The Therapeutic and Biotechnological Potential of : *Pogostemon benghalenesis,* A Comprehensive Review

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ABSTRACT

Pogostemon benghalensis is a fragrant perennial shrub belonging to the family Lamiaceae, widely distributed across tropical and subtropical regions of Asia. It has been extensively utilized in traditional and ethnomedicinal systems for the treatment of wounds, skin infections, fever, digestive disorders, inflammation, and respiratory ailments. The plant is also valued for its antiseptic, aphrodisiac, insect-repellent, and veterinary medicinal properties. Its leaves, roots, and essential oil are incorporated into herbal formulations, natural dyes, cosmetics, and traditional healthcare practices. Recent phytochemical investigations have identified more than 140 bioactive constituents, including sesquiterpenes, monoterpenes, flavonoids, alkaloids, phenolic compounds, lignans, glycosides, tannins, and triterpenoids, which contribute to its diverse biological activities. Experimental studies have demonstrated that these phytochemicals possess significant antibacterial, antifungal, antiviral, antioxidant, anti-inflammatory, larvicidal, hepatoprotective, neuroprotective, and cytoprotective properties. The essential oil exhibits remarkable free radical scavenging activity, inhibition of lipid peroxidation, and potent antimicrobial efficacy, highlighting its therapeutic potential. In addition to its medicinal importance, *P. benghalensis* has emerged as a promising source of eco-friendly biopesticides for sustainable agriculture. Its bioactive metabolites exhibit insecticidal, larvicidal, and pest-repellent activities against several agricultural pests, offering an environmentally safe alternative to synthetic pesticides and contributing to crop protection and environmental restoration. Furthermore, the plant has considerable industrial significance due to its applications in pharmaceutical formulations, herbal cosmetics, perfumery, food preservation, natural fragrances, bioactive packaging materials, and green agricultural products. This review comprehensively summarizes the phytochemistry, pharmacological properties, therapeutic potential, biopesticidal applications, and industrial prospects of *Pogostemon benghalensis*, emphasizing its potential as a valuable natural resource for future drug discovery, sustainable crop management, and environmentally responsible industrial development.

Keywords-

Pogostemon benghalensis, patchouli, ethno medicine, sesquiterpenes, flavonoids, alkaloids, lignans, and glycosidesantimicrobial, anti fungal, anti tumor , antioxidant, patchouli alcohol, hepatoprotective, neuroprotective, phytopharmacology, bio pesticide

INTRODUCTION-

Medicinal plants are an essential source of biologically active compounds and continue to contribute significantly to the pharmaceutical, cosmetic, food, and fragrance industries. Despite advances in synthetic drug development, plant-derived metabolites remain important for the discovery of new therapeutic agents because of their structural diversity and broad pharmacological potential. Consequently, medicinal plants continue to play a central role in both traditional medicine and modern healthcare systems.

Pogostemon benghalensis (Burm.f.) Kuntze is an aromatic shrub native to South and Southeast Asia, commonly distributed across India, Nepal, Bangladesh, Myanmar, Sri Lanka, China, Thailand, Vietnam, and Bhutan. The leaves contain an essential oil rich in sesquiterpenes, obtained mainly through steam distillation. Traditionally, the plant has been used as a medicinal herb, natural insect repellent, and fragrance source. Its essential oil is widely incorporated into perfumes, cosmetics, soaps, incense, and selected food products because of its distinctive aroma and fixative properties.

The therapeutic value of P. benghalensis is largely associated with its sesquiterpenes and phenolic constituents, particularly patchouli alcohol, the principal bioactive compound. Experimental studies have demonstrated that this compound possesses neuroprotective potential and may improve cognitive performance. In addition, the essential oil exhibits a wide range of biological activities, including antimicrobial, antioxidant, anti-inflammatory, antiviral, analgesic, immunomodulatory, and antiemetic effects. These pharmacological properties highlight the potential of P. benghalensis as a promising natural source for future therapeutic and functional health applications.

Leaf Morphology:
Pogostemon species are evergreen perennial shrubs with opposite, ovate leaves that contain abundant glandular and non-glandular trichomes, particularly on the lower leaf surface and along the veins. The glandular trichomes are responsible for the production and storage of essential oil. Fresh leaves have a mild aroma that becomes stronger after drying or fermentation because of changes in volatile compounds. The plant is illustrated in **Figure 1**. Essential oil content varies with cultivar, plant age, and environmental conditions, typically ranging from 0.25–0.75% in fresh leaves. After drying, which removes most of the leaf moisture, oil yield generally increases to 1.8–2.5%, with optimized extraction methods producing yields of up to 5%.

Figure 1. Photograph of *Pogostemon patchouli*

Floral morphology of PP under stereoscope:

Pogostemon produces terminal spike-like inflorescences composed of densely arranged flower clusters. The flowers have a tubular calyx and a bilabiate corolla with purple and white coloration. Four protruding stamens and a long, exserted style facilitate pollination. After flowering, small brown seeds develop inside tiny capsules along the spikes. The plant possesses a well-developed, branched root system that extends deep into the soil, while its leaves, flowers, and seeds all emit a characteristic aromatic fragrance.

Leaf Microscopy:

Microscopic observations indicate that essential oil-producing secretory structures are present in the leaf blade, margins, and petiole of *Pogostemon*. Glandular trichomes are far more abundant on the leaf lamina than on the petiole and occur in greater numbers on the lower leaf surface than on the upper surface. They are distributed throughout the leaf but are most concentrated along the veins, reflecting their important role in essential oil synthesis and storage.

Table 1:

Secondary metabolites	**Chemical constituents**
Sesquiterpenes	Patchouli alcohol, cycloseychellene, pogostol, norpatchoulenol, cadinene, α-patchoulene, β-patchoulene, seychellene α-bulnsene, α-guaiene, β -elemene, α- humulene, caryophyllene
Sesquiterpene alkaloids	Patchouli-pyridine, epiguaipyridine, guaipyridene
Oxygenated sesquiterpenes	1α, 5α-epoxy-α-guaiene, 1,10-epoxy-alphabulnesene, epoxycaryophyllene
Phenolic compounds, Flavonoids, flavonoid glucosides	Eugenol, rhamnetin, apigenin,, Lichochalcone A, ombuine, pachypodol, kumatakenin, 7, 4'-di-o-methyleriodictyol, 7, 3', 4'-tri- o-methyleriodictyol, 3, 7, 4'-tri-o-methylkaemferol

Habitat and distribution

The genus Pogostemon belongs to the family Lamiaceae, one of the largest families of flowering plants. It comprises about 40 species that are mainly distributed across the tropical and subtropical regions of Asia, with China and India being important centers of diversity. Although native to tropical Asia, Pogostemon is cultivated in several countries, while commercial essential oil production is primarily carried out in India, Brazil, Taiwan, and the Seychelles.

Figure 2: Phytoconstituents from *Pogostemon patchouli* [32.33]

Phytochemical studies

Pogostemon benghalensis is an aromatic member of the **Lamiaceae** family that has attracted considerable attention because of its rich phytochemical composition. Its essential oil is dominated by sesquiterpenes, along with smaller amounts of monoterpenes and diterpenes, which contribute to its antimicrobial, antioxidant, anti-inflammatory, and other pharmacological properties. The plant also contains flavonoids, alkaloids, and chalcone derivatives with reported cytotoxic and antimutagenic activities. Owing to its pleasant aroma, the essential oil is widely used in perfumes, cosmetics, aromatherapy, and traditional medicine. Although cultivated for its economic value, the species has become invasive in some regions due to its rapid growth, efficient vegetative propagation, and ability to adapt to diverse environmental conditions.

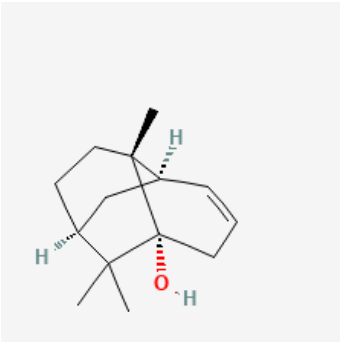
Table II denoting major phytochemiacals retrieved from the essential oil of Patchouli

No.	Phytochemical Compound	Molecular Formula	Molecular Class	Structural Skeleton / Type
1	Patchoulol (Patchouli alcohol)	C15H26O	Oxygenated sesquiterpene	Patchoulane tricyclic alcohol

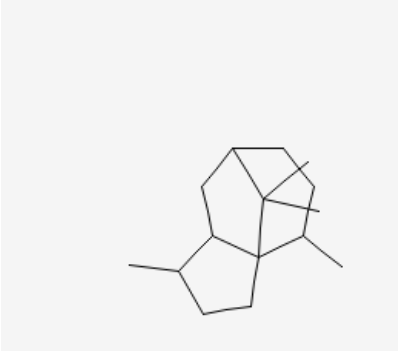
2	α-Bulnesene	C15H24	Sesquiterpene hydrocarbon	Bulnane skeleton
3	α-Guaiene	C15H24	Sesquiterpene hydrocarbon	Guaiane bicyclic
4	Seychellene	C15H24	Sesquiterpene hydrocarbon	Guaiane derivative
5	Pogostol	C15H26O	Oxygenated sesquiterpene	Patchoulane alcohol
6	Norpatchoulenol	C14H24O	Oxygenated sesquiterpene	Patchoulane derivative
7	β-Patchoulene	C15H24	Sesquiterpene hydrocarbon	Patchoulene skeleton
8	α-Patchoulene	C15H24	Sesquiterpene hydrocarbon	Patchoulene skeleton
9	γ-Patchoulene	C15H24	Sesquiterpene hydrocarbon	Patchoulene skeleton
10	β-Caryophyllene	C15H24	Sesquiterpene hydrocarbon	Caryophyllane bicyclic
11	Caryophyllene oxide	C15H24O	Oxygenated sesquiterpene	Epoxidized caryophyllane
12	δ-Guaiene	C15H24	Sesquiterpene hydrocarbon	Guaiane skeleton
13	β-Guaiene	C15H24	Sesquiterpene hydrocarbon	Guaiane skeleton
14	α-Humulene	C15H24	Sesquiterpene hydrocarbon	Humulane monocyclic
15	Germacrene D	C15H24	Sesquiterpene hydrocarbon	Germacrane skeleton
16	Germacrene B	C15H24	Sesquiterpene hydrocarbon	Germacrane skeleton
17	β-Elemene	C15H24	Sesquiterpene hydrocarbon	Elemane skeleton
18	α-Selinene	C15H24	Sesquiterpene hydrocarbon	Selinane skeleton
19	β-Selinene	C15H24	Sesquiterpene hydrocarbon	Selinane skeleton
20	Viridiflorene	C15H24	Sesquiterpene hydrocarbon	Eremophilane derivative
21	Ledene	C15H24	Sesquiterpene hydrocarbon	Ledane skeleton

22	Cubebol	C15H26O	Oxygenated sesquiterpene	Cubebane alcohol
23	Nerolidol	C15H26O	Sesquiterpene alcohol	Acyclic sesquiterpene
24	Farnesol	C15H26O	Sesquiterpene alcohol	Acyclic terpene alcohol
25	Spathulenol	C15H24O	Oxygenated sesquiterpene	Aromadendrane skeleton
26	Globulol	C15H26O	Oxygenated sesquiterpene	Eudesmane alcohol
27	Eudesmol (α-Eudesmol)	C15H26O	Oxygenated sesquiterpene	Eudesmane alcohol
28	β-Eudesmol	C15H26O	Oxygenated sesquiterpene	Eudesmane alcohol
29	Patchouli epoxide	C15H24O	Oxygenated sesquiterpene	Epoxidized patchoulene
30	Azulene derivatives	~C15H18	Aromatic sesquiterpene	Azulene bicyclic

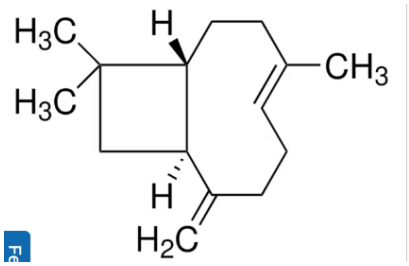
Molecular diagram of some potent Phytochemical compounds present in the Patchouli plant



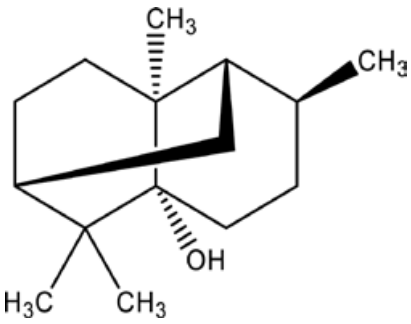
Norpatchoulenol



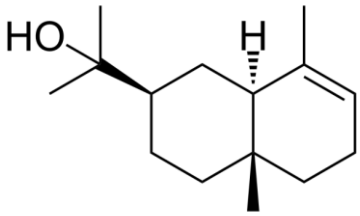
β-Patchoulene



B- Caryophyllene



Patchoulol



Eudesmol (α-Eudesmol)

Taxonomical classification

Pogostemon benghalensis (patchouli) is a flowering, vascular plant of the family Lamiaceae (mint family) and the order Lamiales. It is an aromatic dicot widely recognized for its essential oil and medicinal importance. Morphologically, it is an erect shrub or undershrub with square, hairy stems and opposite, broad ovate leaves having serrated margins. The plant bears fragrant pink to purple or whitish flowers arranged in terminal spikes (verticillasters), while its well-developed fibrous roots enable adaptation to diverse soil conditions. The fruit consists of four small nutlets, and the leaves contain secretory structures responsible for essential oil production

Cultivation:

Pogostemon benghalensis is mainly cultivated for its essential oil, which is obtained from the leaves. The plant grows best in warm, humid climates with fertile, well-drained soil. It is commonly propagated through stem cuttings because they establish more quickly and uniformly than seeds. Appropriate irrigation, regular pruning, and effective pest management are important for maintaining healthy growth and maximizing essential oil yield.

Chemical Composition:

The essential oil derived from patchouli leaves is the most valuable component of the plant. It comprises numerous chemical constituents, such as patchouli alcohol, α-bulnesene, β-patchoulene, and seychellene. Patchouli alcohol, in particular, is the main component responsible for the characteristic aroma and plays a vital role in its various applications.

Vernacular names of Pogostemon benghalenese-

Category	**Details**
Scientific Name	*Pogostemon benghalensis* (=*Pogostemon fructescens* J. Garham, *Pogostemon indicus* (Roth) Kuntze, *Pogostemon purpuricaulis* Dalzell., *Origanum benghalense* Burm.f., *Origanum indicum* Roth, *Mentha integra* Buch.-Ham. Ex Benth.)
Family	Lamiaceae
Order	Lamiales
Common Names	Bengali Pogostemon, Kukeseene Patchouli
Vernacular Names	
Kala Basing	
Lujrya	
Ishwar jata	Hindi
Jui-lata	Bengali
Sukloti	Assamese
Lamgi thoiding	
Pangli	Marathi
Dumobadotoko	Oriya
Poksunga	Oriya
Bhoothachedayan	Malayalam
Arissikai	Tamil
Naati Pachhe thene	Kannada
Pedda Tulasi	Telugu

Gondripula	Telugu
Kasurijang	Telugu
Niam ja ngu	
Rguutili (Dwarpaani)	
Kali-bant	Tharu (Nepalese)
Kali Suhali	Pakistan

Leaves: Fresh leaves are used as poultices to clean wounds and promote their healing. Its essential oil is antifungal[1]. It is also used as styptic [1].S.B. Padal et.al reported leaves are used in fever. [8] Chandra B.N. et.al reported leaf juice administered for fever [9].Kamble et.al reported putting leaf juice on dried gum of Sturculia urens, fried with til oil, becomes black is taken in empty stomach for treating piles [10].

Leaves and shoots are used as Blackish blue Dye.

Stems: Ashes of stems are reported to be used as manure for paddy crops [2].

Roots: Root used in Haemorrhage especially in uterine haemorrhage[1].

Ethnopharmacological Traditional Uses

The essential oil of *Pogostemon benghalensis* is obtained mainly from dried leaves by steam distillation. It contains sesquiterpenes, with patchoulol being the major constituent responsible for its characteristic earthy aroma and long-lasting fragrance. Because of its excellent fixative properties, the oil is widely used in perfumes, cosmetics, soaps, hair care products, and aromatherapy formulations.

Traditionally, the plant has been used to manage respiratory disorders, digestive complaints, skin diseases, wounds, fever, and insect bites. Modern studies also suggest that its essential oil possesses antimicrobial, anti-inflammatory, antifungal, antioxidant, and wound-healing properties, supporting many of its traditional applications.

Besides its medicinal importance, *P. benghalensis* has economic value as a source of essential oil, natural dyes, and aromatic products. In some regions, however, it behaves as an invasive species because of its rapid growth and adaptability, making proper cultivation and management necessary.

Nutritive value Nutritional analysis of Pogostemon benghalensis leaves indicates that they contain carbohydrates, proteins, dietary fibre, fatty acids, tannins, and high moisture content. Fatty acid profiling has identified palmitic acid along with essential unsaturated fatty acids, including oleic, linoleic, and linolenic acids, which contribute to the plant's nutritional and potential health benefits.

Ethnobotanical uses

Different parts of *Pogostemon benghalensis*, particularly the leaves and roots, have long been used in traditional medicine by indigenous communities across Asia. The plant is prepared as decoctions, fresh extracts, infusions, or poultices to treat digestive disorders, fever, skin ailments, and various common illnesses. It is also valued in aromatherapy for its calming, antiseptic, and skin-protective properties, reflecting its importance in traditional healthcare practices.

Pharmaceutical activity Various medicinal properties have been studied with the P. benhalensis plant. Some of the activities of the plant such as antibacterial, antiviral, antioxidant, anti-fungal and anti inflammatory and discussed below..

Antibacterial activity - Extracts and essential oil of *Pogostemon benghalensis* have demonstrated notable antibacterial activity against both Gram-positive and Gram-negative bacteria. Studies have shown inhibitory effects against pathogens such as *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Salmonella typhi*. The essential oil has exhibited particularly strong antibacterial activity, supporting the traditional use of the plant in managing infections, wounds, dysentery, and other bacterial diseases. Differences in antimicrobial efficacy among studies are likely related to variations in plant source, extraction methods, and chemical composition.

Antivirus effect- Pogostemon benghalensis has traditionally been used to treat colds, coughs, and dysentery, suggesting possible antiviral properties. Experimental studies indicate that methanolic extracts of the aerial parts exhibit selective antiviral activity, showing inhibitory effects against Sindbis virus, while limited or no significant activity has been reported against certain other mammalian viruses. These findings suggest that the plant may possess antiviral potential, although further studies are needed to confirm its clinical significance.

Antifungal activity *Pogostemon benghalensis* has been traditionally used to treat fungal skin infections such as scabies and ringworm. Scientific studies have confirmed its antifungal potential, with methanolic extracts and essential oil showing activity against several pathogenic fungi, including *Microsporum gypseum*, *Trichophyton mentagrophytes*, *Fusarium* species, and *Candida albicans*. These findings support its traditional use as a natural antifungal agent and highlight its potential for developing plant-based antifungal therapies.

Antioxidant activity

Singh et al. study evaluated the antioxidant activity of the crude essential oil of ten species of Lamiaceae, including P. benghalensis, using the1,1-diphenyl-2-picrylhydrazyl radical (DPPH)scavenging method. activity and total antioxidant activity (TAA).P. Benghalensis essential oil showed scavenging activity for DPPH and TAA with an EC50 value (half maximum effective concentration) of 171.3 ± 5.74µg/mL, 89.5 ± 2.33 µg/mL, where the corresponding values of DP n e., pH standard butylhydroxytoluene (BHT) and standard removing acid of ascorbic acid forTAA were 156.4 and 165.7 µg/ml. The EC50 value of pogostemon oil was almost close to the standard value for DPPH scavenging activity, and the EC50 value of TAA waslower than the standard value (10)..

Larvicidal activity

Anjana and Thoppil evaluated the larvicidal potential of four types of patchouli essent ial oils, including P bengali, against fourstage larvae of Aedes albopictus. P. benghale nsis essential oil showed 100% larval mortality at concentrations of 100 and 200 ppm as a function of the sesquiterpenerich essential oil (9). Some reports suggest larvicid al effect.

Anti-tumor effect

Patel et al reported the antitumor effect of P.benghalensis and reported that the MST (median survival time) of mouse tumors when treated with HEEPB (hydro ethanol extract) was significant.AEPB (aqueous extract) and 5.-FU (5 fluorouracil) for tumor control. At one month, mice treated with 5-FU (20 mg/kg), HEEPB (500 mg/kg), and nAEPB showed a tumor volume of ±1.90 mL, whereas mice treated with 5FU (20 mg/kg), HEEPB The amount of rats treated w ith (500 mg/kg) was 1.67 mL and 1.62 mL (500 mg/kg). Compared with tumor contro l mice with tumor volume ≤3 ml

Conclusions

Pogostemon benghalensis is a medicinally important aromatic plant with a rich phytochemical profile, including sesquiterpenes, flavonoids, phenolics, tannins, steroids, and essential oils. Its chemical composition varies with geographical location, climate, plant maturity, and extraction methods. Numerous experimental studies have demonstrated antibacterial, antifungal, antiviral, antioxidant, anti-inflammatory, anticancer, and insecticidal activities of its extracts and essential oil, supporting its

traditional medicinal use. Despite these promising findings, evidence from animal studies and clinical trials remains limited. Future research should focus on isolating bioactive compounds, understanding their mechanisms of action, and conducting well-designed preclinical and clinical studies to validate their therapeutic potential. Sustainable cultivation and efficient utilization of *P. benghalensis* could further enhance its value in the pharmaceutical, cosmetic, agricultural, and nutraceutical industries.

References

1. 1.BhuiyanMd N I, Varshney VK, Shiam CV, Arvind T, Farhana. Composition of essential oil of the leaf and inflorescence of Pogostemonbenghalensis (Burm.f.)Kuntze.Int Res J Plant Sci. 2011;2(9): 271-5.
2. 2 The Wealth of India, A dictionary of India raw material and Industrial products, (Publications and Information Directorate, CSIR, New Delhi, 1988) Vol. II, 182-3.
3. 3.net [homepage on the Internet]. Available from: http://www.flowersofindia.net/catalog/slides/Bengal%20Pogostemon
4. 4 ST, Mahbuba K, Husain SZ.A Micromorphological study of Pogostemondesf.Species (Lamiaceae) from Bangladesh. Pak J Bot. 1995; 27 (1): 73-82.
5. 5 NK, Haider SZ, Sah S, Lohani H. J Med Arom Plant Sci. 2008; 30(3): 293-4.
6. 6 Kumar B, Vijayakumar M, Govindarajan R, Pushpangadan P. Ethnopharmacological approaches to wound healing—Exploring medicinal plants of India. J Ethnopharmacol. 2007;114(2):103-13.
7. 7 Unni BG, Archana B, Wann SB, Singh HR, Basabrani D, Bhattacharjee M. Phytochemical and Antibacterial Study of Traditional Medicinal Plants of North East India on E.coli. Asian J Exp Sci. 2009;23 (1): 103-8.
8. 8 Padal SB, Prayaga PM, Srinivasa RD, Venkaiah M. Ethnomedicinal plants from Paderu Division of Visakhapatnam District, A.P, India. J Phytol. 2010; 2(8): 70-91.
9. 9 BN, Tarakeswara NM, Venkaiah M. Ethnomedicinal plants of Kotia hills of Vizianagaram District, Andhra-Pradesh, India J Phytol. 2010; 2(6): 76–82.
10. Kamble SY, Patil SR, Sawant PS, SangitaSawant,.Pawar SG, Singh EA. Studies on plants used in traditional medicine by Bhilla tribe of Maharashtra. Indian J Trad Know. 2008; 9(3): 591-8.
11. Nath A, Maiti GG. Shuktani- a new ethno-medico recipe among the Sylheti Bengali community of Barak valley, Southern Assam, India. Indian J Trad Know. 2012; 11(1): 156-60.
12. Dangol DR. Traditional uses of plants of commanland habitats in Western Chitwan, Nepal.J InstAgricAnim Sci. 2008; 29:71-8.
13. Bhattarai S, Chaudhary RP, Taylor RSL. Ethno-Medicinal Plants used by the People of Nawalparasi District, Central Nepal. Our Nature.2009; 7: 82-92.
14. Sen P, Dollo M, Choudhury M D, Choudhury D. Documentation of traditional herbal knowledge of Khamptis of Arunachal Pradesh. Indian J Trad Know. 2008; 7(3): 438-42.

15. Harvey A.L. Natural products in drug discovery. *Drug Discov.* 2008;13:894–901. doi: 10.1016/j.drudis.2008.07.004. [PubMed] [CrossRef] [Google Scholar] [Ref list]

16. Meena A.K., Bansal P., Kumar S. Plants-herbal wealth as a potential source of ayurvedic drugs. *Asian J. Tradit. Med.* 2009;4:152–170. [Google Scholar] [Ref list]

17. Sucher N.J., Carles M.C. Genome-based approaches to the authentication of medicinal plants. *Planta Medica.* 2008;74:603–623. doi: 10.1055/s-2008-1074517. [PubMed] [CrossRef] [Google Scholar] [Ref list]