IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

REVIEW OF ANTI BACTERIAL ACTIVITY OF MELALEUCA VIMINALIS L.

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ABSTRACT:

Weeping bottlebrush, scientifically known as Melaleuca viminalis (formerly called Callistemon viminalis), belongs to the Myrtaceae family and is well-regarded for its therapeutic properties. This ornamental plant is celebrated for its multifaceted qualities, which encompass molluscicidal, antioxidant, antifungal, antibacterial, antiplatelet aggregation, allelopathic, anti-infective, anti-quorum sensing, and antihelminthic attributes. Additionally, it has been observed that these aesthetically pleasing plants possess outstanding insecticidal properties. The secondary metabolic products of this plant encompass a diverse range, including essential oils, pyrrole derivatives, monoterpenes, triterpenoids, phenolics, steroids, flavonoids, and steroidal glycosides.

Previous research indicates that monoterpenes are the predominant constituents of C. viminalis and play a pivotal role in mediating the plant's various biological functions. This review aims to delve into the physicochemical composition, morphology, cultivation techniques, phytochemical constituents, and microscopic characteristics of Melaleuca viminalis, with the goal of harnessing its potential for the betterment of society.

KEYWORS: Callistemon viminalis, Phytoconstituents, Essential oil, Biological activity

1. INTRODUCTION

Throughout history, historical records have highlighted the valuable contributions of herbal remedies to human well-being. In recent times, their popularity has surged significantly, owing to their diverse range of beneficial properties. Herbal medicine has been a cornerstone of healthcare practices among indigenous cultures in remote regions for millennia, and its utilization remains prevalent in numerous developing nations.

The widespread use of synthetic chemicals has far-reaching consequences on all forms of life, often leading to their proliferation. Given the intricate chemical compositions of these synthetic compounds, there is a potential for a spectrum of adverse effects, ranging from mild to severe. Therefore, it is imperative that scientific research is meticulously designed to include comprehensive toxicity assessments and conventional methodologies aimed at substantiating the safety of herbal medicines [1].

2. CLASSIFICATION

Taxonomical investigations place significant emphasis on anatomical characteristics [1]. The family Myrtaceae exhibits a rich diversity, encompassing approximately 130 genera and 3000 varieties of trees and plants. This botanical family thrives in subtropical, temperate, and tropical regions, with primary concentrations in Australia and tropical America [4]. Notable members of this family include Syzygium aromaticum L., Myrtus communis L., Psidium guajava L., Eucalyptus camaldulensis, and Callistemon viminalis.

The differentiation among these species primarily arises from distinctive structural traits. Numerous morphological disparities have been identified across various plant species. For instance, when examining the leaves of plants such as C. viminalis and P. guajava, a notable absence of stomata is observed on their abaxial surface. Conversely, P. guajava leaves feature a hypodermis layer. Furthermore, the stems of Callistemon viminalis and/or the leaves of E. camaldulensis exhibit undulating cross-sections, while the mesophyll of C. viminalis and petioles of P. guajava contain prismatic crystals within their druses. These distinctive characteristics play a crucial role in distinguishing these plant species from one another [15].

3. Taxonomy of M. viminalis

M. viminalis can be taxonomically classified within the following hierarchical categories:

Kingdom: Plantae

Subkingdom: Tracheobionta

Superdivision: Spermatophyta

Division: Magnoliophyta

Class: Magnoliopsida

Order: Myrtales

Within the family Myrtaceae, C. viminalis belongs to the genus Callistemon. Noteworthy species related to C. viminalis include Metrosideros viminalis Sol. ex Gaertn., C. viminalis (Sol. ex Gaertn.) G. Don, and Melaleuca viminalis (Sol. ex Gaertn.) Byrnes.

4. CULTIVATION AND MORPHOLOGY

The species M. viminalis and its cultivated varieties have been widely planted both in Australia and abroad. There is a diverse range of well-established cultivars of C. viminalis [16]. Among these cultivars, one of the most renowned is Callistemon 'Captain Cook.' This particular cultivar gained significant popularity in commemoration of the 200th anniversary of Captain James Cook's exploration of the east coast of Australia in 1770 and continues to enjoy widespread popularity to this day [17].

In its natural habitat, C. viminalis is typically found along watercourses and thrives when provided with a consistent water supply. Once it has established its roots, it can withstand prolonged periods of dry weather [17]. The plant performs optimally in soils of medium to heavy texture and can tolerate less than ideal drainage, although its growth may be impeded by moderate to heavy frost. Regular fertilization after flowering is beneficial [18]. While the plant does respond well to pruning, excessive pruning can compromise the appearance of its weeping forms. Like other bottlebrushes, it flourishes in sunny locations but can tolerate some shade, although this may reduce its flowering performance. C. viminalis exhibits adaptability to various soil conditions and can thrive with minimal maintenance [16].

This plant is commonly found in many regions, with the exception of extremely cold and arid areas. It is also commonly seen along streets and in botanical gardens [15, 17]. Propagation of C. viminalis is easily achieved through both seeds and cuttings. Callistemon cultivars produce viable seeds that readily germinate. However, due to seedling variation, plants grown from these seeds may not be identical to the parent plant [9]. Plants produced from cuttings, which typically root easily, will be genetically identical to the parent. C. viminalis boasts exceptionally beautiful stamens that adorn its long, flexible shoots [16]. During its flowering period, C. viminalis is characterized by its striking scarlet blossoms and also yields substantial quantities of nectar [14]. Typically, C. viminalis can reach heights of up to 8 meters (Fig. 1A). Its lanceolate leaves measure 0.3-0.6 cm in width and 4-7 cm in length. The flowers are arranged in spikes that are 14-15 cm long, featuring prominent red stamens measuring 1.50-2.50 cm in length (Fig. 1B). Petals are small, inconspicuous, and often have a greenish or pale coloration. As the flowers mature, they develop into woody capsules [18].

fig(a) **fig(b)**

fig. (1) photograhs of melaleuca viminalis showing (a) shoot and leaves (b) flower

5. MICROSCOPIC STUDY OF MELALEUCA VIMINALIS

The leaf surface exhibits anomocytic stomata, a distinctive feature commonly found in plants of the Myrtaceae family. In the transverse section, we can observe the epidermal layer, followed by the cuticle layer, vascular bundles (comprising xylem and phloem), pericyclic fibers, collenchyma cells, and unicellular trichomes, among other structures [19].

When examining the transverse section of the stem, one can identify the epidermal layer, typically consisting of 2-3 layers of cork tissue, followed by 7-8 layers of cortex tissue. Further inward, we observe medullary rays, the endodermis, xylem vessels, oil glands, sclereids within the stellar region, and the central pith.

Several histochemical reactions have been conducted on both leaves and stems to characterize their constituent metabolites. These reactions involve the use of different substrates, each resulting in a distinct color that corresponds to specific metabolites [19-20]. For example, when cortex lignin is treated with aniline sulfate and sulfuric acid, it produces a yellow color, whereas lignin from xylem vessels and medullary rays, when treated with phloroglucinol and hydrochloric acid, yields a pink color [21]. Starch in the cortex, when exposed to a weak iodine solution, turns blue. The volatile oil present in the cortex, when treated with Sudan Red II, takes on a red hue [21]. Proteins within the pith, upon reaction with Millon's reagent, exhibit a white coloration [21]. Calcium oxalate in the cortex, after being subjected to sulfuric acid, displays a prismatic coloration [19, 20, 21].

6. ESSENTIAL OIL CONSTITUENTS

A total of 42 significant oil components have been isolated from the leaves, spanning various chemical classes such as alcohols, esters, aldehydes, acids, hydrocarbons, N-containing compounds, and ketones. Among these, the predominant constituents are menthyl acetate, terpineol, pinene, and 1,8-cineole, while thujene, pinene, and myrcene are present in smaller quantities. The mixture also includes compounds like p-cymene, terpinene, terpinolene, linalool, transpinocarveol, borneols, humulene, alloaromadendrene, spathulenols, and globulols [2].

It's worth noting that the composition of essential oil components can vary significantly due to various environmental factors such as longitude, geographic location, and more. Comprehensive investigations into C. viminalis essential oil have been conducted in South Africa, Brazil, Australia, India, Cameroon, and Egypt [22, 23]. For instance, oil extracted from specimens in northern Indian plains is characterized by its high content of menthyl acetate, α

mong these, the primary components are 1,8-cineole, α-pinene, and menthyl acetate, alongside their respective minor constituents, including β-thujene, β-pinene, and myrcene. Additionally, the aromatic compounds bearing the

7. PHARMACOLOGICAL APPLICATIONS OF MELALEUCA VIMINALIS

ANTIBACTERIAL ACTIVITY

The in-vitro bactericidal activity of essential oils extracted from C.citrimes and M.viminalis was evaluated using both broth microdilution and disk diffusion methods. While these oils exhibited effectiveness against certain bacterial strains, they demonstrated particularly potent inhibition zones against S. faecalis, both strains of S. aureus, B. cereus, and S. macrcesens. Notably, Staphylococcus macruri and Pseudomonas aeruginosa were also sensitive to the oils. Certain extracts from M. viminalis displayed efficacy against a range of bacterial strains, including S. aureus, Streptococcus pneumonia, Staphylococcus epidermidis, and Klebsiella pneumonia. The methanol extract, in particular, exhibited notable activity against methicillin-resistant S. aureus. Both aqueous and alcoholic extracts of the leaves exhibited effectiveness against bacteria such as Klebsiella oxytaci, Proteus vulgaris, and E. coli, with the aqueous extract being more efficient than the ethanol extract. The essential oil from M. viminalis was tested for its ability to inhibit the growth of S. aureus and E. coli bacteria, with E. coli showing high sensitivity to the essential oil. S. aureus, on the other hand, appeared to be less affected. The methanol leaf extract demonstrated moderate to excellent antibacterial activity [26, 27].

When examined for its capacity to inhibit human pathogens, the aqueous extract of M. viminalis significantly reduced toxin production by 50–90% and decreased mortality by 60%. This highlights the potential for the development of anti-infective agents [29].

Callistemonone A, isolated from the leaves of M. viminalis, exhibited potent antibacterial activity against Gram-positive bacteria, with Minimum Inhibitory Concentrations and Minimum Bactericidal Concentrations ranging from 5 to 80 µg/ml. However, it displayed inactivity against Gram-negative bacteria due to challenges related to efflux transporter behavior. Callistemonols A and B also demonstrated strong antibacterial properties against Methicillin-Resistant S. aureus, with Minimum Inhibitory Concentrations and Minimum Bactericidal Concentrations ranging from 1.56 to 6.25 µg/ml when assessed using conventional Minimum Inhibitory

HAEMOLYTIC ACTIVITY

The study examined the haemolytic activity of M. viminalis extracts on human blood erythrocytes (RBCs), and the observed lysis percentage of RBCs fell within the range of 1.95%–6.33%. This finding suggests the potential of these extracts as sources for the development of therapeutic drugs [32]. Specifically, the haemolytic effect of the methanol (MeOH) extract from the leaves was observed within the range of 1.79%–4.95% [30]. When considering the various extracts, the order of % haemolysis was as follows: chloroform > ethyl acetate > 90% MeOH > 95% MeOH > absolute MeOH > petroleum ether > n-butanol.

Furthermore, the impact of M. viminalis leaves' alcoholic extract on the renal profile of infected rabbits with Streptococcus pneumonia revealed significant variations in the levels of blood urea nitrogen, creatinine, creatinine kinase, and uric acid [31].

ANTIOXIDANT ACTIVITY

The essential oil extracted from M. viminalis exhibited the highest antioxidant activity at 88.60±1.51%, surpassing the activity of the standard compound, gallic acid, which had an antioxidant activity of 80.00±2.12%. Similarly, the ethyl acetate leaf extract of M. viminalis demonstrated antioxidant activity on par with standard antioxidants like gallic acid, with an activity level of 85.12±1.42% [5].

Furthermore, the petroleum extract of M. viminalis leaves displayed a superior IC50 value of 56.2 ± 0.54 µg/ml in comparison to the standard compound, butylated hydroxytoluene [9].

In addition, the total extracts, including petroleum ether, methylene chloride, and ethyl acetate fractions derived from the fruits and bark of M. viminalis, along with compounds such as methyl gallate, gallic acid, catechin, and ellagic acid, exhibited robust antioxidant activity that was comparable to the performance of the standard antioxidant, ascorbic acid [33].

ANTIFUNGAL ACTIVITY

The essential oil of M. viminalis, primarily composed of 1,8-cineole, α-pinene, and terpinen-4-ol, demonstrated

M

M

M

The leaves of M. viminalis contain aqueous and ethanol extracts that possess anti-quorum sensing activity, contributing to the regulation of pathogenic behavior in various bacterial organisms. This activity has been demonstrated using two biomonitor strains, namely C. violaceum and A. tumefaciens, and it effectively inhibits the genes associated with Quorum Sensing (QS), specifically las and rhl, as well as QS-controlled factors [36, 37].

Quorum sensing, a mechanism for bacterial cell-to-cell communication, plays a critical role in modulating pathogenicity in various bacteria. The leaf extract of M. viminalis has been shown to retain anti-quorum sensing activity in these two bio-monitor strains, C. violaceum and A. tumefaciens. This activity is characterized by its ability to inhibit quorum sensing genes and QS-controlled factors [38, 39].

In an in vitro study, rat platelet aggregation was induced using Epinephrine, Adenosine Diphosphate (ADP), and Thrombin. The anti-platelet aggregation activity of four compounds isolated from C. viminalis leaves, namely Oleanolic Acid (OA), Ursolic Acid (UA), Betulinic Acid (BA), and Maslinic Acid (MA), was assessed. These compounds were investigated for their effects on platelet aggregation induced by thrombin, epinephrine, and ADP. The results demonstrated that among these compounds, OA exhibited the most significant activity, with an IC50 value of 0.84 mg/ml. Furthermore, the combination of BA and OA (referred to as BAOA) displayed the highest level of activity, with an IC50 value of 261 mg/ml. It is worth noting that prior reports have indicated that a concentration of 2.57 mg/ml of BAOA had a substantial impact on epinephrine-induced platelet aggregation [40].

ANTI-INFECTIVE

A study conducted an investigation into the potential anti-infective properties of aqueous extracts from three plant species: M. viminalis, Conozerectus, and Bucida buceras. The researchers evaluated these extracts for their capacity to inhibit the human pathogen Pseudomonas aeruginosa. The results demonstrated a noteworthy reduction in toxin production, ranging from 50% to 90%, coupled with a mortality rate of 60%. These findings strongly indicate the promising potential of these plant extracts for the development of anti-infective treatments [41-42].

CONCLUSION

WHO estimates that 80% of people worldwide, typically those who live in developing countries, rely on pharmacological therapies made from plants for their health care. It's been found that around 60% of medications approved for treating acute illnesses come from plants. Because they have fewer side effects, natural drug treatments are gaining popularity on a global scale. As a result, modern drugs are being used for treating a broadrange of acute afflictions. Numerous tests along with academic investigations have established that C.viminalis is a significant medicinal plant with historical significance. There are still a lot of pharmacological applications that need to be investigated, even if biological and medical uses had been investigated. The majority of studies utilising plant extracts indicated AntioxidantActivities, InsecticidalActivities, MoluscicidalActivities, AntibacterialActivities, AntifungalActivities, AllelopathicActivities, Anti-platelet AggregationActivities, Anti-quorum Sensingactivity, AntihelminthicActivity andactivities of Anti-infective; however, active principle connected behind these properties needs to be investigated.

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