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REVIEW ON *POGOSTEMON CABLIN* BENTH

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ABSTRACT

Patchouli (*Pogostemon cablin* Benth.) is a plant from Lamiaceae, known as 'pehpli', is a perennial herb cultivated mostly in South and Southeast Asia. It is a bushy herb of the mint family about 0.75m in height from where the Patchouli essential oil is obtained from its dried leaves by steam distillation.
It is used in aromatherapy, perfumery, cosmetics, and is also used in the treatment of various ailments due to its therapeutic properties. This is a comprehensive review of its history, cultivation, phytochemical importance, pharmacological importance, and its scenario in the market.

Keywords: patchouli, cultivation, aromatherapy, therapeutic and pharmacological properties, the scenario in the market

INTRODUCTION

Pogostemon cablin

Pogostemonis Herba, the dried aerial part of *Pogostemon cablin* (Blanco) Benth (Labiatae), is commonly known as "guanghuoxiang" in Chinese and patchouli in English. Patchouli oil is an important essential oil in the perfume industry, due to its characteristic pleasant and long-lasting woody and camphoraceous odor, patchouli oil is used in cosmetics, fragrances, and aromatherapy. Patchouli alcohol 1 (PA, C15H26O), a naturally occurring tricyclic sesquiterpene, is the critically biological active constituent among the patchouli oil extracted from *Pogostemon cablin*. It was a long time that Pogostemonas Herba has been used traditionally for the treatment of fatigue, summer heat, nausea, vomiting, abdominal distension, antidepressant, antiphylactic, antiseptic, aphrodisiac, astringent, cicatrisant, cytophylactic, deodorant, febrifuge, fungicide, tonic, stimulant, euphoric.[3] Patchouli oil possesses multi-beneficial pharmacological and therapeutic properties, such as immunomodulatory, anti-inflammatory, antioxidative, antitumor, antimicrobial, insecticidal, antiatherogenic, antiemetic, whitening, and sedative activities.[1]

Patchouli alcohol provides prospective treatment options against SARS-CoV-2 infection by potentially inhibiting virus duplication though more research is guaranteed and secured.[2]

Patchouli alcohol exerts therapeutic effects against osteoporosis in ovariectomized mice, supporting the use of Patchouli alcohol as a treatment for osteoporosis in the future.[3]

Fig 1: Patchouli plant

History of Pogostemon Cablin Benth

During AD 420–589 and later it was cultivated in the Guangdong Province of Southern China around the 11th century. However, it is not clear when the Philippines plant reached China. Lophanthus rugosus Fisch. & C.A. Mey. [Agastache rugosa (Fisch. & C.A. Mey.) Kuntze] and Microtoena patchouli (C.B. Clarke ex Hook.f.) C. Y. Wu et Hsuan (Lamiaceae), which are indigenous to China, has been used in Chinese medicine for many centuries for various ailments. As patchouli looks similar and has an odour similar to those of these two species, the Chinese may have started using patchouli in place of L. rugosus. Since patchouli was initially cultivated in Guangdong Province, in Chinese it has been called 'Guang-Huo-Xiang' to differentiate it from L. rugosus, which is called 'Huo-Xiang'.

Introduction of Patchouli into India

Some researchers believe that the patchouli plant originated in India. But it is not indigenous to India and it was introduced here only in 1834. To a query in 1888, relating to the 'actual' source of patchouli, the then Keeper of the Herbarium of the Royal Gardens, Kew, Daniel Oliver opined that the true patchouli of commerce (P. cablin) was not indigenous to any part of India. George King, the then Superintendent (1871–1897) of the Royal Botanic Garden, Calcutta (now the Indian Botanic Garden, Howrah), also affirmed that this plant was not indigenous to India, but it had been introduced into the Royal Botanic Garden, Calcutta from Straits Settlement, received the patchouli plants from G. Porter, the then in-charge of Botanic Garden at Penang, Straits Settlements, where it was cultivated. Before botanically describing this species, i.e.in 1837, it was introduced into India in 1834 as the 'patchouli'plant.

Origin of the name "Patchouli"

P. heyneanus, the Indian patchouli plant, was first described and illustrated as Cottam by van Rheede in 1690 in Hortus Malabaricus.Bentham described P.heyneanus in 1830 based on the specimens collected by Heyne from Ceylon (now Sri Lanka). This plant is indigenous to peninsular India and Sri Lanka. It is widely distributed in the Western Ghats. Earlier, this species was widely cultivated in home gardens for medicinal purposes in peninsular India. Earlier, names such as 'patcha', 'patchapat', or patchouli were invariably applied to any plant that had the characteristic patchouli odour, in the Indian markets. M. patchouli and P. heyneanus were also sold as patchapat or patchouli leaf in Calcutta and Bombay markets respectively. These local names were exclusively applied to P. heyneanus in the western part of India. Therefore, the name patchouli was used in the Indian markets even before the patchouli plant, P. cablin, was described and introduced into India. Further, this species has never been named or called patchouli in the local languages in the Philippines, China, and southeast Asian regions. Earlier, names such as 'patcha', 'patchapat', or patchouli were invariably applied to any plant that had the characteristic patchouli odour, in the Indian markets. Since this word [pacchi (pacchai) means green and ilai means leaf] has been used for centuries for P. heyneanus, the name patchouli must have been derived from Tamil. The Oxford Advanced Learner's Dictionary (7th edn) also affirms that the word 'patchouli' is derived from the Tamil word 'pacculi', this vernacular name was also used for Pogostemon vestitus Benth. Pogostemon heyneanus is also called 'kathir pacchai' in Tamil. 'Kathir' here refers to the spiked nature of inflorescence that is similar to the inflorescence of cereals. Therefore, the name patchouli ought to have originated from the Tamil name 'pacchilai'.

Patchouli Cultivation

Soil

Patchouli is a hardy plant and adapts itself to a wide range of soil conditions. However, a deep loamy soil, rich in humus and nutrients, with a loose friable texture and without an impervious layer at the bottom is the best for optimum production. The pH of the soil from 5.5-6.2 is reported to be ideal.[5]

Climate

It thrives best in hot and humid conditions, therefore, can be grown in coastal areas of South India besides hill stations up to an elevation of 1500 m.[6]

Varieties cultivated

Johore, Singapore, and Indonesia are commonly cultivated. Out of these the first one yields quality oil whereas the other two give a high yield of oil.[5]

Land preparation

This work must be done before the beginning of the rainy season. Slash weeding and spot cleaning are done where planting has to be exactly done.[6]

Fertilization Conditions

Bhaskar and Saha and others compared different nitrogen treatments. The oil yield in kg/ha increased with more nitrogen but an effect on the oil content (in %) was less clear, with only the lowest N dose giving significantly less oil. Also in similar later studies, no or a very limited influence of fertilizer levels on oil content was found but the yield in kg/ha invariably increased. No effect of potassium on the oil content was found. Bhaskar and others investigated the effect of two growth regulators (triiodobenzoic acid and kinetin) on oil content and oil yield. At the maximum dose of both, the oil yield (in kg/ha) more than doubled but the oil content increased only by 25%. In contrast, in another study, a 50 µM application of kinetin gave a 58% increase in % oil content on a shade dry weight basis. The application of benzyl adenine (BA) gave a 50% increase in oil yield but did not influence oil content. Misra obtained the same result for foliar application of gibberellin. When 11 different arbuscular mycorrhizal fungi were tested, one was found to increase significantly both biomass and oil content.[7]

Propagation

Patchouli is propagated by stem cuttings with 4-5 nodes and about 15-20 cm length as the experiments conducted in Tamil Nadu showed that herbaceous cuttings of 20-25 cm length were prepared from healthy top shoots with 4 to 5 pairs of leaves are the best material for propagation.[6] The first 2-3 pairs of leaves of the cuttings are carefully removed and planted in the nursery beds at a spacing of 2-3 cm apart and are then hand-watered and provided with shade. They root in about 4-5 weeks and after about 8-10 weeks they are ready for transplanting. Earthen pots and polythene bags can also be used for raising the nursery stock.[5]

Planting distance

The ideal planting distance is dependent on soil and climatic conditions. In Tripura, planting is done in rows at 30x60 to 90 cm. In Tamil Nadu, a closer spacing of 30x30 cm is found to be ideal. On low land and damp clay soil, patchouli should be planted on ridges at 50x100 cm but on hilly land contour planning at 50x100 cm is advisable.[6]

Transplanting

Transplanting of rooted cuttings is always done during the monsoon season to obtain maximum establishment and to minimize the cost of watering.[5]

Intercropping

As patchouli requires a hot and humid climate, it can be also grown as an intercrop in plantation crops like rubber, coconut, and coffee.[6]

Pests and Diseases

The major insect is the Root-knot nematode (*Meloidogyne* sp. especially)[5], others include *Heterodera* sp, *Meloidogyne* sp., *Helicotylenchus* sp., *Tylenchorhynchus* sp., *Tylenchus* sp. Patchouli is often attacked by *Pachyzancla stultalis*, a leaf-roller, and leaf-eating grasshoppers and leaf-eating crickets (Gryllidae) also have been noticed.[6] Major diseases include Leaf blight, root rot, and wilt diseases.[5]

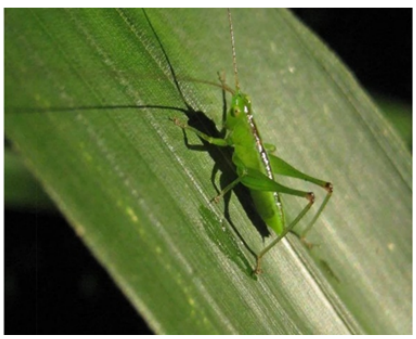

Fig 2: Nematode

Fig 3: Leaf-roller

Fig 4: Root knot

Schedule and Control measures

One of the schedules is to control the nematode by application of Furadon at the rate of 20 kg per ha.[5] These pests can also be easily controlled by spraying with 0.5 percent dieldrin 50 percent WP.[6] Control measures for nematodes consist of following proper crop rotation, especially with a non-host green manure crop like *Mucana puricata*, growing along with bananas, and grapes.[6] And the other is to control leaf blight and root-knot, spray and drench young plants with Contaf at the rate of 10 ml/101.[5] Application of aldicarb 0.5 kg a.i and carbofuran at 0.5 kg a.i/ha are relatively best to reduce the population of the root-knot nematode to half. The application of neem cake (1.0 t/ha) also is effective in controlling the population of nematodes.[6]

Fig 5: Crop-rotation of patchouli

Harvesting

The stage at which the crop has to be harvested is very important for good yield and better quality of the oil. Only matured patchouli leaves are harvested, shade dried and steam distilled. It has to be harvested when the foliage becomes pale green to light brownish and when the stand emits a characteristic patchouli odor, which could be easily smelt by a passer-by, especially in the morning hours.[8] It is recommended that the leaves be harvested when the plant has five pairs of leaves, and only the tops of the plants should be cut, using scissors or sharp knives. If the entire plant is cut, re-growth would take too long and the interval between the harvests would also be prolonged.[6] The first harvest of the crop is taken about 5 months after transplanting. Subsequent harvest can be taken after every 3-4 months depending upon the local conditions and management practices. The crop can be maintained for about 3 years. Usually, the length of the harvested portion ranges from 40 to 60 cm. It is necessary to leave 4-6 juvenile sprouting buds in the basal region for fast regeneration, while harvesting.[8] Harvesting is best done after sunrise or before sunset to avoid loss of essential oil.[5] Overall, the different studies done by investigators do not yield one conclusive picture about the influence of oil yield concerning the number of harvestings and most likely local influences like plantlet type, soil, rain, temperature, weeding, manure, amount of leaves, distillation parameters, etc. play an important role.[7]

Drying

Proper drying is of great importance for obtaining maximum yield and oil of good quality. The harvested herb should be dried in shade allowing free air circulation for about 3d which yields an average of 2.5% essential oil upon distillation. It, however, depends much on available sunshine and atmospheric humidity. Properly dried leaves develop a characteristic patchouli smell which is less noticeable in fresh leaves (Farooqui and others in 2001).[8] Doraswamy stated that leaves should be dried to one-fifth of their original weight to get a high yield and superior quality. When comparing three different drying methods, namely spread drying (8-10 days), heap drying (10 days), and spread (3-4 days) followed by heap drying (2 days), the oil yields were respectively 3.70, 3.35 and 3.87%. [7] The drying characteristics of patchouli herbage were studied under various methods namely, in the shade, tray dryer, and ASTRA Crop Waste Based Dryer. The initial drying bed thickness was uniformly maintained in all methods and the herbage was dried from 80% initial moisture to 11%-12% final moisture. Patchouli required 54 hours of drying time in the shade. In the ASTRA dryer, the drying time was just 14 h. In the convectional tray dryer (electrical), the drying time at 30, 40, 50, 60, and 70℃ was 13, 12, 11, 7, and 6 h, respectively (Anitha,2008).[8] During drying the leaves are regularly turned over by hand or utilizing a stick to promote even and thorough drying and prevent fermentation.[6]

Distillation Technique

Through a truly excellent microanalysis study, Henderson and others showed that in P. cablin volatile constituents are located in two different types of cells. On the leaf epidermis, one can find glandular trichomes. Independent of its size, one leaf contains 60,000 trichomes and each trichome contains 2 ng of essential oil. In the spongy mesophyll of leaves, one can find internal cells containing essential oil. There are approximately 3 times more internal cells than external ones but as the internal ones contain 3 times less essential oil, the amount of PEO stored in both cell types is about the same. Qualitatively there was no difference in composition. The bottom line is that patchouli leaves require

long distillation times, a common feature for all sesquiterpene-rich essential oils.[7] Processed leaves alone should be used for distillation. It is to interchange high and low steam pressure, thus giving full range to the forces and hydro diffusion, which are important in the distillation of dried plant material. Oil recovery generally ranges from 3 to 3.5 percent. The major constituent of oil is *patchouli* which varies from 30 to 40 percent in patchouli oils.[6]

Steam distillation of patchouli essential oil

Various studies done by investigators show that steam distillation is being more effective than hydrodistillation.[9] Although there are other extraction techniques (hydrodistillation, microwave distillation, supercritical fluid extraction, ultrasound extraction), from the consumer point of view steam distillation remains the preferred process for the extraction of essential oils from plant materials. The simplicity and transparency of the process give reassurance of purity since the process uses only water (Anon, 2011). The steam distillation equipment consists of a boiler, distillation still, condenser and receiver. The distillation still is generally made up of mild steel with perforated bottom to support loaded herb for distillation. The herb should be evenly/tightly packed inside the still as otherwise, steam channels may form during the distillation resulting in a poor yield of essential oils.

The water level in the boiler should be well maintained by frequent checking. Maintenance of high and low pressures i.e. 1.4–3.5 kg/m2 produces better quality as more cell walls rupture in this process. The duration of the distillation varies from 6-8 h. The condenser cools the vapors received from the distillation still. It consists of many tubes made up of copper or stainless steel and mounted inside a jacket. The condenser is provided with an inlet and outlet for the circulation of cooling water. The hot vapors consisting of steam and essential oil vapors are cooled in the condenser tubes and the condensate flows out into the receiver. The essential oil vapor and spent steam that come out of the distillation still will be condensed back to the liquid phase in the water-cooled condenser and the condensate will be collected in the receiver tank. Steam distillation/condensate results in two separate products: the liquid distillate which contains the volatile, water-soluble parts of the plant materials known as “hydrosol” and the volatile non-water-soluble material of the plant constituents known as the “essential oil” (Tannous and others 2004). The condensate in the receiver tank should be lowed to stand for a sufficient time (overnight) so that the patchouli oil separates as far as possible from the water layer. After the reasonable separation in the receiver tank, the essential oil should be further separated from the water phase using a separating Funnel. The oil is lighter than water and insoluble floats on the top of the receiver and only water get drained out. The oil will be still turbid. All traces of moisture needs to be removed from the oil by adding anhydrous sodium sulfate at the rate of 20–30 g/L and keeping the distillate mixture for 4–5 h, after which the oil is filtered through a Whatman filter paper to get clear essential oil. Moisture can induce polymerization of oil leading to a loss in quality. The clear essential oil thus obtained should be stored in air-tight aluminum containers or colored glass bottles up to the brim and stored in a cool dry place, away from light. On average, 60 kg of oil/hm2 is obtained in a year (Ramya, 2010; Anon, 2011a; Anon, 2013). Essential oil yield and its quality by steam distillation technique were studied in a pilot-scale steam distillation unit at different ‘charge’ packing bed densities and distillation periods using shade-dried patchouli herbage (cv. Johore). For different bed packing densities of the distillation still, the patchouli essential oil yields for 4, 5 and 6 h distillation were: 2.40%, 2.63% and 2.78% at 8 kg/m3; 2.35%, 2.57% and 2.70% at 10 kg/m3; and 2.06%, 2.52% and 2.60% at 12 kg/m3, respectively (Ramya, 2010). Newly distilled patchouli oil contains a fresh, green, slightly harsh aroma. As the oil ages, it mellows considerably, becoming sweeter and more balsamic.[8]

Fig 6: Dried leaves of Patchouli used in the extraction process

Fig 7: Pilot-scale patchouli steam distillation unit

Fig 8: Patchouli essential oil

Pharmacological activities of Pogostemon Cablin Benth

Antibacterial activity

In traditional medicine, patchouli plants are used for treating common cold and fungal infections. Patchouli oil was found to be more effective in inhibiting 20 bacterial strains and all 12 fungi. The essential oils of *P. cablin* from three different geographic regions (China, India, and Indonesia) were assessed *in vitro* against 17 pathogenic fungi and 16 commensal bacteria (from the skin, mucous membrane, nail, foot, and armpit) to reveal a clear antifungal and antibacterial. The essential oil of patchouli was effective in inhibiting *Acenitobacter baumanii*, *Aeromonas veronii*, *Candida albicans*, *Enterococcus faecalis*, *Escherichia coli*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*, *Salmonella enteric* and *Staphylococcus aureus* (even the epidemic methicillin-resistant *S. aureus*), *Streptococcus* species and *Bacillus subtilis*.[10,11,1]It also have antibacterial activity against *Actinobacillus*, *Capnocytophaga*, *Fusobacterium*, *Eikenella*.[12] Mainly the constituents, pogostone and (−)-patchoulol had broader therapeutic prospects in bacterial infection. The nano biosystems made of essential oils of vanilla, patchouli, and ylang-ylang were very effective against adherence and biofilm formation by clinical strains of *Staphylococcus aureus* and *Klebsiella pneumonia*. Selective antibacterial activity against *Helicobacter pylori* was exhibited by patchoulol without affecting the normal flora of the gastrointestinal tract.[10]

Antifungal Activity

Patchouli oil is effective against the mycelial growth of *C. Albicans*, Patchouli alcohol (44.52%) of the plant essential oil showed antifungal activity against a population of *Aspergillus* species like *Aspergillus niger and Aspergillus flavus*.[10,12] Further, pogostone and its synthesized analogues showed effective activities against Gram-positive, Gram-negative bacteria and *C. albicans*, and vulvovaginal candidiasis. Based on molecular docking studies, it was suggested that a promising antifungal agent can be obtained by appropriate structural modifications of pogostone analogues.[10] Patchouli alcohol inhibits the asexual propagation of fungai and prevention of adhesion of microorganisms to the surfaces so it is used for household purposes, cosmetics, pharmaceuticals, oral hygiene, and dental care compositions.[1]

Antiviral activity

Traditional medicines from herbs, including patchouli were screened for ant-influenza viral activity. It was shown that about 10 µg/mL concentration of methanol extract of patchouli leaves could inhibit influenza virus A/PR/8/34 (H1N1) up to 99.8% and the IC50 values were estimated to be 2.6 µM. Similarly, the results presented by Wu and others suggested anti-influenza A (H2N2) viral activities of patchoulol with an IC50 of 4.0 µM.[10,12] Patchoulol (10 µg/Ml) enhanced the ability of innate immune recognition and response and restrained the expression of IFN-α inflammatory factor to attenuate the inflammatory responses by increasing CD3+ and CD4+ T cell levels as well as CD4+/CD8+ ratio, and anti- IFV IgA, IgM, and IgG to enhance host immune response and by restraining TNF alpha, IL-4, and IFN- gamma inflammatory factors.[10,1]

Treatment of HIV/AIDS and Opportunistic Infections

Essential oils are used to treat specific opportunistic infections caused by *Candida albicans*, *Cryptococcus neoformans*, methicillin-resistant *Staphylococcus aureus*, and *Herpes simplex* type I and II found in Acquired Immunodeficiency Syndrome patients.[10]

Gastrointestinal Protective Activity

Water extract of *P. cablin* was shown to protect and maintain the membrane fluidity of intestinal epithelial cells by regulating the levels of nitric oxide and tumor necrosis factor in serum. This study provides an experimental basis for gastrointestinal protection against trauma or surgical operation.[10]

Antiemetic activity

Hexane extracts of patchouli plant leaves showed anti-emetic activity in young chicks.[12] Patchoulol, pachypodol, pogostol, retusin, and stigmast-4-en-3-one demonstrated anti-emetic properties at doses of 50–70, 10–50, 20–50, and 50 mg/kg, respectively[10] by lowering excessive contraction of digestive organ smooth muscles by reducing extracellular Ca_+ influx.[1]

Antioxidant activity

Patchouli oil showed an efficient free radical scavenging activity and inhibited the oxidation of hexanal to hexanoic acid. Reactive oxygen species-induced brain cell injury can be treated by using patchouli herb. *P. cablin* protected from cell death due to necrosis and apoptosis induced by hydrogen peroxide in human neuroglioma cell line A172, thus suggesting its use for treating many neurodegenerative disorders like Alzheimer's disease.[1,10] Patchouli oil prevented photoaging by exhibiting antioxidative properties and maintained skin structural integrity caused by UV irradiation by 28.8% by blocking the malondialdehyde formation from squalene.[1,10]Similarly, the use of patchoulol increased the revitalization of UV-induced skin lesions through antioxidant and anti-inflammatory actions together with down-regulating the expression of matrix metalloproteinases (MMP-1 and MMP-3).[10]

Analgesic and Anti-Inflammatory Activities

The methanol extract of patchouli plants was demonstrated to have analgesic and anti-inflammatory activity in mice. Methanol extracts of patchouli (1.0 g/kg), exhibited a strong anti-inflammatory response by regulating interleukin-1β (IL-1β) and prostaglandin E(2). Likewise, patchoulol effectively regulated the expression of TNF-α, IL-1β, IL-6, iNOS, and COX-2 mRNAs in RAW264.7 cells due to lipopolysaccharide-induced inflammation. Similarly, patchouli oil and ethanol extract of its root and rhizome exhibited strongly *in vivo* anti-inflammatory properties.[10] Pogostone possessed an anti-inflammatory effect and suggested its use for the development of a pharmaceutical drug to treat septic shock.[10] Water extracts of patchouli herb suppressed colon inflammation by suppressing the expression of pro-inflammatory cytokines which was performed in LPS-induced acute lung injury as well as mastitis.[1]

Antitumor activities

The compounds 5,7-dihydroxy-3′,4′-dimethoxyflavanone, ombuin, and licochalcone A were shown to exhibit cytotoxicity. The compound, licochalcone A, showed PI-PLC-gamma 1 inhibition activity. When licochalcone A was applied to polycytic leukaemia cells (HL-60), terminal differentiation along with the production of monocytes was observed.[10] Patchoulol inhibited HeLa cell proliferation, suppressed cell differentiation, and enhanced apoptosis in HCT116, SW480 (human colorectal cancer cell lines), MCF-7 (human breast cancer cells), BxPC3 (pancreatic cancer cells), and PC3 (human prostate cancer cells).[10,1] It also leads to alteration of morphological and biochemical features of apoptosis and further elucidated dissipation of mitochondrial membrane potential after elevating the ratio of Bax/Bcl-2, releasing cytochrome c to the cytosol following the activation of caspase-3, and repressing living protein expression.[1]

Antiatherogenic activities

This is done by attenuating atherosclerotic plaque burdens in both the aortic root, reducing macrophage infiltration, and repressing inflammatory response via downregulation of MCP-1, iNOS, IL-1b, IL-6, CXCL9, and CXCL11 expressions.[1]

Inhibitor of SARS-CoV-2

According to the article, considering the current dramatic and fatal situation due to the high spreading of SARS-CoV-2 infection, there is an urgent unmet medical need to identify novel and effective approaches for prevention and treatment of Coronavirus disease (COVID 19) by re-evaluating and repurposing of known drugs. For this, patchouli alcohol has been selected as a potential drug for combating the virus. This hit compound was subsequently docked into the active site and molecular docking analyses revealed that the drug can bind the active site of SARS-CoV-2 3CLpro, PLpro, NSP15, COX-2, and PLA2 targets with several important binding interactions. A molecular dynamics study of 100 ns was carried out towards 3CLpro, NSP15, and COX-2 which indicated that the protein-ligand complex was stable throughout the simulation period, and

minimal backbone fluctuations have ensued in the system. Post dynamic MM-GBSA analysis of molecular dynamics data showed promising mean binding free energy 47.4633 ± 9.28, 51.8064 ± 8.91, and 54.8918 ± 7.55 kcal/mol, respectively. Likewise, in silico ADMET studies of the selected ligands showed excellent pharmacokinetic properties with good absorption, bioavailability, and devoid of toxicity. Therefore, patchouli alcohol may provide prospective treatment options against SARS-CoV-2 infection by potentially inhibiting virus duplication though more research is guaranteed and secured.[13]

Suppression of Osteoclastogenesis

Patchouli alcohol (PA), a natural compound extracted from *Pogostemon cablin* that exerts anti-inflammatory effects, is used as a treatment for gastroenteritis. According to the research PA dose-dependently inhibited the receptor activator of nuclear factor kappa-B ligand (RANKL)-induced formation and function of OCs without cytotoxicity. Furthermore, these inhibitory effects were reflected in the significant effect of PA on the NF-κB signaling pathway, as PA suppressed the transcription factors NFATc1 and c-Fos. We also determined that PA activated the expression of the nuclear receptor pregnane X receptor (PXR) and promoted the PXR/Toll-like receptor 4 (TLR4) axis to inhibit the nuclear import of NF-κB (p50 and p65). Additionally, PA exerted therapeutic effects against osteoporosis in ovariectomized (OVX) mice, supporting the use of PA as a treatment for osteoporosis in the future.[14]

Anticancer Activity against Colorectal Cancer Cells

Pogostemon cablin (PCa), an herb used in traditional Chinese medicine, is routinely used in the amelioration of different types of gastrointestinal discomfort. However, the mechanisms underlying the cancer suppression activity of PCa in colorectal cancer (CRC) cells have yet to be clarified. This study aimed to investigate the anticancer effects of PCa, specifically the induction of apoptosis in CRC cells. The growth inhibition curve of CRC cells following exposure to PCa was detected by an MTT assay. Moreover, PCa combined with 5-FU revealed a synergic effect of decreased cell viability. PCa inhibited cell proliferation and induced cell cycle arrest at the G_0/G_1 phase and cell apoptosis through regulation of associated protein expression. An in vivo study showed that PCa suppressed the growth of CRC via induction of cell apoptosis with no significant change in body weight or organ histology. Our results demonstrated that PCa inhibits the growth of CRC cells and induces apoptosis in vitro and in vivo, which suggests the potential applicability of PCa as an anticancer agent.[15]

CONCLUSION

The review on Patchouli oil is done, chemical constituents and its various pharmacological and therapeutic activities are studied.

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