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Comparative Analysis of Effects of the Essential Oil as a Biopesticide against the Sitophilus Oryzae

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ABSTRACT

The rice weevil, *Sitophilus oryzae*, is a major pest in stored grains, causing significant economic losses worldwide. Traditional chemical pesticides are commonly used to control this pest, but their environmental and health impacts have prompted the use of alternative, eco-friendly solutions. This study evaluates the fumigant toxicity of essential oils from *Cinnamomum verum* (cinnamon), *Trachyspermum ammi* (ajwain), *Syzygium aromaticum* (clove), and *Vitex negundo* (Chinese chaste tree) as biopesticides against *S. oryzae* by using controlled laboratory fumigation method. All four essential oils exhibited notable insecticidal activity with s.aromaticum oil showing the higest mortality, followed by t.ammi , c.verum and v.nigundo. the finding suggest that these essential oils ,particularly *Syzygium aromaticum* ,are effective and environmentally friendly alternatives to synthetic chemical fumigants for controlling rice weevil to spread in stored grains .This study supports the potential use of plant-based biopesticides in integrated pest management strategies for sustainable agricultural practices. The study further suggest remedial measures to control the pest.

KEYWORDS: *Sitophilus Oryzae*, Essential Oils, Biopesticides, Fumigation, *Cinnamomum Verum*, *Syzygium Aromaticum*, Pest Control, Sustainable Agriculture

INTRODUCTION

Now a days there has been increasing demand for safer and more sustainable management of pest. Also it has developed more interest in plant-based Bio pesticides as a alternative [1, 2]. One of the most persistent pests affecting stored grains is the rice weevil, *Sitophilus oryzae* (L.), a cosmopolitan insect known for causing both qualitative and quantitative losses during storage [3, 4]. Female *Sitophilus oryzae* depositing eggs inside the kernels of rice grains, where larvae develop, contributing major storage loss [37].

In recent decades, botanical insecticides, particularly essential oils, have emerged as viable eco-friendly alternatives. These volatile compounds are derived from aromatic plants and possess multiple bioactivities, including repellent, fumigant, larvicidal, adulticidal properties [7, 8, & 9]. Their effectiveness, low toxicity to humans, and rapid degradation in the environment make them ideal for integrated pest management (IPM) strategies [10, 11]. Some essential oils disturbs the insect's neuromodulator octopamine or GABA-gated chloride channels of insect pests [17].

The fumigation method—involving the exposure of pests to essential oil vapours in sealed containers—has proven to be one of the most effective delivery systems for evaluating

insecticidal efficacy under controlled conditions. Essential oil of lantana camera possess the excellent fumigant toxicity [20]. Fumes generated enters in the insect body through spiracles, spreads to trachea and tracheoles and binds to the insect's blood components [21]. Adult pests are more susceptible to the fumigation of plant's essential oil [22]. However, despite individual studies on the effects of these oils, comparative studies evaluating their efficacies under identical conditions are still limited.

The essential oil contains the active ingredients have the insecticidal, pesticidal, acaricidal, nematicide and fungicidal properties which can help in crop protection [23]. These oils contain a variety of bioactive compounds, such as phenolics, terpenoids, and aldehydes, which have demonstrated strong biological activity against a broad spectrum of insect pests [24]. Their insecticidal activity can be attributed to mechanisms such as fumigant toxicity, repellence, growth inhibition, and disruption of reproductive systems [25]. Cinnamon oil, clove oil showed toxic effect & Ajwain oil have the insecticidal property against rice weevil [26, 27]. Vitex negundo oil used to control rice weevil by fumigation method [33]. Each of these oils contains distinctive active compounds that contribute to their insecticidal properties.

Cinnamomum verum, commonly known as cinnamon, is renowned for its insecticidal properties, which are primarily attributed to its active compound, cinnamaldehyde. This compound has been shown to exhibit strong fumigant toxicity, inhibiting the respiration and metabolic activity of pests. *C. verum* oil contains high levels of cinnamaldehyde, which has shown strong fumigant activity against adult weevils [16]. Cinnamon oil has been particularly effective in controlling *Sitophilus oryzae*, as evidenced in several studies that demonstrate its ability to kill adult weevils under controlled fumigation conditions [12, 16]. Cinnamon oil showed insecticidal property against ants at certain concentrations [12]. Moreover, the oil has been reported to have relatively low toxicity to non-target organisms, making it a promising candidate for eco-friendly pest control in stored grains [1].

Another essential oil with notable insecticidal activity is that of *Trachyspermum ammi* (ajwain). Rich in thymol, a monoterpenoid phenol, ajwain oil has shown promising results against a variety of storage pests, including *Sitophilus oryzae* [13, 27]. Essential oil extracted from the seeds of ajwain showed insecticidal property against *Callosobruchus chinensis* [13] Ajwain oil is also known for its strong repellent properties. Studies have highlighted its ability to reduce the infestation rate of insects in storage facilities, which further supports its use as a protective agent against pest damage in grains [27]. Ajwain oil showed insecticidal activity in the oviposition, egg hatching and inhibition in development of *Callosobruchus chinensis* [28].

Clove oil, derived from *Syzygium aromaticum*, is another essential oil with potent insecticidal properties. It contains eugenol, which is responsible for its strong repellent, insecticidal, and antimicrobial activity, antioxidant, anti-fungal, anti-viral, anti-diabetic, anti-inflammatory, antithrombotic, anesthetic, pain reliving properties [29]. Clove oil (*S. aromaticum*), rich in eugenol, has been extensively reported for its insecticidal and repellent activities against a variety of stored-product pests. Clove bud and stem possess the insecticidal activity from the powder and the extracts concentrations [18]. Eugenol acts as both a contact

and fumigant toxin, disrupting enzymatic systems and respiratory metabolism in insects [19]. Clove oil used to control pests like flea, Aphids, Nymphal instars, Mites, Imported red fire ants, American and German cockroaches [14]. Eugenol has been found to have high toxicity against various insect pests, including *S. oryzae*, through fumigation and contact toxicity [19, 26]. In addition to its toxicity, clove oil has been found to disrupt insect behaviour, including feeding and oviposition, which further contributes to its effectiveness as a pest control agent.

Nirgundi oil used to control insects like rice leaf folder, Brinjal leaf beetle, Tomato fruit borer, Groundnut cutworm, Rice weevil [15]. Nirgundi oil used to control insects like rice leaf folder, Brinjal leaf beetle, Tomato fruit borer, Groundnut cutworm, Rice weevil [15] .Vitex negundo oil used to control rice weevil by fumigation method [33]. The bioactive compounds, including casticin, have been implicated in its fumigant toxicity. Additionally, research has shown that the oil significantly affects the survival rates of weevils, providing strong evidence for its potential use in pest management strategies.

Incorporating such biopesticides into pest management programs can reduce our reliance on synthetic chemicals and mitigate environmental contamination. Moreover, they can help overcome the challenge of pesticide resistance, which has been a growing concern with conventional insecticides [2]. Due to overuse of chemical insecticides causes problems like pest resistance, residual effect and thus needs to use natural based insecticides to control agricultural pests [14]. Synthetic chemical pesticide such as metal phosphide a highly dangerous substance that can cause serious respiratory issues upon inhalation [5]. For controlling pests Methyl bromide has been used as fumigant. The bromide compounds contributes to the ozone depletion [6]. Synthetic pesticide are harmful for the non-target organism as well and also affects the environment adversely .Also these chemicals shows residual effect and may enter in food chain [36]. Organophosphates, carbamates and pyrthroids like insecticides causes insecticide resistance, increased health and environmental risks [38]. Chemical insecticides causes problems like insecticide resistance, elimination of beneficial insects, environmental persistency, toxic to humans and wildlife and more cost of crop production [39].

Environmental benefits over conventional chemical pesticides are offered by the use of essential oils for pest control. Essential oils are biodegradable, do not persist in the environment, and have low toxicity to non-target organisms such as pollinators and natural predators [26]. Additionally, these oils can be extracted from renewable plant sources, making them a sustainable option for pest management [27]. Moreover, essential oils have the potential to reduce the development of pesticide resistance**.** Unlike synthetic chemicals, which often result in resistance due to repeated use, plant oils act through a variety of mechanisms, making it difficult for insects to develop resistance [28, 29].

The present study attempts to fill that gap by conducting a comparative analysis of the fumigant toxicity of *Cinnamomum verum*, *Trachyspermum ammi*, *Syzygium aromaticum*, and *Vitex negundo* essential oils against *Sitophilus oryzae*. By assessing their insecticidal performance under standardized conditions, this study seeks to identify the most potent oil and contribute valuable insights to the development of plant-based storage pest control strategies.

METHODOLOGY

1. Collection of *sample*

To carry out research, plant material collected from different locations. Specific parts of the plants were harvested at their maturity stage. *Vitex negundo* plants were collected from village chandoli, district Sangli, Maharashtra. Then the leaves were cleaned and dried in shady conditions for 4 days. After drying the leaves were gride and after used for hydrodistillation .the seeds of *Trachyspermum ammi* , aromatic flower buds of *Syzygium aromaticum* and bark of *Cinnamomum verum* were bought from local shop .then they were grided and powder used for hydrodistillation.

Following methods are used for the present study -

A. *Hydrodistillation*

To extract essential oils methods like supercritical conventional hydrodistillation, solvent extraction, fluid extraction, subcritical extraction liquid, solvent free microwave extraction, steam distillation, and hydrodiffusion are used [30, 31]. To extract essential oils or bioactive compounds hydrodistillation method is used. This involves three types: water distillation, water-stem distillation and steam distillation. Fresh plant materials used to extract essential oil by hydro distillation. However, for this the plant materials were transferred to the round bottom flask, water was added in proportion and after that the material was kept for boiling for 4 hours. (The distilled water added to the round bottom flask then added the dried grinded sample to it and run the process for several hours). Distillate was transferred to separating funnel and solvent was added. The funnel was evenly shaken to dissolve oil in solvent. The two layers were separated and the solvent layer was kept for evaporation. After evaporation the oil was stored in glass bottle [32, 35].

B. Fumigant toxicity

The fumigation method has been widely adopted to assess the effectiveness of essential oils as biopesticides. This method involves the exposure of insects to the vaporized form of essential oils in a sealed container, ensuring uniform exposure to the volatile compounds. To study the fumigant toxicity the adults of Tribolium castaneum and *Sitophilus Oryzae* kept at 27±1°C and 60±5% in darkness [33]. An airtight plastic bottle was taken to check the fumigant toxicity of essential oil. Then with the help of Whatman filter paper No.1 a known surface area discs were made. This discs kept suspended in the bottle without making any contact with the bottle. A known volume of essential oil was applied to discs. Then the particular number of specimens were added to the bottle and records were recorded after 24 and 48 hours [34].

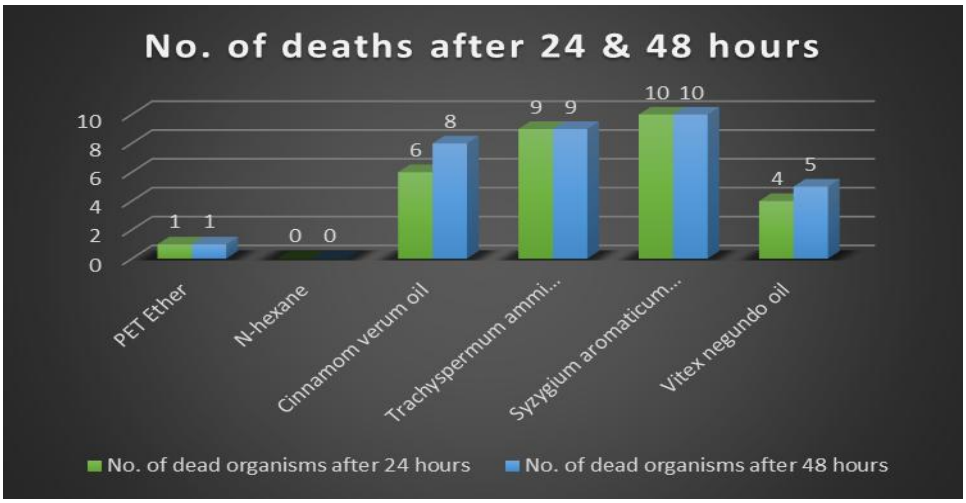
C. Formula & Calculations

$$Mortality\ percentage = \frac{No.of\ dead\ organisms}{Total\ No.of\ organisms} \times 100$$

Table 1 – Number of dead organism and mortality percentage after disc treatment

Solution applied on disc as a treatment	No. of dead organisms after 24 hours	No. of dead organisms after 48 hours	Mortality Percentage
PET Ether	1	1	10%
N-hexane	0	0	0%
Cinnamom verum oil	6	8	80%
Trachyspermum ammi oil	9	9	90%
Syzygium aromaticum oil	10	10	100%
Vitex negundo oil	4	5	50%

To evaluate the insecticidal activity of essential oil against the rice weevil (*sitophilus oryzae*) petroleum ether (PET ether) and N-hexane were used as solvent control. PET ether exhibited limited acitivity,causing 10% mortality, with only one specimen dead after 24 hours and no additional mortality observed after 48 hours. N-hexane showed no adverse effects on the insects throughout the 48 hours exposure period confirming suitability, as a non-toxic solvent control. Among the essential oil tested, clove oil demonstrated highest insecticidal efficacy, achieving 100% mortality within just 24 hours. Ajwain oil showed strong activity, resulting in 90% mortality, with 9 specimen dead at both 24 and 48 hours, indicating rapid action. Cinnamon oil exhibited moderate effectiveness with 80% mortality; 6 insect were dead after 24 hours and the total of 8 by 48 hours. In contrast, nirgundi oil displayed the lowest activity among the essential oil, causing only 50% mortality - 4 dead insects were recorded at at 24 hours and 5 by the end of the 48 hours period. These results suggest that clove and ajwain oil are highly effective natural insecticides against *S. Oryzae*, while nirgundi oil may require higher concentration to enhance the efficacy.



Graph 1: comparison of organism mortality after 24 & 48 hours

DISCUSSION

The present study demonstrated the insecticidal property of essential oils as biopesticide. Hydrodistillation method used to extract essential oil from the bark of *Cinnamomum verum*, seed like fruits of *Trachyspermum ammi,* aromatic flower buds of *Syzygium aromaticum* and fruits, flowers and leaves of *Vitex negundo*. Essential oil of above

plants tested against the major storage pest *Sitophilus oryzae* by fumigant toxicity method and it showed positive results as biopesticide. Also these plants shows resistant to most of the pest. Generally, pesticidal effect of plant's essential oil depends on various factors; the environment and climate conditions under which plant grow, the age of plant and period of sample collection, the solvent used for extraction, the choice of extraction method, the method selected to study the pesticidal property. In this study the extraction was carried out by hydrodistillation and solvents like PET Ether and N-hexane was used to dissolve oil in it. The different solvents were used because solvents possess polarity. This ensures the extraction of active components from material according to solvent polarity and also reduces the antagonist effect of compounds in the extracts. By this study it is found that pesticidal activity is due to presence of bioactive constituents in the essential oils of *Cinnamom verum*, *Vitex negundo, Syzygium aromaticum* and *Trachyspermum ammi.* By this finding it may be suggested that essential oil extracted from plants by hydrodistillation method showed good pesticidal effect against *Sitophilus Oryzae*.

CONCLUSION

The present study was conducted to obtained preliminary information on the pesticidal activity of essential oils extracted from *Cinnamom verum*, *Vitex negundo, Syzygium aromaticum* and *Trachyspermum ammi* by hydrodistillation method. Study revealed that Clove essential oil extracted in N-hexane showed highest mortality with 100% followed by Ajwain oil extracted in PET Ether with 90% mortality. Cinnamon oil extracted in N-hexane showed 80% mortality while the lowest mortality showed with 50% by Nirgundi oil extracted in N-hexane .the study further suggest to use bio pesticides to store food grains.

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