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MYSTIC MARVEL: A REVIEW ON BRAHMA KAMAL

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ABSTRACT

Saussurea obvallata is also known as Brahma Kamal, is an endangered and spiritually important alpine herb of the Himalayan region, which is traditionally used to cure many illness. The review paper is an attempt to summarize currently available information on its ethno-botanical importance, phyto-chemical content, pharmacological interest, and conservation status. This plant have great cultural and therapeutic significance but it is still under-explore, and there are important knowledge gaps concerning its bioactive compounds, pharmacological action mechanism, and eco-friendly harvesting methods. The most important goals of this review are to (i) focus the medicinal and traditional significance of *S. obvallata*, (ii) review the existing studies on its biological activities such as antimicrobial, anti-inflammatory, and antioxidant activity, and (iii) reveal research gaps to inform future research. Important findings indicate that S. obvallata harbors a collection of flavonoids, alkaloids, and phenolics, which are responsible for its medicinal potential. It is negatively impacted by lacking conservation efforts, which compromise its existence and scientific discovery. This review highlights the existing studies on phyto-chemicals present in Saussurea obvallata. The significance of this investigation is to develop various policy for its conservation, and to identify their phyto-chemicals to understand their pharmacological roles.

KEYWORDS: *Saussurea obvallata*, brahma kamal, medicinal plant, phyto-chemicals, Himalayan flora, traditional medicine.

1. INTRODUCTION

Saussurea is a significant genus of the family Asteraceae that includes about 493 species of flowering plants, native to temperate, cool and arctic regions of Europe, Asia and North America.[1] The plants belonging to this genus have traditionally been used in the medicinal folk systems of countries like India, Nepal, China, Tibet, Pakistan, Bangladesh, Uyghur, Mongolia, and Kazakhstan. About 300 types of the *Saussurea* plant are reported in China. In the Indian Himalayan Region, 62 types are noted; out of these, 18 types were found in Uttarakhand Himalaya. Most species of *Saussurea* genus are classified as threatened because of their large use in various applications and wrong conservation plan. Of the *Saussurea* genus 44 species are classified as rare, whereas 2 classified as critically endangered and also 2 as endangered.[2] *S. obvallata* has been acknowledged as the state flower of Uttarakhand. It is utilized for it devotional, ethic and traditional purposes.[3] It has historically been used to treat mental, cardiac, and wound conditions as well as cerebral ischemia, paralysis, and other conditions.[4,5,6,7] In the Garhwal region of the upper Himalayas, the plant has great religious value. As a result, the plant's flowers are utilized for the devotions of goddess Nanda Devi and also for lord Shiva in Kedarnath and Lord Vishnu in Badrinath.[3]

Fig. 1: Brahma kamal flower blooming in valley.[8]

2. HABITAT

Saussurea obvallata is native to India, Pakistan, China, Tibet, Nepal, Myanmar and Bhutan.[9,4,5]

It is native herb of the Himalayan geographic zone and is rich with cultural and medical history. It occurs in the Himalayan alpine medows that extend from jammu and Kashmir up to Arunachal Pradesh at an altitude ranging from 3700 to 4600 meters.

Brahma Kamal occurs mainly in the Kedarnath area of Uttarakhand, also noted at Tungnath, Valley of Flowers, and Hemkund Sahib. Apart from this, *Saussurea obvallata* also grown in Myanmar, Northern Burma, Bhutan, Southwest China, Nepal as well as higher Himalayan zone of India - Jammu Kashmir to Garhwal.[10]

Table 1: Geographical characteristics of *S. obvallata* in the Uttarakhand Himalaya.[11]

Sr. No.	Locations	Altitude (m asl)	Latitude (N)	Longitude (E)
1	Kedarnath	4450	30° 44′ 57.10″	79° 05′ 17.59″
2	Triyuginarayan	3895	30° 41′ 59.36″	78° 59′ 16.78″
3	Tungnath	3858	30° 40′ 58.75″	79° 14′ 37.23″
4	Hemkund Sahib	4340	30° 42′ 08.45″	79° 37′ 2.06″
5	Pindari	4228	30° 16′ 48.27″	80° 01′ 1.97″

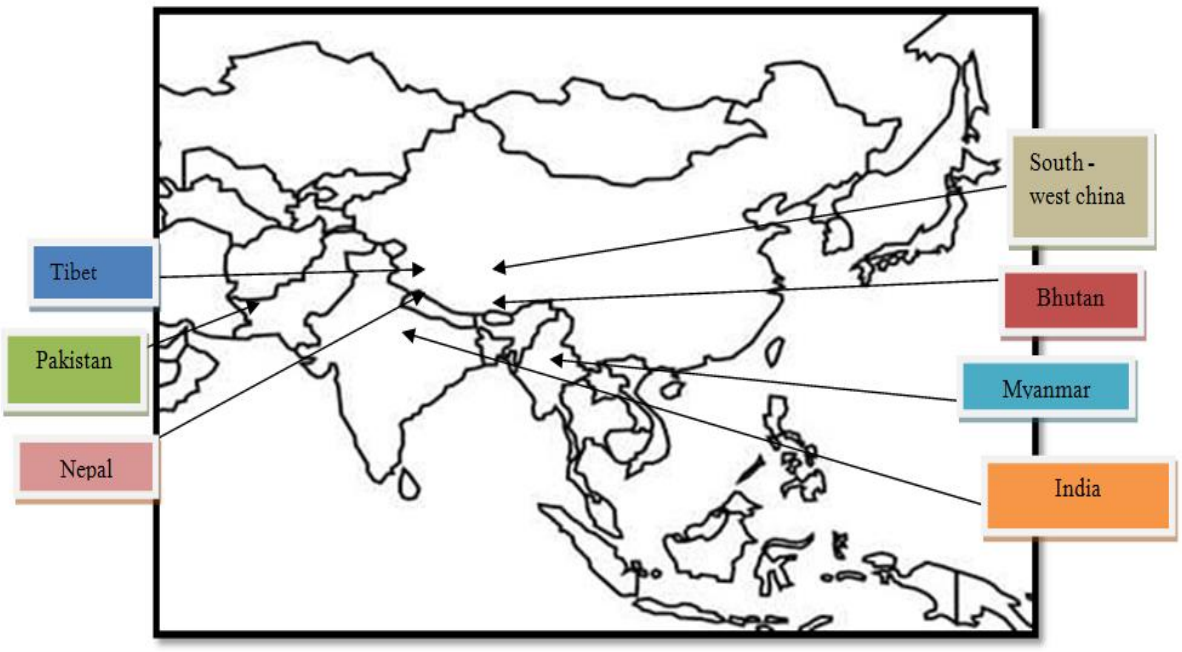


Fig. 2: Map showing habitat of *Saussurea obvallata.*

3. PLANT DISCRIPTION

3.1. TAXONOMIC CLASSIFICATION: The term "*obvallata*" comes from the Latin word "obvallatus," which means "surrounded by wall" and refers to involucral bracts," while "*Saussurea*" honors the Swiss taxonomist and philosopher Horace Benedict de Saussure.[1] Richard Blinkwoth brought the first *Saussurea obvallata* samples from the Kumaon Region of Uttarakhand, India and then submitted to Nathaniel Wallich, a botanist and superintendent of the Calcutta Botanical Garden in the East India Company's London herbarium, which is now known as the Wallich Herbarium at Kew.[1]

Table 2: Taxonomic Hierarchy of *S. obvallata*.[13]

Kingdom	Plantae
Subkingdom	Viridaeplantae
Infrakingdom	Streptophyta
Division	Tracheophyta
Subdivision	Spermatophytina
Infradivision	Angiospermae
Class	Magnoliopsida
Superorder	Asteranae
Order	Asterales
Family	Asteraceae
Genus	Saussurea DC.
Subgenus	Amphilaena
Species	*S. obvallata* (DC.) Edgew.

3.2. VERNACULAR NAMES

The plant is commonly referred as Brahma Kamal, flower of the Lord Brahma, and sacred lotus.[13] It is also known as **night-blooming cereus** and **lady of night.**[14]

Hindi: ब्रह्मकमल.[12]

Sanskrit: ब्रह्मकमलः

Khas Chhetri (Farwest Nepal): ब्रह्मकोइला[12]

English: snow lotus[13], Brahma's lotus, King of Himalayan flowers, Sacred Saussurea.[12]

3.4. BOTANICAL DESCRIPTION

Saussurea obvallata is a perennial aromatic herb that has a short life span and is hermaphrodite with a strong caudex, typically unbranched and reaches height of 15-18.

Stem: The stems are hollow(empty from inside), erect(standing upright), and ribbed.

Leaves

Lower Stem Leaves: leaf blade's base and leaves on the lower stem are petiolate.

Leaf Blade: Shape of the leaf blade (broad, flat part of the leaf) may be ovate, elliptic-oblong, or obovate.It is about 7-32 cm long and 1-6.5 cm wide.

Middle and upper stem leaves: leaves of middle and upper stem have semiamplexicaul base and are sessile .Shape may be elliptic to ovate and it is about 5-16 cm long and 1.5-8 cm wide.

Uppermost stem leaves: Leaves of uppermost stem have pale yellow surfaces on both sides. Its shape may be elliptic or ovate, boat shaped and it is about 5-15 cm long and 1.5-9 cm wide.[16]

Both cauline and basal-shaped leaves are present.

The **basal types** are petiolate and having shape from elliptical to lanceolate.

It sheathing at the base, and wider in size with scarious (thin, dry and papery) and serrated (toothed like saw blade) margins.

Apexes of leaves: Form of **leaves apex** may vary from acute to obtuse to cuspidate.

Cauline leaves may be in the form of lanceolate (longer than wider) or elliptic(shape like ellipse)-spathulate (shape like spatula).

Flowers: Bisexual in nature with tubular shaped corolla and are violet in color. Flower's head is protected by huge cluster of blossoms.

Flowering: July to September.

Fruiting: August to October.[17,18,1]

(a) (b) (c)

Fig. 3: Showing dried sample of (a) rhizome, (b) root, (c) stem of *Saussurea obvallata*.[19]

3.4. ORGENOLEPTIC PROPERTIES

The whole plant of *Saussurea obvallata* is odorless, but the flower and leaf are highly aromatic. The rhizome leaf and stem are more pleasant in taste ,whereas bract at the base of the flower is sweet and acrid. The organoleptic properties of the *Saussurea obvallata* are shown in Table 3.[16]

Table 3: Organoleptic properties of *Saussurea obvallata*.[16]

Parts	Color	Odor	Taste
Rhizome	Dark Brown	Odorless	Bitter, astringent
Stem	Brown	Odorless	Astringent
Leaf	Green	Aromatic	Bitter, astringent
Flower	Purple, Bract, Yellow	Aromatic	Sweet, Astringent

(a) (b) (c)

Fig. 4: Showing Organoleptic study of (a) Flower of S. obvallata, (b) leaf of S. obvallata, (c) rhizome of S. obvallata.[19]

3.5. MICROSCOPY

Microscopic analysis of leaves	Single layer of the epidermis made of parenchymatous cells are present. Presence of vascular bundles at centre and Stomata, Palisade, and spongy parenchyma tissue at the lower side of the epidermis.[19]
Powder microscopy of the leaf	Cork cells, xylem fragments, pitted vessels and endocarp pieces are present[19]
Transverse section of the stem	Numerous ridges are present on the outermost side. Parenchymal cells make up the epidermis and few layers of collenchyma cells make up the hypodermis. Vascular bundles are arranged in rings and are wedge shape (broad at top and taper toward bottom).[19]
Powder microscopy of the stem	Cork cells, pitted vessels, annular vessels are present. Calcium oxalate crystals, iodine, and group of lignified fibre are visible.[19]
Transverse section of roots	Epidermis, cortex, endodermis, single layered pericycle, vascular bundles, and a small pith region are present.[19]
Powder microscopy of the root	Cork cells, tracheids, fibres, tracheids reticulate vessels, and starch are present.[19]
Powder microscopy of the flower	Tracheids, prismatic crystals, parenchyma cells, pitted vessels, fibres, and oil globules are present.[19]
Fluorescence analysis	Number of fluorescent compound are present in leaves and when exposed to either shorter or longer UV light then emit fluorescence.[20]

(a) (b) (c)

Fig. 5: Showing (a)T.S of stem, (b) T.S of leaf, (c) T.S of Root of *Saussurea obvallata*.[19]

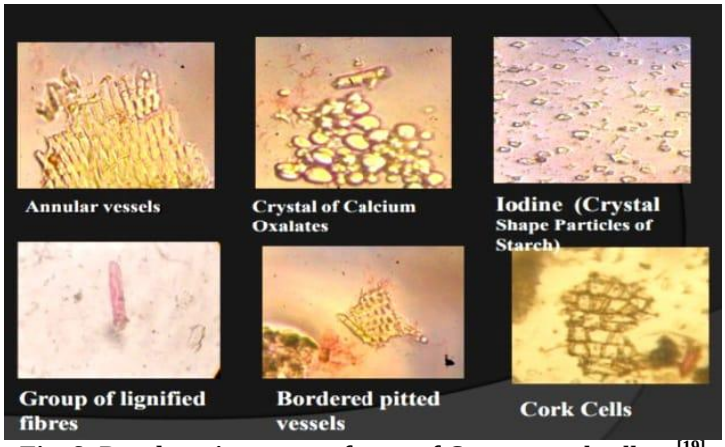


Fig. 6: Powder microscopy of stem of *Saussurea obvallata*.[19]

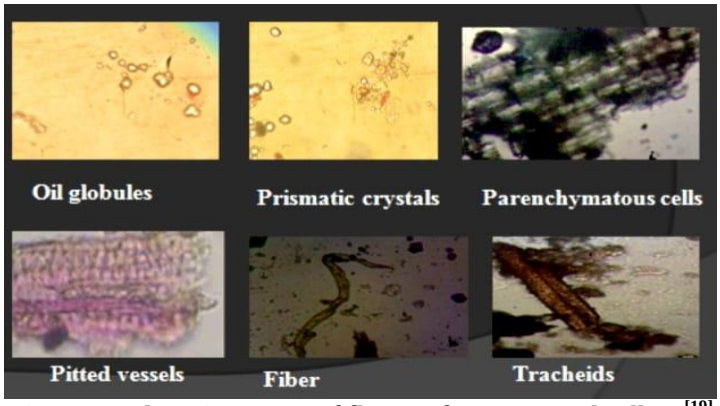


Fig. 7: Powder microscopy of flower of *Saussurea obvallata*.[19]

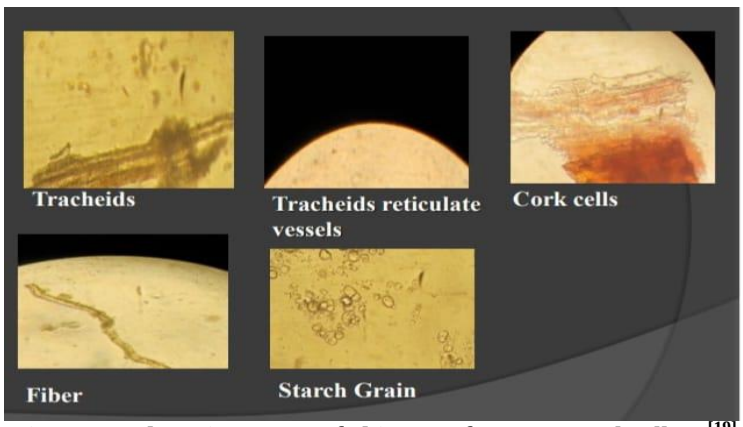


Fig. 8: Powder microscopy of rhizome of *Saussurea obvallata*.[19]

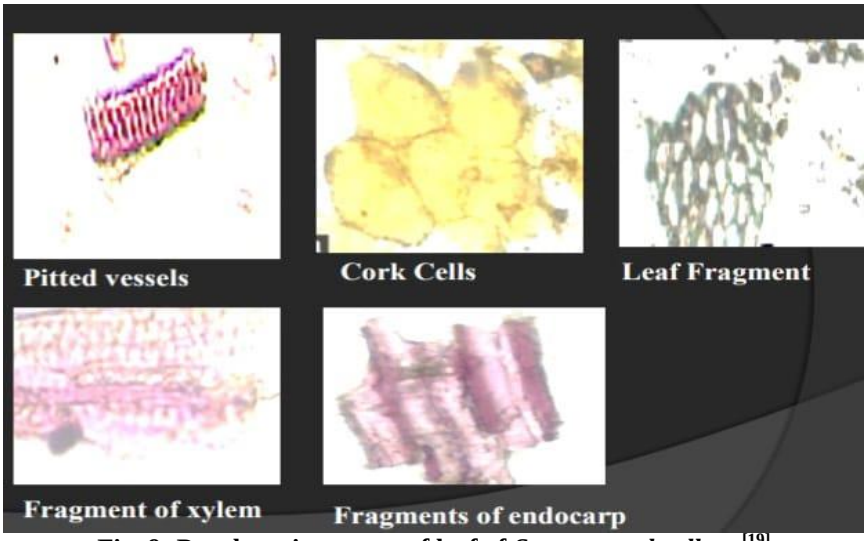


Fig. 9: Powder microscopy of leaf of *Saussurea obvallata*.[19]

3.6 CONSERVATION STATUS

Most of the species fall under the threatened category due to their widespread usage in various applications. Forty-four species belonging to this genus are classified as rare, and two as endangered (*S. obvallata* (DC.) Edgew; *S. simpsoniana* (Field&Gard.) Lipsch.) and two as critically endangered (*S. gossypiphora* D. Don; *S. costus* (Falc.) Lipsch.) due to extreme pressure on these plants for their various traditional uses.[2] Three plants of this genus are cited under IUCN Red List including, *Saussurea costus*, *Saussurea seoulensis*, and *Saussurea pinnatiphylla*.[21] All parts of S. obvallata are being utilized for various traditional, religious, medicinal, ornamental and socio-economic uses.[4] As a result of the various applications, the species has been ranked as an endangered species by the CAMP (Conservation Assessment Management Plan) and listed as one of the highest-ranking priority species for conservation.[22,23,5]

4. ETHNO-MEDICINAL USES

4.1. TRADITIONAL USE

The species is frequently used in traditional medicine, and continuing to play a primary role in the treatment of all kinds of old and new diseases. Most of the species in the genus Saussurea are being utilized in various traditional/folk medicine systems of India, China, Tibet, Nepal, Pakistan, Bangladesh, Uyghur, Mongolia, Kazakhstan, and other countries of Asia.[1,2] S. obvallata is utilized by the Himalayan people of Tibet, China, Nepal and Indian Himalaya for the treatment/remedy of numerous diseases and disorders like paralysis, cerebral ischemia, wounds, cardiac and mental disorders; some use it as antiseptic and for healing cuts, etc.[9,4,23, 24,25] Table 4 provides the details information of uses of S. obvallata.

Table 4: Traditional uses of *Saussurea obvallata*

Plant Parts	Ethno-pharmacological uses	Dosage form	Country	Referen-ces
Whole Plant	Utilized to treat cerebral ischaemia and limb paralysis.	-	Tibet	[25]
	Used to cure body pain including headaches.	Paste of whole plant is prepared and applied	India	[26]
	Utilized to shield woolen clothing from insects damage		India	[27]
	Utilized to cure bruises.	Paste of whole plant is prepared and applied	India	[28]
Roots	Utilized to treat cuts and bruises and also used as antiseptic.	Paste made from root is used.	India	[9,29]
	Utilized to treat cuts, bruises and boils.	Paste of root is prepared and applied	Pakistan	[30]
	Utilized to treat leucoderma.	Paste of root is prepared and applied	India	[31]
	Utilized to treat fever and cough.	-	India	[32,33]

	Utilized to treat cardiac disorders.	200 ml decoction of roots mixed with 100 ml (2-3 spoons full) of Cedrus deodar oil.	India	[24]
	Utilized to treat bruises and fracture.	200 ml decoction of roots mixed with 100 ml (2-3 spoons full) of Cedrus deodar oil.	India	[34]
Leaves	Utilized to treat cuts, wounds and boils.	100 ml Decoction of dried leaves blended with salt (half spoonful) and its few drops applied on the infected area; (20 ml × 3 days)	India	[34,24]
	Utilized to treat fractures and bruises.	200 ml decoction of dried leaves mixed with 100 ml (2-3 spoons full) of Cedrus deodar oil.	India	[24]
	Utilized to treat cuts and wounds.	100 gm of dried leaves mixed with 10 gm salt and applied on infected area.	India	[35]
Flower buds	Utilized to cure boils and to treat hydrocele and reproductive disorders.	-	India	[35]
	Utilized to treat cuts, bruises and boils.	Paste of flower is prepared and applied.	Pakistan	[30]
	Utilized to cure coughs, bone-ache, urinary track problems and intestinal ailments.	-	India	[23]
	Employed to cure cattle's urinary infections.	Raw form	India	[36]
	Head of flower are utilized to treat hydrocele.	Head of flower are roasted with ghee and given to patient (1-2 tea spoons full) for 3- 6 days in morning.	India	[37]
Bracts	Utilized to cure cough and problems related to respiration.	-	India	[37]
Seeds	Employed to cure mental disorders.	One cup of the seed powder was soaked in water for the entire night and then filtered.	India	[24]

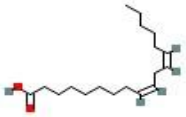
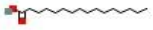
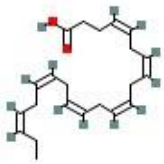
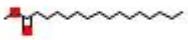
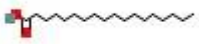
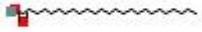
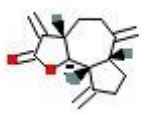
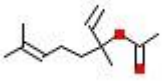
4.2 RELIGIOUS AND CEREMONIAL USE

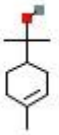
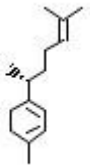
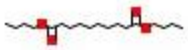
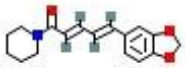
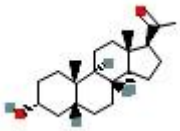
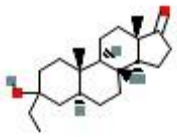
In traditional Indian system, *S. obvallata* has sacred importance in the Himalayan region and it is offered in various temples to local deities of sacred shrines like Kedarnath, Badrinath,Tungnath, Rudranath, and Triyuginarayan where it is dispensed as Prasaad (the vegetarian material substance dispensed in pilgrimage).[38] Locally, inflorescences are gathered and sold as single or in garland forms.[38]

5. PHYTOCHEMISTRY

Generally, medicinal plant produces a large number of secondary metabolites, but many Himalayan species of medicinal plants produces more due to cold stress caused by critical weather conditions.[39,40] These plants are gaining importance due to their unique therapeutic applications.[41,42] Previous reports on phyto-chemical investigations identified, saponins, phenol, tannins, terpenoids, flavonoids, glycosides, proteins, and alkaloids in the leaves and flowers extracts of *S. obvallata*.[6] The GC-MS methods reported the presence of squalene and α-linolenic acid methyl ester in petroleum ether extract of *S. obvallata*.[43] Another study on phytochemical investigations reported the qualitative and quantitative analysis of chemical constituents present in leaves and flower extracts of S. obvallata.[6,18] Preliminary investigations about the phytochemicals found in *S. obvallata* (qualitative) have been reported by Semwal[6], and its mineral composition has been described by Mishra et al.[44] The results of these studies showed the presence of 78 phytoconstituents in methanolic leaves and flowers extracts of S. obvallata. Few major compounds are presented in the Table 5.

Table 5: Some of the major constituents in *S. obvallata* extracts.[18]

Compounds	Molecular Formula	PubChem CID	Chemical Structure (2D)
Linoleic acid	C18H32O2	5280450	
Palmitic acid	C16H32O2	985	
Doconexent	C22H32O2	445580	
Methyl palmitate	C17H34O2	8181	
Stearic acid	C18H36O2	5281	
1-Docosanol	C22H46O	12620	
Gondoic acid	C20H38O2	5282768	
Henicosanoic acid	C21H42O2	16898	
Methyl oleate	C19H36O2	5364509	
Pentacosanoic Acid	C25H50O2	10468	
Dehydrocostus lactone	C15H18O2	73174	
Linalyl acetate	C12H20O2	8294	

Litsomentol	C30H52O2	12311315	
α –Terpineol	C10H18O	17100	
γ-Curcumene	C15H24	12304273	
Dibutylsebacate Piperine	C18H34O4	7986	
Piperine	C17H19NO3	638024	
Eltanolone	C21H34O2	31402	
Androstan-17-one, 3-ethyl-3-hydroxy-, (5alpha)-	C21H34O2	14681481	
Methyl asterrate	C18H18O8	5249326	
Bupleuronol	C17H20O2	46881232	

Gas chromatography-mass spectrometry (GC–MS) analyses

Gas Chromatography-Mass Spectrometry (GC-MS) analyses of crude methanolic extracts of flowers and leaves of *S. obvallata* have been conducted for identifying active components.[45] GC-MS analyses and identification of components of methanolic extracts of leaves and flowers of Saussurea obvallata were conducted at the University Science Instrumentation Centre, Jawaharlal Nehru University, Delhi, India. The analyses were conducted according to Ezhilan and Neelamegam[46], and Das.[47]

GC-MS analyses of methanolic leaf extracts of *Saussurea obvallata*

Result of GC-MS analysis of *Saussurea obvallata* leaf methanolic extracts of revealed the presence of 36 components, on the basis of separation of individual peaks by GC according to their retention time (Rt) and area per cent under individual peaks.

Major constituents in the methanolic leaf extract of *S. obvallata* were:Linoleic acid (22.50%); Dehydrocostus lactone (21.98%); Palmitic acid (11.84%); Eltanolone (11.43%); and Doconexent (9%).[18]

Table 6: Chemical composition of methanolic leaf extract of *Saussurea obvallata*.[18]

Sr. no.	Name of Components	Molecular Formula	Area per cent (%)
1	Octyl cyanide	$C_9H_{17}N$	0.17
2	Benzeneacetaldehyde	C_8H_8O	0.10
3	Pyranone	$C_6H_6O_4$	0.72
4	Pentadecane	$C_{15}H_{32}$	0.21
5	(RS)-nicotine	$C_{10}H_{14}N_2$	0.07
6	Tetradecane	$C_{14}H_{30}$	0.27
7	Amantadine	$C_{10}H_{17}N$	0.18
8	Hexadecane	$C_{16}H_{34}$	0.16
9	α-Bisabol oxide B	$C_{15}H_{26}O_2$	0.15
10	Blumeno C	$C_{13}H_{22}O_2$	0.12
11	Tetradecanoic acid	$C_{14}H_{28}O_2$	0.10
12	N-Acetylimidazole	$C_5H_6N_2O$	0.15
13	Androsterone, trifluoroacetate	$C_{21}H_{29}F_3O_3$	0.08
14	Phytol	$C_{20}H_{40}O$	0.25
15	Diisobutyl phthalate	$C_{16}H_{22}O_4$	0.06
16	Etlanolone	$C_{21}H_{34}O_2$	11.43
17	Proximadiol	$C_{15}H_{28}O_2$	9.04
18	Docosenext	$C_{22}H_{42}O_2$	9.00
19	Palmitic acid	$C_{16}H_{32}O_2$	11.84
20	Dehydrocostus lactone	$C_{15}H_{18}O_2$	21.98
21	Strophanthidin	$C_{30}H_{44}O_6$	0.25
22	n-Nonadecanol-1	$C_{19}H_{40}O$	0.11
23	Methyl linoleate	$C_{19}H_{34}O_2$	0.26
24	Linoleic acid	$C_{18}H_{32}O_2$	22.50
25	Stearic acid	$C_{18}H_{36}O_2$	2.38
26	1-Docosanol	$C_{22}H_{46}O$	1.75
27	Methyl oleate	$C_{19}H_{36}O_2$	0.09
28	Bupleurolol	$C_{17}H_{20}O_2$	1.23
29	Andrographolide	$C_{20}H_{30}O_5$	0.31
30	Nitrocylododecane	$C_{12}H_{23}NO_2$	0.16
31	1,2-Benzenedicarboxylic acid	$C_{24}H_{38}O_4$	0.10
32	Stachydrine	$C_7H_{13}NO_2$	0.37
33	Gama-Stearolactone	$C_{18}H_{34}O_2$	0.91
34	Talaroconvolutin B	$C_{32}H_{43}NO_4$	0.11
35	22-Tricosenoic acid	$C_{23}H_{44}O_2$	0.68
36	Litsomontol	$C_{30}H_{52}O_2$	2.25

Total identified compounds: 90.70%
Unknown compounds: 00.36%

GC-MS analyses of methanolic flower extracts of *Saussurea obvallata*

The results of GC-MS analyses of *Saussurea obvallata* methanolic flower revealed the presence of 48 components, on the basis of separation of individual peaks by GC according to their retention time (Rt) and area per cent under individual peaks.

Major constituents in *S. obvallata* methanolic flower extract are:

Methyle palmitate (12.18%); Linalyl acetate (4.94%); Palmitic acid (4.65%); Methyl stearate (3067%).[18]

Table 7: Chemical composition of methanolic extract of flowers of *Saussurea obvallata*.[18]

Sr. no.	Name of Components	Mol. Formula	Area per cent (%)
1	α-Terpineol	$C_{10}H_{18}O$	0.04
2	Methyl octanoate	$C_9H_{18}O_2$	0.35
3	Cinnamaldehyde	C_9H_8O	0.44
4	Amyl acetate	$C_7H_{14}O_2$	0.94
5	Eugenol	$C_{10}H_{12}O_2$	0.66
6	Geranyl ethyl ether	$C_{12}H_{22}O$	1.21
7	Eugenene	$C_{10}H_{10}O$	0.56

8	n-Heptadecanol-1	$C_{17}H_{36}O$	0.08
9	Caryophyllene oxide	$C_{15}H_{24}O$	0.56
10	Geranyl linalool isomer b	$C_{10}H_{18}O$	0.14
11	n-Pentadecanol	$C_{15}H_{32}O$	0.53
12	Heptadecane	$C_{17}H_{36}$	0.59
13	Pentadecyclic acid	$C_{15}H_{30}O_2$	0.42
14	Methyl palmitoleate	$C_{17}H_{32}O_2$	0.38
15	Methyl palmitate	$C_{17}H_{34}O_2$	1.18
16	Bicycloheptyl	C_7H_{12}	0.12
17	Palmitic acid	$C_{16}H_{32}O_2$	0.91
18	Stearic acid	$C_{18}H_{36}O_2$	0.43
19	Lignoceric acid	$C_{24}H_{48}O_2$	0.45
20	Methyl stearate	$C_{19}H_{38}O_2$	0.61
21	Camphor	$C_{10}H_{16}O$	0.96
22	Dibutyl sebacate	$C_{18}H_{34}O_4$	1.05
23	Methyl linoleate	$C_{19}H_{34}O_2$	0.11
24	Prodlure	$C_{13}H_{20}O$	0.14
25	Menthyl acetate	$C_{12}H_{22}O_2$	0.12
26	Rishitin	$C_{14}H_{22}O_2$	0.07
27	1-Docosanol	$C_{22}H_{46}O$	0.09
28	Methyl linolenate	$C_{19}H_{32}O_2$	0.14
29	Methyl oleate	$C_{19}H_{36}O_2$	0.11
30	Henicosanoic acid	$C_{21}H_{42}O_2$	2.24
31	Bornyl cinnamate	$C_{18}H_{24}O_2$	1.21
32	Gama-Stearolactone	$C_{18}H_{34}O_2$	0.22
33	Docosanoic acid	$C_{22}H_{44}O_2$	0.32
34	Tridecanoic acid	$C_{13}H_{26}O_2$	0.11
35	Gondoic acid	$C_{20}H_{38}O_2$	2.92
36	Tricosanoic acid	$C_{23}H_{46}O_2$	1.46
37	Deflazacortalcohol	$C_{21}H_{29}NO_5$	0.10
38	Methyl nervonate	$C_{24}H_{46}O_2$	0.15
39	Pentacosylic acid	$C_{25}H_{50}O_2$	0.17
40	Squalene	$C_{30}H_{50}$	0.52
41	17-Pentatriacontene	$C_{35}H_{70}$	0.06
42	Eicosane	$C_{20}H_{42}$	0.11
43	Piperine	$C_{17}H_{19}NO_3$	0.18
44	Nonacosane	$C_{29}H_{60}$	0.18
45	β-Sitosterol	$C_{29}H_{50}O$	0.17
46	Tetratriacontene	$C_{34}H_{68}$	0.10

Total identified compounds: 50.70%
Unknown compounds: 39.53%

10. PHARMACOLOGICAL ACTIVITIES

Phyto-chemicals present in Brahma kamal exhibit certain pharmacological activities:

Table 8: Bioactive Components Present in the Methanolic Extracts of Leaves and Flowers of *Saussurea obvallata.*

SN	Components	Biological Activity	References
1	Benzeneacetaldehyde	Anti-microbial, anti-inflammatory.	[48]
2	Pyrazone	Anti-microbial, anti-inflammatory, anti-oxidant, anti-proliferative.	[49]
3	Tetradecanoic acid	Anti-fungal, anti-oxidant, cancer-preventive, cosmetic.	[50]
4	Phytol	Anti-microbial, anti-inflammatory, anti-nociceptive.	[51]
5	Palmitic acid	Anti-androgenic, hemolytic, cancer preventive, sunscreen, perfumery.	[52]

6	Methyl linoleate	Hepatoprotective, anti-microbial.	[53]
7	Linoleic acid	Anti-inflammatory, anti-microbial.	[54,55]
8	Gamma-Sitosterolactone	Anti-tumor, anti-inflammatory, anti-convulsant activity.	[53, 56–58]
9	α-Terpeniol	Contractile activity; anti-bacterial; anti-microbial; insecticidal.	[58–62]
10	Cinnamaldehyde	Anti-cancer, anti-microbial, anti-oxidant.	[63]
11	Curcumin	Anti-tumor, anti-bacterial, anti-inflammatory, sedative, fungicide.	[64–69]
12	Nerolidol	Anti-tumor, analgesic, anti-inflammatory, sedative, fungicide.	[70, 71]
13	n-Heptadecanol-1	Anti-microbial, anti-inflammatory.	[72,73]
14	Caryophyllene oxide	Anti-inflammatory, anti-oxidant.	[74–78]
15	Pentacosylic acid	Anti-bacterial.	[53, 78,79]
16	1-Docosanol	Anti-oxidant, anti-herpetic agent, wounds, anti-herpes.	[80-82]
17	Methyl acetate	Anti-oxidant, anti-microbial, anti-inflammatory and phyto-toxic.	[83]
18	Piperine	Anti-oxidant, anti-microbial, anti-tumor, pesticide.	[84,85]
19	β-Sitosterol	Anti-microbial, thyroid inhibitory, hypoglycemic effects.	[86, 87]
20	Stigmasterol	Anti-oxidant, thyroid inhibitory, hypoglycemic effects.	[86,87]
21	Squalene	Anti-oxidant, anti-microbial, cancer preventive, pesticide.	[88]

Antioxidant activity: ROS are molecules with a very short t1/2 and are very reactive because of their incomplete valances. Overproduction of free radicals causes oxidative stress. Oxidative stress is thought to be involved in many age-related diseases like Alzheimer's, Parkinson's, arthritis, and cancer.[89] Antioxidants are compounds that battle free radicals and inhibit oxidative stress.[90] Aqueous and methanol extract of *Saussurea obvallata* leaves and flowers were tested by using a standard diphenylpicrylhydrazyl and hydrogen peroxide assay against ascorbic acid. The researchers found that methanol and aqueous extracts of flowers exhibited 82.88 ± 0.48% and 29.25 ±0.86%, of free radical scavenging activity of DPPH.[18]

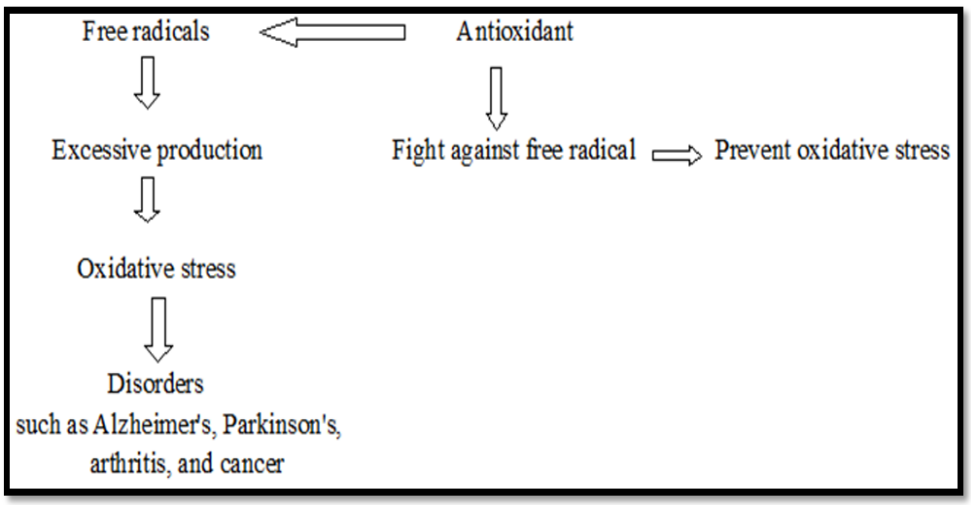


Fig. 10: Role of antioxidant in preventing oxidative stress.

Anticancer and radioprotective activity: Liang-wen and his colleagues explored the radioprotective activity of *S. obvallata* and proposed that *S. obvallata* may cause a dose-dependent effect of radioprotection in radiation-exposed animals, But Ying et al. 2015 revealed that the aqueous extract of *S. obvallata* exhibits moderated radioprotective activity. Also, a review article revealed that the when leaf and flower extracts of *S. obvallata* were tested for their anticancer potential against MCF-7 breast cancer cell lines, the result of the study indicated that the extracts possess a noteworthy anticancer activity when compared with the positive control.[91]

Wound healing activity: Wound healing is a dynamic biological process of the body in which the dead and damaged cells are replaced by newly formed cells or tissue. Inflammation, tissue repair, and remodeling are the primary steps involved in wound healing. The ethanol extract of leaf of Brahma kamal showed the excellent wound healing activity in experimental animals compared to control 10% w/w Povidone-iodine ointment.[92]

Antibacterial and antifungal activity- Mishra studied the antibacterial properties of *S. obvallata* leaves against gram-positive and gram-negative bacteria. Petroleum ether extract exhibited tremendous antibacterial activity with 87.2 ± 1.6, 98.4 ± 1.1, and 90.2 ± 1.8 µg/ml, respectively.[42] The results of the research proved that the minimum inhibitory concentration of petroleum ether extract was just a little greater for gram-negative than gram positive bacteria. Additionally, Semwal and Painuli also studied the antibacterial and antifungal activity of Saussurea obvallata leaves and flowers against the four strains of bacteria (Pseudomonas aeruginosa, Escherichia coli, Staphylococcus aureus, and Klebsiella pneumonia bacteria) and three strains (Candida albicans, Candida glabrata, and Candida tropicalis) of fungus. Both Saussurea obvallata leaf and flower extracts exhibited strong antibacterial activity against all the three bacterial strains.[18] It also contain Cinnamaldehyde which show antimicrobial property.[63]

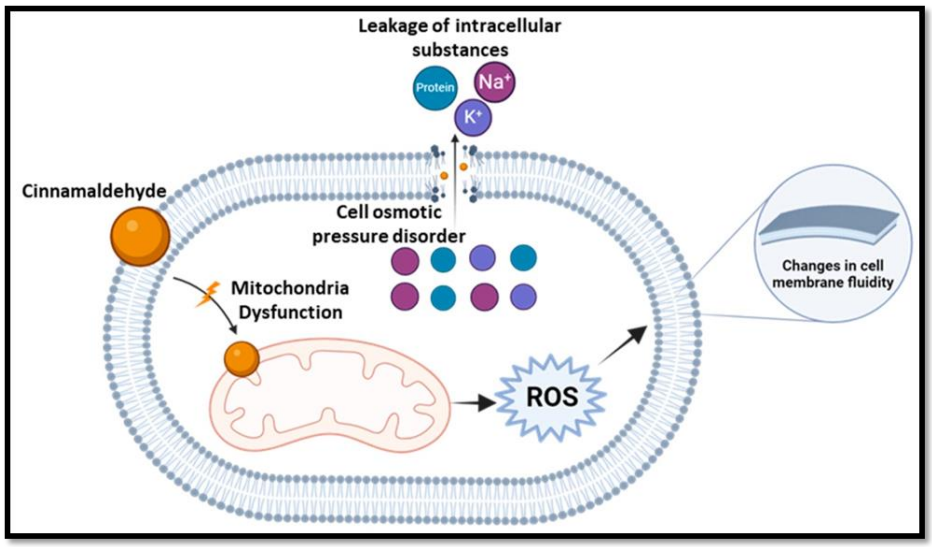


Fig. 11: Mechanism of action of cinnamaldehyde as antimicrobial.[93]

Anti-hypoxic activity: Ma tested the 20 herbs for their anti-hypoxic activity with a Normobaric hypoxia model and estimated Brahma Kamal to have the highest survival time among the other herbs.[94] For Schurr, the level of lactic acid in the blood is an indication of anaerobic respiration because the higher the concentration of lactic acid, the lower the anti-hypoxic activity. The bioactive phytoconstutents found in petroleum ether fraction of Brahma Kamal could be useful in the treatment of acute mountain sickness.[95]

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