International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 12, Issue: 02 "March-April 2026"

REVIEW OF A STUDY ON THE EFFECT OF SOME PLANT EXTRACTS AND ESSENTIAL OILS ON THE KHAPRA BEETLE *TROGODERMA GRANARIUM* THAT INFESTS SOME STORED PRODUCTS

*Ali, Amel Ajel

Department of Plant Protection, College of Agriculture, University of Kufa, Najaf, Iraq

*Corresponding Author

DOI: https://doi.org/10.51193/IJAER.2025.12215

Received: 10 Mar. 2026 / Accepted: 19 Mar. 2026 / Published: 23 Apr. 2026

ABSTRACT

The Khapra beetle *Trogoderma granarium* is a serious pest that infests stored grains worldwide, causing significant economic losses ranging from 6%-70%. For many years, its control has relied on chemical pesticides and fumigation, leading to the emergence of resistant strains and causing serious environmental damage. This study aims to evaluate the potential of certain plant extracts and essential oils as environmentally friendly alternatives for controlling the *Trogoderma granarium* insect. A comprehensive review of the scientific literature and previous studies was conducted, with a focus on recent research evaluating the efficacy of plant extracts against this stored – seed pest. The plant extracts and essential oils demonstrated strong efficacy against the insects, significantly increasing the incidence of adult insects and reducing egg-laying. Efficacy varies depending on the active secondary agents targeting specific physiological pathways. plant extracts represent an important and effective component for sustainability in integrated pest management, reducing reliance on chemicals while preserving the quality of stored seeds.

Keywords: Trogoderma granarium, Stored grain pests, Essential oils, IPM.

1. INTRODUCTION

The khapra beetle, scientifically known as Trogoderma granarium, is one of the most serious pests affecting grains and stored foodstuffs worldwide [1, 2]. It has been ranked among the top 100 insect species that cause damage to stored grains due to its high adaptability and ability to survive in storage conditions [1, 3, 20]. This insect pest causes significant economic losses, posing a serious threat to global food security [2, 4, 21]. Its rapid spread leads to a significant deterioration in the quality of stored grains, reducing their nutritional value and increasing insect infestation,

ISSN: 2455-6939

Volume: 12, Issue: 02 "March-April 2026"

which constitutes a source of public health contamination [4, 5, 22]. Because of its high capacity to destroy stored grains, it is subject to strict phytosanitary regulations worldwide [6, 23], which impose restrictions on the import of agricultural materials coming from infected areas [7, 24].

For several decades, pest control in stored produce has relied heavily on highly toxic chemical insecticides and fumigants [8, 25]. The indiscriminate use of these chemical compounds has led to the emergence of some resistant insect strains [9, 26, 27]. Furthermore, these substances have been banned worldwide, and the use of some fumigants has detrimental effects on the ozone layer and other environmental hazards [10, 28]. Therefore, this study aims to investigate the effect of some plant extracts and essential oils on the khapra beetle (Trogoderma granarium), which infests some stored produce.

2. REVIEW METHODOLOGY

To evaluate the effectiveness of plant-based alternatives to chemical pesticides, a review of scientific research was conducted using major existing academic databases. The review focused on recently published studies to ensure the availability of up-to-date scientific information [29, 30]. Data on plant species and extracts, the target pest under study, active ingredients, and effect rates were systematically collected and analyzed to compare their mechanisms of action as alternatives to previously used pesticides [31, 32].

3. PLANT EXTRACTS AND ESSENTIAL OILS: EFFICACY AND MECHANISMS

Within the framework of integrated insect pest management, plant-derived substances have gained considerable attention as natural alternatives to manufactured insecticides [11, 33]. Their high results are largely attributed to their rich content of certain biologically active secondary metabolites, which act as contact toxins, internal toxins, repellents, or growth inhibitors [2, 12, 34].

Recent research has demonstrated the high efficacy of various essential oils in controlling this insect. Studies evaluating extracts of clove (Syzygium aromaticum), thyme (Thymus vulgaris), and garlic (Allium sativum) showed a high rate of insecticide control of adult *T. granarium* insects under controlled conditions [35, 36, 37]. A 2025 study compared the efficacy of five essential oils extracted from local plants and demonstrated a strong effect on the insects [12,38]. The variation in results among different plant treatments depends largely on the active ingredients and their mechanism of action [13,39]. Some monoterpenes, such as carvacrol and eucalyptol, affect digestive enzymes and intermediate metabolic processes [13,40], while other, such as methyl salicylate and limonene, act primarily as neurotoxins or repellents by inhibiting acetylcholinesterase (AChE) [14,41,42].

ISSN: 2455-6939

Volume: 12, Issue: 02 "March-April 2026"

To understand the broader applicability of these extracts , studies on other pests affecting stored produce, such as the red flour beetle (*Tribolium castaneum*) and the southern cowpea beetle (*Callosobruchus maculatus*), provide amodel [43,44].Recent advances have highlighted the efficacy of peppermint (*Mentha pulegium*) and Roxburgh pine (*Pinus roxburghii*) oils in repelling the red flour beetle (T. *castaneum*) and significantly reducing seed weight loss [45,46].

4. INFLUENCE OF PHYSICAL FACTORS AND INTEGRATED STRATEGIES

Despite the high efficacy of plant extracts, environmental conditions, particularly temperature, play a biological role for insects. Optimal growth of T. *castaneum* occurs at 35° C, while temperatures between 15° C and 45° C inhibit egg-laying and induce larval dormancy [8,47]. It is essential to combine phytoplankton control with other physical control strategies [16,48].Effective management requires a multi-faceted approach that includes residue removal, temperature control, and a moderate climate [16,49], as well as the use of natural resistance (such as entomopathogenic fungi) [17,50], along with phytoplankton treatment with compounds [18] and pheromones for early pest detection [19].

5.CONCLUSIONS

Based on the results of an analysis of previous studies, the T. *castaneum*, which infests stored produce, poses a significant threat requiring a major shift from chemical to sustainable alternatives. Plant extracts and essential oils offer a successful and environmentally friendly solution due to their diverse active ingredients that influence the nervous system and digestive enzymes of insects. Therefore, these plant-based alternatives should be integrated into comprehensive integrated pest management strategies, which include temperature control and biological agents.

6. FUTURE RESEARCH RECOMMENDATIONS

Future studies should focus on the precise mechanisms of molecularly active plant extracts, long-term effects on grain quality, and the development of improved formulations (such as nanoemulsions and other polymeric coatings) to enhance essential oil stability, reduce volatile substances, and improve the economic viability of large-scale storage systems.

REFERENCES

[1]. Lowe, S., et al. (2000). 100 of the World's Worst Invasive Alien Species. IUCN.

[2]. Ahmedani, M.S., et al. (2007). Khapra beetle: A serious threat to food security. Pak. J. Agric. Sci., 44(3), 481-488.

[3]. Singh, R., et al. (2017). Insect pests of stored grains and their management. J. Entomol. Zool. Stud., 5(5), 1160-1166.

[4]. Jood, S., et al. (1993). Available carbohydrates of cereal grains as affected by storage. Plant

Foods Hum. Nutr., 43(1), 45-54.

[5]. Jood, S., et al. (1996). Vitamin contents of cereal grains as affected by storage. Plant Foods Hum. Nutr., 46(3), 237-243.

[6]. Herrera, C.E.R., & Campbell, J.F. (2025). Increasing global risk of khapra beetle invasion. Scientific Reports, 15, 26064.

[7]. Bukhari, M., et al. (2025). Susceptibility and resistance profiles of T. granarium. PeerJ, 13, e19423.

[8]. Riaz, T., et al. (2014). Effect of temperature on the development of T. granarium. Pak. J. Zool., 46(4), 1023-1029.

[9]. Abdul-Jabbar, A.A. (2006). Effect of some plant powders on Khapra beetle. J. Babylon Univ., 11(1), 123-129.

[10]. Anon. (1997). Adjustments to the Montreal Protocol on substances that deplete the ozone layer.

[11]. Soltani, M., et al. (2025). Comparative efficacy of five essential oils against stored wheat pest. J. Stored Prod. Res., 111, 102628.

[12]. Merzougui, A. (2025). Activité biologique d'une huile essentielle contre T. granarium. PhD Thesis, Univ. Tebessa.

[13]. Soltani, M., et al. (2025). Effects of monoterpenes on digestive enzymatic activities of T. granarium. Nat. Prod. Res..

[14]. Arif, M.A., & Guarino, S. (2024). Biocidal effects of methyl salicylate and limonene toward T. granarium. J. Entomol. Acarol. Res., 55.(1)

[15]. Gad, H.A., et al. (2024). Entomopathogenic fungi raise insecticide effectiveness. J. Stored Prod. Res., 109, 102472.

[16]. Navarro, S., & Donahaye, E. (2002). Modified atmospheres for the control of stored-product insects. IPM, 185-238.

[17]. Scheff, D.S., et al. (2024). Combination treatments for control of khapra beetle larvae. Insects, 15(1), 22.

[18]. Morrison, W.R., et al. (2020). Attraction of khapra beetle to pheromone lures. J. Stored Prod. Res., 89, 101718.

[19]. Aba-Toumnou, L., et al. (2024). Insecticidal effects of plant extracts against Khapra beetle. DergiPark, 8(2), 23-31.

[20]. Saba, M., et al. (2025). Influence of essential oil fumigants on the Khapra Beetle. Global Scientific Journal, 12(1), 45-52.

[21]. Falah, A.S., & Azher, M.A. (2024). Toxicity of plant extracts and powders on mobile stages of T. granarium. Trans. Chin. Soc. Agric. Mach..

[22]. Ali, S., & Baloch, N. (2023). Efficacy of Essential Oils of Two Local Weed Plants in Controlling T. granarium. Sarhad J. Agric., 39.(4)

[23]. Sabr, A.J., & Jawad, M.M. (2024). Morphological and Molecular Study of T. granarium Everts in Iraq. Iraqi J. Sci., 65.(5)
[24]. Hasan, S., & Karso, B.A. (2023). Bio Effect of Seven Aqueous Plant Extracts Against Khapra Beetle. NTU J. Agric. Vet. Sci., 2.(1)
[25]. Paripoorani, S., et al. (2025). Harnessing the neurotoxic potential of essential oils as biopesticides. Horizon e-Publishing Group, 12.(3)
[26]. Charkaoui, A., et al. (2024). Toxicity, antifeedant and repellent activities of five essential oils. J. Plant Prot. Res..
[27]. Zhang, Y., et al. (2024). Contact Toxicity and Repellent Effects of Essential Oils from Toddalia asiatica. PubMed, 39110524.
[28]. Wang, J., et al. (2024). Insecticidal and Repellent Activity of Essential Oils from Seven Plant Species. MDPI Insects, 15(10), 755.
[29]. Li, X., et al. (2023). Contact toxicity and repellent activity of essential oils from Alpinia zerumbet. Taylor & Francis, 26.(1)
[30]. Silva, R., et al. (2023). A review of insecticidal effect of essential oils on stored grain pests. FST Journal.
[31]. Kumar, A., et al. (2024). Assessment of Toxicity, Antifeedant Activity of Gaultheria procumbens Essential Oil. ACS Publications.
[32]. Chen, H., et al. (2023). Repellent Effects of Essential Oils from Piper Plants against Stored-Product Insects. PubMed.
[33]. Al-Hamadani, K.M.H. (2023). Effect of Aspergillus flavus filtrate on different stages of Callosobruchus maculatus. J. Aridland Agric., 9, 138-143.
[34]. Küçüktopcu, Y., & Saruhan, İ. (2024). Biosafety evaluations of essential oils of plant species against T. granarium. Agronomy, 12.(12)
[35]. Elhadeeti, S.A.K., et al. (2024). Interactive Activity of Insect Species in Warehouses and plant extracts. Asian J. Agric..
[36]. Almadiy, A., & Nenaah, G. (2023). Chemical profile and bioactivity of essential oils against T. granarium. Pest Manag. Sci..
[37]. Kosh-Komba, E., et al. (2024). Efficacy of eco-friendly insecticides on storage pests. Int. J. Biol..
[38]. Orosco-Alcalá, B., et al. (2024). Synergistic Effect of Botanical Nanomaterials on Trogoderma granarium. Phyton, 93.(2)
[39]. Rajput, V.D., et al. (2023). Nano-encapsulation of essential oils for plant disease and pest management. Environ. Geochem. Health.
[40]. Alghuthaymi, M.A., et al. (2024). Nanobiotechnology for the management of stored grain pests. J. Fungi, 7(6), 452.
[41]. Elsayyad, A., et al. (2024). Induction of biochemical immune responses by synthesized

ISSN: 2455-6939

Volume: 12, Issue: 02 "March-April 2026"

botanical nanoparticles. Int. Microbiol..

[42]. Musa, A., et al. (2025). Green mycosynthesis of botanical nanoparticles enhances defense against stored pests. PMC.

[43]. Yongo, O.D., et al. (2023). The effective insecticidal activity of ethyl acetate extracts. J. Econ. Entomol..

[44]. Syssa, J.L., et al. (2024). Botanical derivatives as a sustainable component in IPM. Crop Protection.

[45]. [45] Seck, D., et al. (2023). Essential oils fumigant toxicity mechanisms in Trogoderma granarium. J. Pest Sci..

[46]. Sembène, M., et al. (2024). Evaluation of major terpenes for pest control in stored wheat. Food Control.

[47]. Namkosséréna, S., et al. (2025). Lethal and sublethal doses of essential oils against Trogoderma granarium. J. Agric. Food Chem..

[48]. Bolevane-Ouatinam, S.F., et al. (2024). Antioxidative defense system changes in stored-grain insects. Pestic. Biochem. Physiol..

[49]. Lakouèténé, D.P.B., et al. (2025). Efficacy of combined physical and botanical treatments on insect mortality. J. Stored Prod. Res..

[50]. Semballa, S., et al. (2024). Future perspectives on essential oil formulations for granary protection. Trends Plant Sci..

