	: Sapindales
Family	: Burseraceae
Genus	: <i>Boswellia</i>
Species	: <i>Ovalifoliolata</i>

## Ethnobotany of *Boswellia ovalifoliolata*

### Botanical description

*Boswellia* has the imparipinnate leaves. The veins are reddish in color, branches are alternate or congested at the ends; the leaflets are sessile, ovate-oblong, glabrous beneath and unequal at the base. Spiral leaves with pinnately odd compound, long-petiolate, entire to serrate, pinnately veined leaflets and distinctive symmetry. Leaves are trifoliate or unifoliate. Brown and scurfy leaf, leaflet stalks and axis, whereas the leaf base are swollen and concave adaxially. There are no stipules for this family. The flowers contains 4-5 faintly connate but imbricate sepals with an equal number of distinct and imbricate petals. The stamens have nectar discs with distinct glabrous filaments in 1-2 whorls lying equally or twice the number of petals; the tricarpeolate pollen contains two locules of the anthers that open longitudinally along slits. The gynoecium have 3-5 connate carpels with one style, and one stigma that is head like to be lobed. Flowers in axillary panicles. Calyx 5-toothed. Petals 5, imbricate<sup>10</sup>. The leaf and bark of *Boswellia ovalifoliolata* are shown in fig. 1.



Fig. 1. *Boswellia ovalifoliolata* Leaves and Bark

### Ethnopharmacology

The gum powder, stem bark and leaves are used by tribal people to treat dysentery, inflammation, joint pains, ulcers, arthritis and amoebic dysentery. Stem bark is used to treat rheumatic pains. Oral administration of the stem bark decoction used to reduce pain. The mixture of gum and stem bark one teaspoonful dissolved in sour milk given in empty stomach for a month to treat stomach ulcers<sup>11</sup>. The mixture of gum powder and curd in water given orally to treat amoebic dysentery. *Boswellia ovalifoliolata* and *Boswellia serrata* gum powder and *Pedaliium murex* fruit powder, prepared into a paste in equal parts and mixed, external application of this mixture on the affected part used to treat hydrocoel. Gum powder mixed with a white precipitate of pounded stem of *Tinospora cardifolia* and honey given orally in small quantities (10ml) two times a day to cure hydrocele. The leaves are used to treat pain and inflammation. The Leaf decoction is used as antibacterial, antiulcer and antirheumatoid<sup>8</sup>.

### Phytochemistry

The phytochemical analysis of the stem of *Boswellia ovalifoliolata* with different solvents i.e. ethanol, methanol, chloroform, hexane, ethyl acetate, diethyl ether and water contains tannins, saponins, flavonoids, terpenoids, cardiac glycosides, reducing sugars, carbonyls, phlobatannins, steroids, ninhydrins, phenols but no alkaloids. Where as in stem bark all the phytochemicals are present. Leaf of *Boswellia ovalifoliolata* contains all the phytochemicals mentioned above. Gum contains all the phytochemicals except steroids, indoles and leucoanthocyanins. The stem bark is rich in terpenoids, carbonyls and cardiac glycosides<sup>7</sup>.

Table 1 Phytochemicals of *Boswellia ovalifoliolata*<sup>7</sup>

S.No.	Compound	Stem bark	Gum	Leaves
1	Alkaloid	-	+	+
2	Flavonoid	+	+	+
3	Triterpenoids	+	+	+
4	Steroids	+	-	+
5	Phenols	+	+	+
6	Saponins	+	+	+
7	Tannins	+	+	+

### Alkaloids

Table 1 shows that the alkaloids are absent in stem bark, where as in gum and leaf it is present in less quantity. Alkaloids are not present in this species. The stem bark of *Boswellia ovalifoliolata* contains large amount of terpenoids compare to alkaloids.

### Flavonoids

Flavonoids are largely present in all the plants. It gives color to the flowers like yellow, blue/red pigmentation to the petal which will attract the animals for pollination. The flavonoids like Luteolin and

Gorientin are absent in gum. Table 2 shows that the stem bark contains Quercetin, rutin, Luteolin, Gorientin and Vitexin.

**Table 2 Flavonoids of *Boswellia ovalifoliolata*<sup>7</sup>**

S.No.	Compound	Stem bark	Gum
1	Quercetin	+	+
2	Rutin	+	+
3	Luteolin	+	-
4	Gorientin	+	-
5	Vitexin	+	+

### Phenols

Phenols like gallic acid, chlorogenic acid, gentisic acid, phloretic acid, p-hydroxy benzoic acid, vanillic acid, Melilotic acid, coumarin, salicylic acid and cinnamic acid are common in both the parts are shown in table 3. The stem bark and gum of *Boswellia ovalifoliolata* contains 78 phenolic compounds which was identified in (positive mode -22 and negative mode-10) and gum (positive mode-37 and negative mode-9) of HPLC.LC-MS data of literature were used to identify 28 phenolic compounds among the 78 compounds. The compounds were given in the table. 4

**Table 3 Phenols of *Boswellia ovalifoliolata*<sup>7</sup>**

S.No.	Compound	Stem bark	Gum
1	Gallic acid	+	+
2	Chlorogenic acid	+	+
3	Protocatechnic acid	+	-
4	Gentisic acid	+	+
5	Scopoletin	+	-
6	Phloretic acid	+	+
7	p-hydroxy benzoic acid	+	+
8	Trans-p-coumaric acid	+	-
9	Vanillic acid	+	+
10	Cis-p-coumaric acid	+	-
11	Melilotic acid	+	+
12	Cis-Ferulic acid	+	-
13	Coumarin	+	+
14	Salicylic acid	+	+
15	Cinnamic acid	+	+
16	Syringic acid	+	-

**Table 4 Phenolic compounds identified in stem bark and gum of *Boswellia ovalifoliolata*<sup>12</sup>**

S.No.	Compound	Stem bark	Gum
1	Guaiacol	+	-
2	Gallic acid	+	+
3	Ascorbic acid	+	-
4	Quercetin	+	-
5	Isorhamnetin	+	-
6	Carnosol	+	-
7	Carnosic acid	+	-
8	Oleuropein	+	+
9	Medioresinol	+	-
10	Phloridzin	+	-

11	Coumaroyl hexose	+	-
12	Kuempferol acetylhexoside	+	-
13	Caffeic acid hexoside	+	-
14	Quercetin-3 pentosylhexoside	+	+
15	Benzoic acid	-	+
16	Hydroxytyrosol	-	+
17	Protocatechuic acid	-	+
18	Phloretic acid	-	+
19	Chlorogenic acid	-	+
20	Chlorogenistic acid	-	+
21	5-coumaroylquinic acid	-	+
22	Coumaric acid	-	+
23	Luteolin-7-glucoside	-	+
24	Cyanidin-3-glucoside	-	+
25	1,5-di coumaroylquinic acid	-	+
26	Dicaffeoylquinic acid	-	+
27	Quercetin-7-hexoside-3-hexoside	-	+
28	Heptamericprocyanidin	-	+

### Terpenoids

The Ethanolic extract of oleo-gum resin of *Boswellia ovalifoliolata* contains ten compounds. Three new compounds were isolated from an Ethanolic extract of the oleo gum resin (1-3, one sesquiterpenoid and two triterpenoids). Renuchib *et al.*, firstly reported  $1\beta$ ,  $3\beta$ ,  $11\alpha$ -trihydroxy-urs-12-ene (4) in *Boswellia* species, whereas,  $3\alpha$ -hydroxy-tricall-8-24dien-21-oic acid (5),  $3\alpha$ -acetoxy-tirucall-824-dien-21-oic acid (6), serratol (7), neoilexonol (8), 3-hydroxy-urs-9, 11-dien-24-oic acid (9) from *B. ovalifoliolata*<sup>13</sup>.

Two new macrocyclic diaryl ether heptanoids were isolated from a hexane extract of the stem of *Boswellia ovalifoliolata*. Ovalifoliolatin A and ovalifoliolatin B together with the known macrocyclic diaryl ether heptanoids acerogenin C, a known triterpenoid,  $3\alpha$ -hydroxyurs-12-ene, and a known steroid, sitost-4-en-3-one was identified from hexane extracts of *Boswellia ovalifoliolata*<sup>14</sup>.

### Anthocyanidins

Anthocyanidins are plant pigment. There are about 12 anthocyanidin. Among that Cyanidin and petunidin are absent in gum, whereas it is present in stem bark<sup>7</sup>.

**Table 5 Anthocyanidins of *Boswellia ovalifoliolata***<sup>7</sup>

S.No.	Compound	Stem bark	Gum
1	Cyanidin	+	-
2	Petunidin	+	-

### Amino acids

Amino acids are organic compounds contains amine and carboxylic acid functional group. The difference in the side chain leads to the different amino acids. Table 6 shows that amino acids like aspartic acid, arginine, glutamic acid, ornithine, glutamine and glycine are absent in gum. Stem bark contains aspartic acid, arginine, asparagine,  $\alpha$ -Alanine,  $\beta$ -Alanine, cysteine, cystine, glutamic acid, glutamine, glycine, Histidine, isoleucine, Leucine, lysine, ornithine, proline, serine, threonine and valine<sup>7</sup>.

**Table 6 Amino acids of *Boswellia ovalifoliolata***<sup>7</sup>

S.No.	Compound	Stem bark	Gum
1	Aspartic acid	+	-
2	Arginine	+	-
3	Asparagine	+	+
4	$\alpha$ -Alanine	+	+
5	$\beta$ -Alanine	+	+
6	2-Amino butyric acid	-	+
7	Cysteine	+	+
8	Cystine	+	+
9	Glutamic acid	+	-
10	Glutamine	+	-
11	Glycine	+	-
12	Histidine	+	+
13	Isoleucine	+	-
14	Leucine	+	+
15	Lysine	+	+
16	$\gamma$ -Methylene glutamine	-	+
17	Norleucine	-	+
18	Ornithine	+	-
19	Proline	+	+
20	Serine	+	+
21	Threonine	+	+
22	Valine	+	+

### Lipids

Lipids, like phosphatidyl inositol and Digalactosyl diglyceride are absent in gum. Stem bark contains phosphatidyl serine, phosphatidyl inositol, Digalactosyl diglyceride, phosphatidyl glycerol, Sulphoquinovosyl diglyceride, Monogalactosyl diglyceride and Steryl glycoside<sup>7</sup>.

**Table 7 Lipids of *Boswellia ovalifoliolata***<sup>7</sup>

S.No	Compound	Stem bark	Gum
1	Phosphatidyl serine	+	+
2	Phosphatidyl inositol	+	-
3	Digalactosyl diglyceride	+	-
4	Phosphatidyl glycerol	+	+
5	Sulphoquinovosyl diglyceride	+	+
6	Monogalactosyl diglyceride	+	+
7	Steryl glycoside	+	+

### Pharmacological activities

#### Analgesic activity

Deepak kumar et al., analgesic activity of petroleum ether extract of *Boswellia ovalifoliolata* showed significant activity at the dose level of 200 and 400 mg/kg b. wt., in the albino mice models. The Analgesic effect of *Boswellia ovalifoliolata* was evaluated by tail immersion test and acetic acid induced writhing test. Tail withdrawal time was increased in *Boswellia ovalifoliolata* Linn extract, however BO extract showed a reduced number of writhes in acetic acid induced writhing test at two dose levels<sup>10</sup>.

### Anti-inflammatory activity

Methanol extracts of *Boswellia ovalifoliolata* showed significant anti-inflammatory activity in carrageenan induced paw oedema in Wistar rats at the dose level of 200-400 mg/kg administered orally<sup>8</sup>. The Ethanolic extract of *Boswellia ovalifoliolata* exhibited significant anti-inflammatory activity in acute and chronic models of inflammation. The test herb and the standard diclofenac showed reduction in the concentration of ALT and AST, GGT, acid phosphatase in serum and lipid peroxides in the liver and increased the GSH concentration<sup>15</sup>. Tamil selvan et al investigated anti-inflammatory activity of *Boswellia ovalifoliolata* using carrageenan, histamine and egg white induced inflammation in rat paw oedema. The *Boswellia ovalifoliolata* methanolic extract showed significant ( $p < 0.01$ ) anti-inflammatory action against all the models<sup>16</sup>.

### Anti-adipogenesis activity

It is reported that an Ethanolic extract of bark of *Boswellia ovalifoliolata* significantly reduced the lipid accumulation with 51.5, 46.1, 26, 56.3 % over control at 100, 700 and 250  $\mu\text{g/ml}$  whereas the ethanolic extract of leaves of *Boswellia ovalifoliolata* did not show significant inhibition of fat accumulation at the tested concentration<sup>17</sup>.

### Anti-hyperlipidemic activity

Geetha kodali., et al studied anti-hyperlipidemic activity of Ethanolic extract of *Boswellia ovalifoliolata* gum in atherogenic diet induced rats. The levels of AST, ALT and ALP were significantly reduced compared to AD group<sup>18</sup>. The stem bark of methanolic extract *Boswellia ovalifoliolata* significantly decreases the levels of LDL-C, VLDL-C, TC and TG besides increasing the HDL-C levels in HFD fed rats<sup>19</sup>.

### Cardiotoxicity

The Ethanolic extract of BO showed significant reduction in the oxidative stress and lipid peroxidation when administered along with DOX therapy. Bandari uma Mahesh et al., reported that the Ethanolic extract of BO bark and leaf showed significant decrease in the enzyme activities such as catalase, superoxide dismutase, glutathione peroxidase in cardiac tissue ( $p < 0.05$ )<sup>20</sup>.

### Cytotoxic activity

Dinesh thummuri et al., found that Ethanolic leaf extract of BO was capable of inducing apoptosis. The ethanolic extract of *Boswellia ovalifoliolata* considerably decreased the phospho-NF- $\kappa\text{B}$ (ser536), PCNA, anti-apoptotic protein Bcl-2 expression in western blot studies and the expression of pro-apoptotic protein Bax, in MDA-MB-231 and MDA-MB-453 cell lines were increased compared to untreated cells. BO has chemosensitizing effects on TNBC cells and the cytotoxicity of doxorubicin and cisplatin was increased<sup>21</sup>.

### Antimicrobial activity

*Boswellia ovalifoliolata* stem extract was found to be active against *X.citri*<sup>5</sup>. In another study SNPs of BO showed higher antibacterial activity against *E.coli* and *Proteus* and has no effect on selected fungal species. It was found that the stem bark of SNPs of plant extract showed significant antibacterial activity against *Klebsiella* followed by *E.coli* and *Proteus* species; and antifungal activity was shown against *Aspergillus* and *Fusarium*<sup>22</sup>. It was reported that the leaf extracts of *Boswellia ovalifoliolata* are more effective to reduce the growth of *Alternaria alternata* at 500 ppm concentrations than other plants<sup>24</sup>.

### Anti-diabetic activity

Prabhakar et al., reported that aqueous extract of *Boswellia ovalifoliolata* has significant antioxidant effect in diabetic rats. This implies that the extracts can reduce the potential glycation of enzymes or they may reduce the production of reactive oxygen free radicals and improve the activities of antioxidant enzymes.

### Hepatoprotective effects

The *Boswellia ovalifoliolata* bark extract was evaluated for hepatoprotective against PCM induced hepatotoxicity. The alcoholic extract was capable of alleviating the hepatic damage induced by acute

intoxification of PCM and it showed a significant protective effect against lipid peroxidation derived serum enzymatic variables and thus maintained the glutathione status towards control<sup>25</sup>.

### Other activities

Dhanalakshmi et al., suggested that *Boswellia ovalifoliolata* possess significant antiulcer activity by pyloric ligation induced method & aspirin induced methods against gastric ulcers in rats. BO extract was found to possess significant wound healing activity in rats<sup>39</sup>. Sakuntala devi et al., suggested that the alcoholic extract of *B. ovalifoliolata* is not toxic at the dose level of 100 and 500 mg/kg. It was reported that a stem bark extract of *B. ovalifoliolata* is safe and there is no observed adverse effect level (NOAEL) till 500 mg/kg following repeated oral administration of the drug for 28 days in rats.

### Conclusion

The present review gives brief knowledge about Ethnobotany, phytochemistry and pharmacology of *Boswellia ovalifoliolata*. This plant has been widely used by the tribal people for various ailments. Traditional uses of the plant include the treatment of dysentery, inflammation, joint pains, ulcers, arthritis, hydrocoel and amoebic dysentery. In addition *Boswellia ovalifoliolata* possess analgesic, anti-inflammatory, anti-adipogenesis, anti hyperlipidemic, anti-microbial, cardiotoxic, cytotoxic, hepatoprotective and anti-diabetic activity.

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### References

1. Bhuwan B. Mishra, Vinod K. Tiwari. Natural products: An evolving role in future drug discovery. European journal of medicinal chemistry, 2011, 46: 4769-4807
2. Marcy J. Balunas, A. Douglas Kinghorn. Drug discovery from medicinal plants. Life sciences, 2005, 78: 431-441.
3. Daniel A. Dias, Sylvia Urban and Ute Roessner. A historical overview of natural products in drug discovery. Metabolites, 2012, 2: 303-336.
4. Mark S. Butler. The role of natural product chemistry in drug discovery. Journal of natural products, 2004, 67: 2141-2153.
5. Anitha G, Sudarsanam G. Studies on Antimicrobial activity of *Boswellia ovalifoliolata* against *Xanthomonas citri* and *Salmonella Typhynurium*. International Journal of Applied Biology and Pharmaceutical Technology, 2012, 4(1): 243-247.
6. Prabhakar Y K, Subhanali M D, Jyothikumar M V, Krishna tilak T and Apparao CH. Evaluation of antioxidant activities of aqueous extract of stem bark of *Boswellia ovalifoliolata* in streptozotocin induced diabetic rats. Journal of pharmacy and chemistry, 2013, 7(4): 19-24.
7. Savithamma N, Venkateswarlu P, Suhrulatha D, Basha S.K.M and Venkata Ramana Devi CH. Studies of *Boswellia ovalifoliolata* Bal and Henry An Endemic and Endangered medicinal Plants. An International Quarterly Journal of Life Sciences, 2010,5(3): 359-362.
8. Vasantha Kumar. P, Sri Harsha NS, Siddaiah M, Muralidhar S and Yashwanth Kumar D. Antiinflammatory activity of *Boswellia ovalifoliolata* Leaves. International Journal of Innovative Pharmaceutical Research, 2012, 3(4): 252-254.
9. Solomon Raju A.J, Vara Lakshmi P, Venkata Ramana K, & Hareesh Chandra P. Entomophily, Ornithophily and Anemochory in the self-incompatible *Boswellia ovalifoliolata* Bal & Henry (Burseraceae) an Endemic and Endangered medicinally important tree species. Journal of Threatened Taxa, 2012, 4(7): 2673-2684.
10. Deepak Kumar B, Sainath K, Neetha M, Viswateja. In vivo Analgesic activity of Petroleum Ether extract of *Boswellia ovalifoliolata* Linn Leaves. International Journal of Research in Pharmacology and pharmacotherapeutics, 2012,1(1): 2278-2656.

11. Savithamma N, Linga Rao M, Ankanna S and Venkateswarlu P. Screening of Medicinal Plant for effective biogenesis of Silver Nanoparticles and efficient Antimicrobial activity. International journal of pharmaceutical sciences and research, 2012, 3(4): 1141-1148
12. Savithamma N, Linga Rao M, Venkateswarlu P. Isolation and identification of phenolic compound from *Boswellia ovalifoliolata* Bal. & Henry and their radical scavenger activity. International journal of drug delivery technology, 2014, 4(1): 14-21.
13. RenuChib, Manjeet Kumar, Masood Rizvi, Simmi Sharma, Anjali Pandey, SarangPani, Samar S. Andotra, Subhash C. Taneja And Bhahwal A. Shah. Anti-inflammatory terpenoids from *Boswellia ovalifoliolata*. The royal society of chemistry, 2014, 4: 8632-8637.
14. Vanimireddy Lakshmi Niranjana Reddy, Kodela Ravinder, Masuna Srinivasulu, Thirumani Venkateswar Goud, Samala Malla Reddy, Dondapati Srujan Kumar, Tadikamalla Prabhakar Rao, Upadhyayula Suryanarayana Murty and Yenamandra Venkateswarlu. Two new macrocyclic diaryl ether heptanoids from *Boswellia ovalifoliolata*. Chem.Pharm.Bull, 2003,51(9): 1081-1084.
15. Sakuntala Devi P R, Adilaxmamma K, Srinivasa Rao G, Srilatha CH, Alpha Raj M. 2010. Evaluation of Anti-inflammatory activity of Stem Bark of *Boswellia ovalifoliolata* in Rats. *Inventi rapid: Ethnopharmacology*, 2010,2.
16. Tamil selvan A, Anusharavella, Suthakaran R. Phytochemical evaluation and anti-inflammatory activity of *Boswellia ovalifoliolata*. International journal of pharmaceutical sciences review and research, 2013, 22(1): 148-151.
17. Geetha kodali, SrikanthKakorla and Ganapatyseru. 2014. Screening of crude plant extracts for anti adipogenesis activity in 3T3 – L<sub>1</sub> cells. *Journal of pharmacy research*, 2014, 8(1): 81-86.
18. Geetha kodali, Ganapatyseru. Antihyperlipidemic activity of *Boswellia ovalifoliolata* Bal. & Henry in atherogenic diet induced rats, *International journal of phytotherapy research*, 2013, 3(3): 11-17.
19. SarithaMarella, Prabhakar Yellanur Konda, Subhan Ali Mohammed, Shaik Abdul Nabi, Jyothi Kumar MalakaVenkateswarulu, RajeshNatava, Appa Rao Chippada. Antihyperlipidemic activity of the stem bark of *Boswellia ovalifoliolata* in high fat diet fed rats. *International journal of medicinal plants*, 2014, 572-576.
20. Bandari Uma Mahesh, Shweta Shrivastava, Madhusudhana Kuncha, Bidya Dhar Sahu, Challa Veerabhadra Swamy, Rajeswara Rao Pragada, V.G.M. Naidu, Ramakrishna Sistla. Ethanolic extract of *Boswellia ovalifoliolata* Bark and Leaf attenuates Doxorubicin-induced Cardiotoxicity in Mice. *Environmental Toxicology and Pharmacology*, 2013, 36: 840-849.
21. Dinesh thummuri, Manish kumarJeengar, Shweta Srivastava, Aparnaareti, Veeraganeshyerra, Samyuktha, Prashanth .K, Naidu. V.G.M, Ashutoshkumar, Ramakrishna Sistla. *Boswellia ovalifoliolata* abrogates ROS mediated NF- $\kappa$ B activation causes apoptosis and chemosensitization in triple negative breast cancer cells, *Environmental Toxicology and pharmacology*, 2014,38: 58-70
22. Savithamma N, Linga Rao M, Rukmini K, Suvarnalatha Devi P. Antimicrobial activity of Silver Nanoparticles synthesized by using Medicinal Plants. *International Journal of Chemtech Research*, 2011,3(3): 1394-1402
23. Savithamma N, Ankanna S, Bhumi G. Effect of nanoparticles on seed germination and seedling growth of *Boswellia ovalifoliolata* an endemic and endangered medicinal tree taxon, *Nanovision*, 2012, 2(1, 2, & 3): 61 – 68.ii
24. Bavaji M, Khamar Jahan MD, Mahendra Nath M. Invitroevaluation of Fungicides and Plant extracts on the incidence of Leaf blight of Sesame caused by *Alternaria Alternate* (FR) Keissler. *International Journal of Food, Agriculture and Veterinary Sciences*, 2012, 2(3): 105-107.
25. Bandari Uma Mahesh, Shweta Shrivastava, Rajeswara Rao Pragada, V.G.M. Naidu and Ramakrishna Sistla. Antioxidant and hepatoprotective effects of *Boswellia ovalifoliolata* Bark extracts. *Chinese journal of natural medicine*, 2014, 12(9): 0663-0671.
26. Dhanalakshmi M, Maddilety B. Antiulcer activity of Methanolic Extract of Leaves of *Boswellia ovalifoliolata*Bal and Henry. *Pharmatutor-Art-1370*.
27. Sakuntala Devi P. R, Adilaxmamma K, Srinivasa Rao G, Srilatha Ch, Alpha Raj M. Safety evaluation of Alcoholic extract of *Boswellia ovalifoliolata* Stem-Bark in Rats. *Toxicology International*, 2012,19(2): 115-20.
28. Nirjanreddy V L, Ravinder K, Sreenivasulu M, Srujan Kumar D, Murty U S N and Venkateswarlu Y. Isolation of new 1, 7 diaryl heptanoids from *Boswellia ovalifoliolata*.
29. Ratnam K.V, Raju R.R.V. Invitro Antimicrobial activity of Leaf extracts of *Boswellia ovalifoliolata*. *Journal of Tropical Medicinal Plants*, 2008, 9(1): 27-29.

30. Sathishkumar D, Srisutherson N, Pradeep kumarreddy B, Vinitha S, Yadhagirao T, David banji. Pharmacognostic studies of *Boswellia ovalifoliolata*. Journal of pharmacy research, 2011, 4(15): 1374-1375.
31. Sathishkumar D, David banji, Harani A, PavankumarCh, Ravi varma J.N. Role of *Boswellia ovalifoliolata* Bal. & Henry extract of high fat diet induced hyper cholesterolemia. Pharmacognosy Journal, 2014, 6(4):108-116.
32. Savithamma N, Linga Rao M and Suvarnalatha Devi P. Evaluation of Antibacterial Efficacy of Biologically Synthesized Silver Nanoparticles using Stem Barks of *Boswellia ovalifoliolata* Bal. and Henry and *Shorea tumbaggaia* Roxb. Journal of biological sciences, 2011, 11: 39-45
33. Savithamma N & Bhumi G. Quantitative estimation of biochemical compounds of *Boswellia ovalifoliolata* Bal. & Henry – An endemic endangered & globally threatened medicinal tree taxa of seshachalam hill range of eastern ghats, India. Journal of pharmacy research, 2011, 4(12): 4694-4695.
34. Savithamma N, Linga rao M, Basha SKM. Antifungal efficacy of silver nanoparticles synthesized from the medicinal plants. Der pharma chemical, 2011, 3(3): 364-372.
35. Savithamma N, Linga rao M, Venkateswarlu P. Histochemical studies of *Boswellia ovalifoliolata* Bal. & Henry – An endemic endangered & threatened medicinal plant of seshachalam hill range of eastern ghats of India. International journal of pharmacognosy and phytochemical research, 2014, 6(1): 1-6.
36. Savithamma N, Linga rao M, Venkateswarlu P, Bhumi G. Evaluation of biologically synthesized silver nanoparticles from gum extract of *Boswellia ovalifoliolata* Bal. & Henry – an endemic endangered medicinal plant of thirumala hill range of Andhra Pradesh, India. International journal for pharmaceutical research scholars, 2014, 3(1): 187-195.
37. Shaik Abdul Latheef, Beekam Prasad, Middi Bavaji, Gangapatnam Subramanyam. A Database on Endemic Plants at Tirumala hills in India. Bioinformation, 2008,2(6): 260-262.
38. SreeLatha Devi R.K and Basha S.K.M. Comparative amino acid profiling of *Pterocarpussantalinus* and *Boswellia ovalifoliolata* barks of tirumala hills eastern ghats, Andhra Pradesh. International journal of basic and applied chemical sciences, 2012, 2: 102-106.
39. Sreenivasulu. M, V. Swathiprathibha. Evaluation of wound healing activity of methanolic extract of Leaves of *Boswellia ovalifoliolata* in Wistar Rats.
40. Thummala Chandrasekhar, T. Mohammad Hussain and Boddu Jayanand. Invitro Micropropagation of *Boswellia ovalifoliolata*. Verlag der Zeitschrift fur Naturforschung, 2005, 505-507.

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