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EXPLORING BIOLOGICAL FRONTIERS FOR A GREENER PLANET
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**CONFERENCE PROCEEDINGS ON SUSTAIN LIFE 2026: EXPLORING
BIOLOGICAL FRONTIERS FOR A GREENER PLANET - VOLUME I**

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Stored Pulse Protection: Role of Essential Oils in Managing the Pulse Beetle, *Callosobruchus chinensis*

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Introduction

Pulses are an important part of Indian agriculture and daily nutrition. They are a major source of protein, People who refrains from consuming meat and fish. In India, people take their protein sources by pulses, it may fulfil to help in meeting their protein and nutrient requirements. They also provide vitamins and essential micronutrients that are necessary for good life (Joshi and Saxena, 2002). The main pulses grown in India are chickpea, pigeon pea, green gram, black gram, lentil, field pea, and etc. India is the largest producer and consumer of pulses in the world. More than 35 million hectares of land in the country are used for pulse cultivation. India contributes about 37 percent of the total area under pulses globally and produces nearly 29 percent of the world's total pulse production. Since pulses are harvested during specific seasons, proper storage is necessary to ensure availability throughout the year. Stored grains are continuous supplied to the market during the demanded period, which helps in maintaining price stability and maintain the price fluctuation. Storage is also important for preserve the seed quality. It maintains seed viability and keeps seed vigour at a period from the time of harvest to the next planting season.

However, stored pulses are highly prone to insect attack. Among the storage pests, the pulse beetle, *Callosobruchus chinensis* (L.), is one of the most serious and economically important pests. It infests almost all types of stored pulses in India. In some cases, insect damage in stored pulses has been recorded as high as 60%. Species of *Callosobruchus* will cause up to 100 percent damage to pulses in storage conditions (Govindan et al., 2023). The infestation generally starts from the field. Adult beetles lay their eggs on green or drying pods. A single female can lay 82 to 85 eggs per time. The eggs stick to the surface of the pods. After hatching, the young grub enters into the seeds by boring through the pod wall and start feeding inside the seed. As a result, damaged seeds lose weight, become unsuitable for consumption, seed purpose. For controlling *Callosobruchus maculatus*, phosphine fumigation is commonly used and is considered effective. However, frequent use of synthetic pesticides can cause harmful residual effects on food chain (Rajendran, 2003) and our environment. One of the most promising ways to reduce dependence on pesticides in agriculture is to plant insect resistant cultivars, which is one of the most effective, feasible, economical and environmentally safe pest management tactics (Pedigo, 1996). Therefore, alternative methods are being explored like botanical powders, essential oils and plant extract. Plant based Essential oils are gaining importance as they are safer, biodegradable, and more eco-friendly compared to synthetic methods. Their complex chemical composition also reduces the chances of insects developing resistance but create harmful effect in food chain. Hence, essential oils are considered a promising and sustainable method for managing pulse beetles in stored pulses.

Life Cycle of *Callosobruchus chinensis*

The infestation starts from field, where adult female lays eggs on the maturing green pods, the pest then gain entered into storage bins. The adult pulse beetles do not consume the seed, they only mate and lay eggs on the surface of seed or pod. Damage is caused by grubs which penetrate inside the pod and remain concealed within the developing seeds as hidden infestation rendering them almost hollow, which become unfit for human consumption and production of sprouts. Earlier, the biology of *Callosobruchus sp.* has been studied by various workers (Raina, 1970; Butani et al. 2001; Mondal and Konar, 2006; Pokharkar and Mehta, 2011; Chakraborty and Mondal, 2016; Hosamani et al. 2018, Jaiswal et al. 2014, Devi et al. 2014, Solanki and Mittal, 2018 and Mishra and Jena, 2015) and it is essential to control this pest at right stage of its infestation. *C. chinensis*. In this investigation, shortest developmental time, highest adult survival and susceptibility index.

Table no:1 Developmental period of different stages of *Callosobruchus chinensis* on pulses under laboratory condition

Life Stages of <i>Callosobruchus chinensis</i>	Duration in days
Egg	3
Larve and Pupae	21
Adult	6
Adult female	6
Adult male	7
Total life cycle	31
Pre oviposition period	0
Oviposition period	6
post oviposition period	1

Reference: These findings are in confirmation with Chakraborty and Mondal (2015); Jaiswal et al. (2018); Hosamani et al. (2018); Thakur and Pathania (2013). While it contradicts with the result of Quazi (2007); Samyuktha (2019) who reported that average life span of *C. chinensis* were 22 days and 24.65 days, respectively.

Nature of Damage:

Infestation generally begins in the field and continues during storage. The larvae possess biting and chewing type mouthparts, enabling them to bore into seeds and feed internally. As development progresses, the seed becomes hollow and loses weight. Severely damaged grains become unsuitable for human consumption, seed purposes, and sprouting. The hidden nature of larval feeding makes early detection difficult, thereby increasing storage losses.

Role of essential oils used for Control the *Callosobruchus chinensis*

The excessive use of chemicals in storage leads to increases the harmfulness and affect the food chain. Their harmful effects on non-target living organisms and ecosystems have need to alternative option for pest control. As well as plant-based insecticides, especially essential oils, botanical powders etc., it has wide availability, and low-cost that more useful for small and marginal farmers. Essential oil how bioactive compounds of indigenous plant extracts have various effects on insects i.e., anti-feedant action, insect growth regulatory activity inhibits juvenile hormone synthesis, oviposition deterrent, repellent action, reduction of life span of

adults and intermediates are formed giving rise to larval-pupal, nymphal-adults, and pupal-adult intermediates and the mode of action of oils is partially attributed to interference in normal respiration, resulting in suffocation (Schoonhoven, 1978). It is also thought that oils exert some lethal action on developing embryos or first-instar larvae, for example, by the reduction in rate of gaseous exchange due to a barrier effect and/or direct toxicity by penetrated oil fractions (Don Pedro, 1989). Essential oils are natural secondary metabolites produced by aromatic plants. They play an important role in pest control by the plant parts. These oils are synthesized through specific biochemical pathways by using the plant materials. Because of their biological activity and biodegradability, essential oils are considered a promising alternative to synthetic insecticides.

Essential oil as biopesticides

Essential oils are emerged as an effective biopesticides as they contain hundreds of individual compounds and their mixtures, that give physical, chemical and biological characteristics of them. The main active constituents with insecticidal activity are monoterpenes, sesquiterpenes and related phenylpropenes. EOs can be applied as pesticides as their active components is use as "Active ingredient" or as co-adjuvants in pesticide formulations which enhanced the pesticidal activity of that formulation (Mossa ATH 2016). However, they can be acted as a contact and stomach poison, causing changes in the pathways of biochemical metabolism of the insect.

1. Fumigant Activity: Due to their volatile nature, essential oils readily vaporize at room temperature and act as fumigants. Their vapors penetrate storage environments and exhibit broad-spectrum toxicity against storage pests, leaving minimal harmful residues (Ebadollahi, 2010).

2. Antifeedant Activity: Compounds such as azadirachtin, thymol, and carvacrol interfere with feeding behavior by affecting insect sensory mechanisms. This results in reduced feeding, impaired development, and suppressed oviposition (Shukla, 2012).

3. Repellent Activity: Active constituents including eugenol, thymol, limonene, α -pinene, and β -pinene exhibit strong repellent properties, preventing insects from approaching and infesting stored commodities (Thongdon-a, 2009).

4. Insect Growth Regulator (IGR) Activity: Certain essential oils disrupt juvenile hormone regulation and interfere with molting and metamorphosis, thereby affecting growth and reproduction (Abdelaziz, 2014).

5. Insecticidal Activity: Essential oils containing 1,8-cineole, carvacrol, eugenol, and linalool exhibit ovicidal, larvicidal, pupicidal, and adulticidal effects. Oils extracted from *Coriandrum sativum* and *Carum carvi* have shown significant toxicity against storage pests such as *Sitophilus oryzae*, *Rhyzopertha dominica*, and *Cryptolestes pusillus* (Abdelgaleil, 2009).

Essential oils Used to control the *Callosobruchus chinensis*

S.No.	Name of the essential oil	Scientific name	Active component	Control Mechanism	Reference
1.	Neem oil	<i>Azadirachta indica</i>	Azadirachtin, Salannin, Nimbin, Meliantriol.	Antifeedant, oviposition deterrent, insect growth regulator and sterlant	Campos et al. (2016 review on botanical insecticides)
2.	Eucalyptus oil	<i>Eucalyptus globulus</i>	1,8-Cineole (Eucalyptol), α -Pinene, Limonene, Terpeneol	Fumigant and repellent	Nerio et al. (2010)
3.	Mustard oil	<i>Brassica juncea</i>	Allyl Isothiocyanate, Sinigrin (glucosinolate precursor), other isothiocyanates.	Contact toxicity	Tripathi & Upadhyay (2003)
4.	Clove oil	<i>Syzygium aromaticum</i>	Eugenol, β -Caryophyllene, Eugenyl acetate	Paralysis and death	Regnault-Roger et al. (2012 review)
5.	Basil oil	<i>Ocimum basilicum</i>	Linalool, Estragole, Methyl chavicol, Eugenol	Repellent and oviposition deterrent	Pavela (2015 review)
6.	Marigold oil	<i>Tagetes erecta</i>	Tagetone, Limonene, Ocimene	Fumigant and repellent properties	Pavela (2016)

7.	Jasmine oil	<i>Jasminum grandiflorum</i>	Benzyl acetate, Benzyl alcohol, Linalool	Repellent and behavioural modifier	Pavela & Benelli (2016 review)
8.	Lemongrass oil	<i>Cymbopogon citratus</i>	Citral, Myrcene, Geraniol	Fumigant and contact toxicity	Pavela (2015)
9.	Sweet flag oil	<i>Acorus calamus</i>	β Asarone, α -Asarone, Acorone	Powerful fumigant toxicity	Pavela (2016)

Future scope Essential oil for controlling the *Callosobruchus chinensis*

In India, small and marginal farmers often suffer heavy post-harvest losses in pulses due to poor storage facilities and insect infestation. Although synthetic insecticides are widely used to control storage pests, their repeated use has led to problems such as toxic residues, health risks, environmental pollution, and resistance development. These concerns highlight the need for safer alternatives. Plant-based bio-pesticides, including botanical extracts and edible oils, have gained attention for their effectiveness and minimal environmental impact (Varma and Pandey, 1978; Jane et al., 2009). Among them, essential oils have shown promising potential as eco-friendly grain protectants for managing pulse beetles during storage.

Conclusion

Essential oils offer a promising and eco-friendly approach for managing *Callosobruchus chinensis* in stored pulses. Their multiple modes of action disrupt pest growth, behaviour, and survival, while reducing the risk of resistance development. Although limitations such as volatility and instability may affect performance, improved formulations like nano-encapsulation can enhance their effectiveness. Compared to synthetic insecticides, essential oil-based products are safer and more environmentally compatible, making them suitable for sustainable pest management, especially for small and marginal farmers. Among the oils evaluated, sweet flag oil has shown comparatively higher bio-efficacy under laboratory conditions and warrants further investigation for practical use.

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