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Plectranthus amboinicus Essential Oil - An Effective Antimicrobial and Insecticidal Agent

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Abstract: ***The perennial herb Plectranthus amboinicus, which is a member of the Lamiaceae family, grows natively in warm climates in Africa, Asia, and Australia. Its natural phytochemical components, which are highly prized for their fragrant quality and capacity to produce essential oils, are responsible for its nutritional and medicinal qualities. In traditional medicine, it is used to cure ailments like cough, asthma, and colds. Carvacrol and thymol, two significant phenolic monoterpenes found in this herb's essential oil, have antifungal and insecticidal properties. The essential oil from P. amboinicus has antifungal, anti-inflammatory, anticancer, wound-healing, antioxidant, and analgesic properties in addition to insecticidal efficacy against a variety of insects, such as termites, cowpea weevil, mosquito larvae, and red flour beetles. Chemicals such as ethylene dibromide and phosphorus are used to fumigate groundnut storage. Despite its effectiveness and ease of use, there are a number of negative consequences, including irritation of the skin and respiratory system, liver, kidney, and lung damage, and in extreme cases, death. Therefore, Plectranthus amboinicus essential oil is employed as a cost-effective, organic substitute. In order to produce a fumigant as an antifungal and pesticide, the MIC value against Aspergillus species that induce infection in stored groundnuts must be determined.***

Keywords: Plectranthus amboinicus, essential oil, groundnut storage, Aspergillus sps, antifungal activity.

I. INTRODUCTION

A. *Morphology*

P. ambonicus is a succulent shrub that usually creeps or climbs. In the wild, it can grow more over 1 m in height and even wider. This huge succulent herb spreads widely and has a strong aroma. About 30 to 90 cm of fleshy stems are either tomentose (densely coated with soft, short, and upright hairs, pubescent) or have long, inflexible hairs. Undivided, broadly ovate to suborbicular, tapering-tipped, and extremely thick, the leaves are heavily studded with hair, with the lower surface bearing the greatest number of glandular hairs, giving the impression of frosted leaves. This leaf has a nice, reviving scent and a delightfully delicious taste. Pale purplish flowers are arranged in dense whorls at distant intervals in a long, slender raceme on a short, short-pedical stem. The calyx of flowers is fashioned like a bell. The corolla has a slender tube, is five times longer than the calyx, and is pale violet. Fruit nutlets are 0.7 mm long, 0.5 mm broad, and smooth with a light brown hue. Rarely, *P. amboinicus* blooms and seeds are hard to gather. [Wagner, W.L.; Lorence et al.,2016]

B. *Orgin & History*

Because some species of the genus have spur-shaped flowers, the name Plectranthus is derived from the Greek words "plectron," which means spur, and "anthos," which means flower. Many taxonomic issues with species naming have led to species being misplaced in some closely related genera, like Coleus, Solenostemon, and Englerastrum, because there are insufficient morphological characteristics to differentiate species within the genus Plectranthus and its closely related genera. Originally assigned to the genus Coleus, the species *P. amboinicus* was later transferred to the genus Plectranthus. [Roshan.P et al.,2010]

C. *Essential Oil Extraction*

For the extraction of *P. amboinicus* essential oil, a hydro distillation process is frequently used, utilizing a Clevenger type equipment for 3–4 hours. Nevertheless, it was demonstrated that the volatile components of *P. amboinicus* leaf that were extracted using hexane, steam distillation, and supercritical CO2 extraction techniques differed chemically. [Pino. J.A et al]

II. VOLATILE AND NON-VOLATILE COMPOUNDS

Numerous kinds of phytocompounds, including 76 volatiles and 30 non-volatile compounds, have been highlighted by the literature review. A total of 76 volatile components were found in the essential oil extracted from the leaves and stem explants. The two main phenolic chemicals used in the pharmaceutical sector, carvacrol and thymol, were present in large amounts in the essential oil. Oxygenated monoterpenes, monoterpene hydrocarbons, sesquiterpene hydrocarbons, and oxygenated sesquiterpenes are abundant in *P. amboinicus* oil. [Khare, R.S et al]

Phenolic acids, flavonoids, monoterpene hydrocarbons, sesquiterpene hydrocarbons, oxygenated monoterpenes, and esters are among the thirty non-volatile chemical components listed in the literature. To separate non-volatile components, the silica gel column chromatography technique was used to fractionate the chloroform extract of *P. amboinicus* air-dried leaves. Later, three flavones—Crisimaritin, Salvigenin, and Chrysoeriol—were discovered from the isolated compounds using ultraviolet (UV), 1-D nuclear magnetic resonance (NMR), and 2-D NMR spectroscopy. Carvacrol, the main chemical found in the aqueous extract of *P. amboinicus* plants, was examined using high pressure liquid chromatography (HPLC). According to the results, there was a significant amount of carvacrol in the aqueous extract (1.88 mg/g).

These isolated compounds were identified as 5,4′-Dihydroxy-3,7-dimethoxy flavone (3-methoxy genkwanin), 5,4′-Dihydroxy-6,7-dimethoxy flavone (Crisimaritin), p-Coumaric acid (Hydroxy cinnamic acid), Caffeic acid, 3,5,7,3′,4′-Pentahydroxy flavanone (Taxifolin), Rosmarinic acid, Apigenin, and 5-O-Methyl-luteolin based on their physical data and UV and NMR spectra. They discovered that this plant contains 3-Methoxy genkwanin, p-Coumaric acid, and 5-O-Methyl-luteolin for the first time. According to the literature review, the stem extract had a greater total phenolic content (9.6 mg/g) than the leaf extracts (8.4 mg/g) and the root extracts (5.4 mg/g). [El-hawary, S.S et al, 2012, Chiu, Y.J. etal, 2012]

A. *Antibacterial Activity*

P. amboinicus has long been used as a folk remedy to combat pathogenic bacterial activity; patients with TB or chronic cough were given a decoction of the leaves, and subsequent research found that *P. amboinicus* had anti-Mycobacterium tuberculosis activity. *Salmonella typhimurium* and *Escherichia coli* were inhibited in their growth by a hot water extract of *P. amboinicus* leaves, whereas *Lactobacillus plantarum* was stimulated. The combination action of polyphenol adsorption to bacterial membranes, membrane breakdown, and subsequent cellular contents leaking is most likely what causes the antibacterial activity of plant extracts.

Additionally, it was demonstrated that *P. amboinicus's* unsterilized ethanolic leaf extract has antibacterial action against *E. coli, S. aureus, P. mirabilis, P. aeruginosa, and K. pneumonia*, as well as diabetic wound infections. As a result, *P. amboinicus* essential oil may contain a natural substance that has the ability to change bacterial resistance. In a different work, zinc oxide nanoparticles (Pam-ZnO NPs) were biologically synthesized using *P. amboinicus* leaf extract. At concentrations of 8–10 g·mL−1, these Pam-ZnO NPs effectively inhibited the formation of methicillin-resistant *Staphylococcus aureus* biofilms (MRSA ATCC 33591). [Vijayakumar.S, et al, 2015, Sivaranjani D,et al, 2019]

B. *Antifungal Activity*

There is also ample evidence that *P. amboinicus* is essential in preventing the growth of fungi that cause disease. The usefulness of the compounds when combined with industrial medications, however, is not well understood. *P. amboinicus* essential oil demonstrated varying degrees of interference when tested against the anti-Candida action of several clinically used antifungals, including itraconazole, ketoconazole, and amphotericin B. Itraconazole's efficacy was significantly disrupted by essential oil, which had a synergistic effect on *Candida albicans*, *Candida tropicalis, Candida krusei, and Candida stellatoidea*. However, when ketoconazole interacted with *Candida albicans, Candida guilliermondii, and Candida stellatoidea*, it had antagonic and synergistic effects on its anti-yeast efficacy. The anti-yeast activity, however, was slightly interfered with by amphotericin B. In another study, an agar well diffusion susceptibility test was used to examine the volatile oil's antifungal efficacy against a variety of fungi. In that, 10 µL of volatile oil suppressed the growth of *Aspergillus ochraceus, Aspergillus niger,* and *Penicillium* sp. by 60%, 64%, and 60%, respectively. [Pushpa S. et al, 2009, Negero Gemeda, et al, 2014]

C. *Insect Repellent Property*

The pod sucking bug, red flour beetle, stable fly, horse fly, cowpea weevil, and mosquito larvae are powerful insects that can harm groundnuts that have been stored. This can result in powdered leaves, a decrease in the amount of oil, and financial loss for the farmers.

The effects of *P. amboinicus* essential oil on horseflies and stable flies were studied. *P. amboinicus* essential oil has the potential to be used as an alternative control agent because the study demonstrated that it has insecticidal action with a death rate of 90 to 100% depending on the time of exposure. [Vijayakumar.S et al, 2015, Leesombun A, et al , 2022]

D. Nutritional Value

Since ancient times, herbs have been widely employed in cooking. Various nutritional herbs are used in many of the delectable cuisines we enjoy to enhance the food's flavor and taste. Because of their high nutritional value, herbal plants also offer numerous health advantages. Therefore, P. aromaticus may be a valuable source of nutritional components that improve food products' flavor and extend their shelf life. The existence of high minerals, specifically calcium and potassium, at 0.158% and 0.138%, respectively, is confirmed by a study. The nutritional components are discussed in depth.

Strong bones must be formed and maintained, and the heart, kidneys, muscles, and nerves must continue to work normally. Additionally, *P. amboinicus* has a noteworthy amount of iron (0.262%). Hemoglobin contains iron, which helps red blood cells transport oxygen throughout the body. About two-thirds of the iron in the body is found in hemoglobin, and anemia results from a lack of it. Furthermore, this plant has 0.356 mg/g of dry weight in total xanthophylls, which include zeaxanthinics, leutin, violaxanthin, and neoxanthin. Furthermore, it contains β-Carotene (0.0035 mg/g of dry weight) and α-Carotene (0.157 mg/g of dry weight) [104]. *P. amboinicus* is a special dietary supplement because of all of this. [Khan, M.C.P.I.et al , 2013]

E. Chemical Fumigant

These are typically the kinds of fumigants that are available for use in grain storage programs for fumigation purposes.

1) Methyl bromide: It works quickly, and after 12 to 24 hours of application, the grains can be aerated. Nevertheless, it is colorless, odorless, and extremely poisonous.
2) Aluminum phosphide: Phosphine is the gas that is emitted from this chemical. This fumigant has a high capacity for penetration. It spreads easily among the grains that are being stored when it comes into contact with air. For the majority of pests, this works quite well. Additionally, it doesn't leave any residue on the grain, making it acceptable for usage with food grains. Furthermore, it has no effect on the capacity of seeds to germinate, therefore it is safe to use for seed storage as well.

However, because it is combustible at room temperature, caution should be used when applying it. Compared to other fumigants, this one requires a longer fumigation duration because of its delayed release. Depending on whether methyl bromide or phosphine is utilized, the fumigation process should last at least seven days for phosphine and 24 to 48 hours for methyl bromide.

Because it is easier to apply in the form of pellets dispersed throughout the grain mass, aluminum phosphide is utilized more frequently. However, it is crucial to understand that fumigants are extremely toxic to humans, thus those who are going to apply them need to be properly trained in their use. The primary route of exposure is inhalation, and high concentrations can cause immediate, severe symptoms like pulmonary edema & even death. Therefore, it is crucial to strictly follow the recommended protective and safety measures (masks, gloves, hand-washing, hermetic sealing of phosphine containers, etc.) for all of these treatments [http://supplycokerala.com/syllabus/QA.pdf]. The side effects can include headaches, nausea, dizziness, visual disturbances, respiratory irritation, skin irritation, neurological damage, and in severe cases, coma, and death. [R. Pleština,et al , 2003]

III. FUTURE PERSPECTIVE

These days, the spore inhibition assay is carried out using a hemocytometer to count the number of spores in the positive control and the number of spores in sample with *Plectranthus amboinicus* essential oil. Calculations are made to determine the inhibition level and formulation to a fumigant to be done. The fungicidal concentration is also to be done with the aid of PDA or SDA agar plates. The MIC value is to be checked by the broth dilution method using saboraud dextrose broth, and the fungicidal concentration is then determined.

IV. CONCLUSION

It is evident from the literature review that *Plectranthus amboinicus* contains a variety of compounds that are advantageous to us in a number of ways. It is also confirmed that the essential oil has antifungal and insect repellent properties, which can be used in groundnut storage to stop fungal growth and inhibit the production of mycotoxin because the chemical fumigant has a number of negative reactions as mentioned above.

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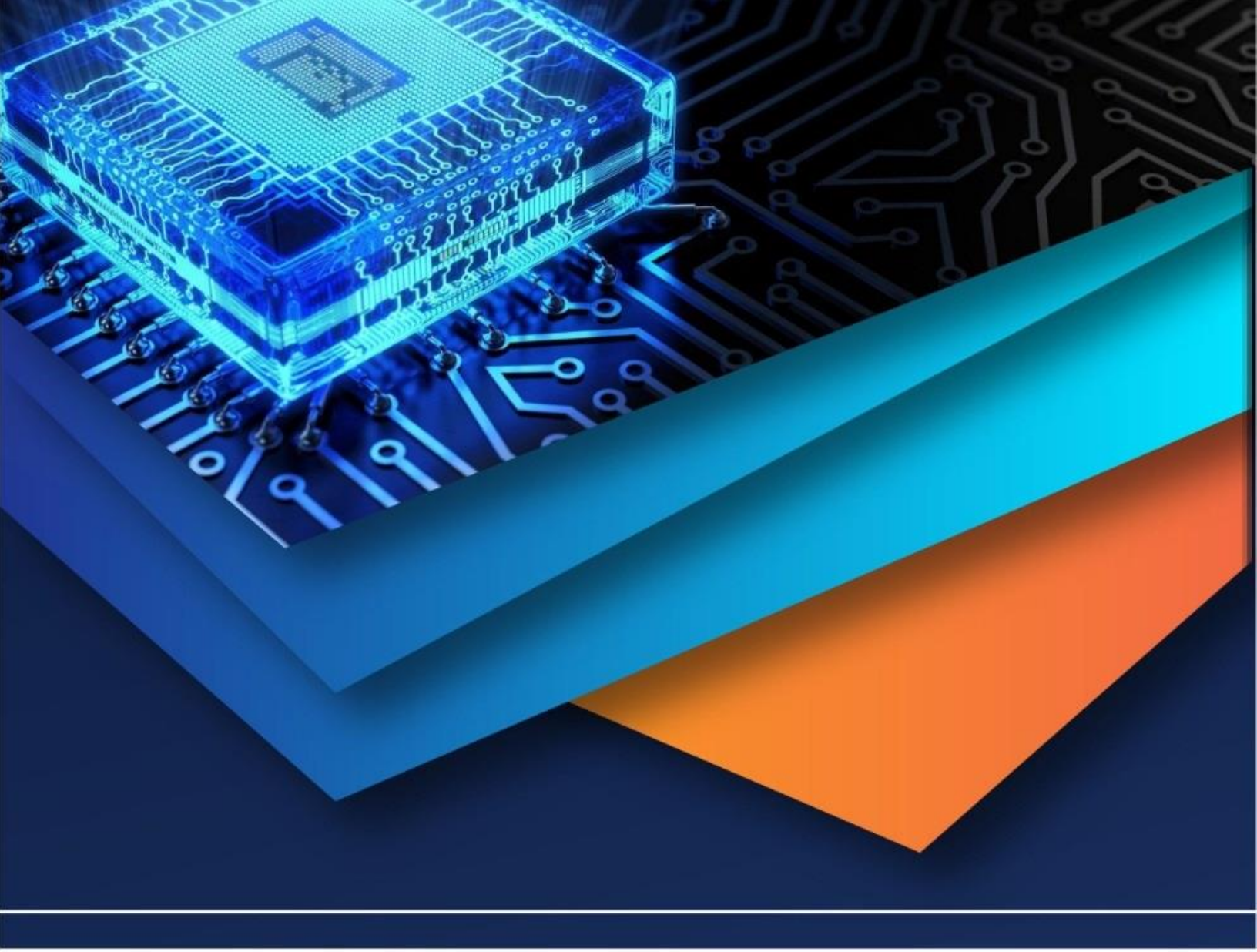

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