**Recent Development and Reviews on Botanicals from Plants To Stored Grains.**

**Abstract:**

There have been numerous reports of insect infestations being connected to grains that have been stored. Almost all species multiply at astonishingly fast rates and may even reproduce sexually.10-15% of the grain is destroyed, and the remaining portion is tainted with unpleasant smells and scents. Beetles (Callosobrunchus sp., Trogoderma granarium, and Tribolium confusum), weevils (Sitophilus oryzae, S. granarius, etc.), moths (Corcyra cephalonica), rats, and weevils are the main pests of stored grains. Botanical extracts have antifeedant and arrestant properties, kill and repel pests, and have an impact on insect growth and development. The indiscriminate and ongoing use of pesticides has resulted in the accumulation of hazardous residues on food grains used for human consumption as well as the emergence of resistant breeds of pests.

Recently, attention has been focused on using plant products as a novel strategy for protecting grains in many parts of the world. The bioactivity of plant derivatives against several pests found in storage has already been reported in numerous scientific literature. Because of their generally safe antimicrobial properties, higher plants like neem have also been utilized as antibacterials against storage pests.

People have utilized a variety of herbs and spices (such as turmeric, garlic, and cloves, among others) to manage storage pests. Plant-based products might be able to address issues with synthetic pesticides like resistance, cost, availability, and health hazards. More study is required to determine the effectiveness of biocontrol and the practical applicability of botanical insecticides. It is important to do biosafety studies to determine how dangerous they are to people, animals, and crop plants.

As different insect life stages cause financial harm and degrade the quality of food grains and food products, infestation of stored grains is a highly important issue. Due to unmanaged environmental conditions and subpar warehousing technologies, numerous stored grain insect pests infest food grains in farmer stores and public warehouses. However, very specific and more suitable current measures should be applied to control the expanding insect population.

The use of entomopathogens and a few key techniques including microwave and ionizing radiation, pheromone-baited traps, IGRs, and microwave radiation have all been shown to be particularly successful against stored grain insects. Since the beginning of time, botanicals have been employed to protect stored goods from prevalent pests. By acting as chemosterilants or insect growth and development inhibitors, they operate as repellents, antifeedants, toxicants, and natural grain protectants.

**Keywords: Botanicals, Stored Grains, Pests, Protection,**

**Introduction:**

A major issue, especially in poorer nations, is food grain losses from pest infestation during storage. In addition to the direct loss of kernels, insects can also result in the buildup of exuviae, webbing, and dead animals. Insect waste accumulation at high levels can lead to grain that is unfit for human consumption and loss of food commodities in terms of both quality and quantity. Changes in the storage environment brought on by insect infestations may result in warm, wet "hotspots" that favor storage fungus that increases losses. More than 20,000 species of field and storage pests are thought to be responsible for one-third of the world's food production losses, which are estimated to cost more than $100 billion annually, with the majority of these losses (43%) occurring in developing nations. In the tropical zone, insect pest damage to stored grains and grain products may be between 20 and 30 percent, and between 5 and 10 percent in the temperate zone. In 2010–2011, India produced 250 million tonnes of food grains, of which 20–25% were harmed by pest insects that feed on stored grain. The objective of entomologists around the world has long been the effective management and elimination of stored grain pests from food commodities.

The principal pests, or those that can penetrate stored grains and pulses, are divided into two categories by the Indian subcontinent.

secondary bugs that cannot infest the whole grain but feed on broken kernels, debris, high moisture weed seeds, and grain damaged by primary pests. and infesting intact kernel of grain and developing immature stages within kernel of grain. The immature stages of secondary pest species are typically located outside of the grain. It's a common misconception that secondary intruders can't start an infestation. Sitophilus oryzae (L.), Sitophilus granaries (L.), Rhyzopertha dominica (F.), (Coleoptera: Bostrichidae), Khapra beetle (Trogoderma granarium (Everts), (Coleoptera: Dermestidae), and pulse beetle (Callosobruchus chinensis) (L.) are the major primary pests.

The secondary pests are the sawtoothed grain beetle, Oryzaephilus surinamensis (L.), rusty grain beetle, Cryptolestes ferrugineus (L.), (Coleoptera: Cucujidae), mites, Liposcelis corrodens, and (Psocoptera: Liposcelidae).

**Types of Botanicals Used to Protect Stored Food:**

Plants or products derived from plants that include active components for the control of pests in storage are known as botanicals. These are spices and medicinal and other plants.

**Spices:** Spices have been used since the dawn of time to taste meals as well as keep pests away from stored goods. The use of extracts or oils has lately undergone experimental testing with good results. Traditionally, pieces of dried or crushed spices were sprinkled over or mixed with preserved meals.

**Medicinal and Other Plants:** Numerous other plants have also been utilized to fight stored bugs in addition to spices. Among these are plants known to have an impact on stored pests, as well as medicinal herbs, which are typically used to treat human illnesses but can also be used to safeguard stored food.

All of the plants' leaf extracts—Prosophis species, Nerium species, Ocimum species, Acalypha species, Catharanthus species, and Vitex species—had a noticeable ovipositional deterrent effect in pulse beetles.

Catheranthus sp. leaf extract (56.7%) and Vitex sp. leaf extract (61.7%) both significantly reduced the viability of eggs.

Maximum adult emergence reduction was seen in seeds treated with Vitex sp at a level of 5%, followed by Catheranthus sp. (83.7%), Acalypha sp. (73.3%), Nerium sp. (70.0%), and Ocium sp. (68.7%), while Prosphis sp. showed the least amount of adult emergence reduction (68.0%) (Sathyseelan et al., 2008).

A. mexicana, P. juliflora, and T. purpurea plant powders were examined for their ability to resist T. castaneum. According to Pugazhvendan et al. (2009), all plant powders show repellent properties in general.

By having fewer holes per seed, damaged seeds overall, a lower percentage of damaged seeds, and less weight loss, bean seeds treated with pyrethrum outperformed alternative treatments. Garlic outperformed no pesticide application treatment in lowering the number of holes per seed, the percentage of damaged seeds, and weight loss (Mulungu, 2007).

The sweet flag rhizome powder @ 10.0 g / kg of seed performed better than the untreated control at the end of the 10th month of storage, recording significantly higher germination percentage (87.00%), vigour index (2694), dry weight of seedlings (329.50 mg), and lower electrical conductivity (0.488 dSm1) and insect infestation (3.33%).

Derbalah (2012) found that the tested botanical extracts (Cassia senna, Caesalpinia gilliesii, Thespesia populnea var. acutiloba, Chrysanthemum frutescens, Euonymus japonicus, Bauhinia purpurea, and Cassia fistula) were highly effective against T. granarium in terms of adult mortality and progeny. The most successful herbal remedy for T. granarium was C. senna.

The sugar apple seed is poisonous to a variety of insects. Certain components in its leaves prevent certain stored grain insects from growing. Indian privet leaves have an insecticidal effect on insects that feed on grains that have been kept (Narong Chomchalow, 2003).

According to Abdullahi et al. (2011), Vittallaria paradoxa has a lot of promise for application as a plant-based biopesticide for preventing the spread of the Callosobruchus maculates pulse beetle.

The bitter gourd, karanja, and urmoi ethanol seed extract demonstrated grain protection properties over wheat grains for up to 30 days.

Even after three months of treatment, the extracts had no negative effects on the ability of wheat seeds to germinate (Islam, 2002).

According to Abdullahi et al. (2011), lime peel oil is efficient at protecting maize from the weevil Sitophilus zeamaise.

Mamun et al. (2009) found that extracts of plants (Bazna (Zanthoxylum rhetsa), Ghora-neem (Melia sempervirens), Hijal (Barringtonia acutangula), Karanja (Pongamia pinnata), Mahogoni (Swietenia mahagoni) and Neem (Azadirachta indica)) have direct harmful impact on red flour beetle.

Neem seed extract had the highest level of toxicity (death rate: 52.50%), whereas Hijal leaf extract had the lowest level of toxicity (death rate: 22.24%).

Dodder vine extract was discovered to be useful for monitoring oviposition, adult progeny development, and seed damage severity. Callosobruchus chinensis was less likely to choose seeds treated with a 5% concentration of dodder vine extract for oviposition, adult emergence, and seed weight loss (Rahman et al., 2010). This conc. may help protect pulse seed.

The toxicity of plant extracts and plant powders (kaner leaf extract (Nerium indicum), khejri leaf extract (Prosopis cineraria), neem leaf extract (Azadirachta indica), safeda leaf extract (Eucalyptus globulus), tomato leaf extract (Lycopersicum esculentum), and mustard seed extract (Brassica compestris) and four plant powders viz.,

In a study, Ipomea carnea plant stacks were used to build a storage structure, which was then filled with bengalgram. For a longer time, no infection was discovered, and during the first five months of storage, there was no weight loss in this structure (Ahmed and Dwyer, 1988).

It has been observed that mixing grains with V. negundo and neem powders and placing them between layers of grain-filled sacks protected paddy (Vivekanandan, 1993; 1994).

**Classification of Botanical Insecticides:**

Based on the physiological processes that occur in insects. Traditionally, scientists divided plant parts into six categories: attractants, feeding deterrents/antifeedants, toxicants, growth retardants, and chemosterilants.

**Repellents:**

The compounds used in repellents are desirable because they protect while having little effect on the ecosystem. By stimulating olfactory or other receptors, they drive away insect pests from the treated materials. Plant-based repellents are thought to be safe for use in pest control since they minimize pesticide residue and protect humans, food, and the environment. Different bioactive plants' plant extracts, powders, and essential oils have been reported to be effective insect pest repellents for stored grain. For instance, it has been discovered that Callosobruchus maculates and Tribolium castaneum are both repulsive to Artemisia annua essential oil.

**Antifeedants/Feeding Deterrents:**

Antifeedants, often known as "feeding deterrents," are substances that prevent or obstruct insect feeding by making the treated materials unpleasant to the touch or taste. Some naturally occurring antifeedants that have been characterised include triterpene hemiacetal, aromatic steroids, hydroxylated steroid meliantriol, glycosides of steroidal alkaloids, and glycosides of steroidal alkaloids. Spodoptera litura synergism, or additive effects of combination of monoterpenoids from essential oils, have been documented against Spodoptera litura larvae. Essential oil compounds such as thymol, citronellal, and a-terpineol are efficient as feeding deterrents against tobacco cutworms. The root bark of Dictamnus dasycarpus was shown to have a strong feeding deterrent against two stored-product insects after screening many therapeutic plants.

**Toxicants:**

Despite the increased attention given to the creation of synthetic pesticides, research on novel toxins of plant origin has not decreased in recent years. Numerous plant derivatives are poisonous to insects that feed on stored goods, according to accounts from around the world. There have been numerous reports of the oils, extracts, and bioactive components of Ocimum species having insecticidal properties against different insect species.

**Natural Grain Protectants:**

Plant products have been employed as organic grain protectors since ancient times. According to accounts from around the world, plant leaf, bark, seed powder, or oil extracts added with stored grains decrease the rate of oviposition of stored product insects, stop them from emerging as adults, and also lessen the rate of seed damage. The most well-known example is the Indian neem plant, which has been used in many forms, including leaves, crushed seeds, powdered fruits, oil, and so on, to prevent pests from infesting stored grain.

**Chemosterilants/Reproduction Inhibitors:**

Numerous studies found that adding plant materials to grains—including parts, oils, extracts, and powder—reduced insect oviposition, egg hatchability, postembryonic development, and progeny generation. Numerous ground plant components, extracts, oils, and vapors also keep a lot of insects at bay.

**Insect Growth and Development Inhibitors:**

Plant extracts harmed the growth and development of insects, significantly decreasing the weight of the larvae, pupae, and adults, lengthening the larval and pupal durations, and decreasing pupal recovery and adult eclosion. A bug like Sitophilus oryzae was fully prevented from growing on grains treated with plant extracts. Furthermore, the survival rates of larvae, pupae, and adult emergence are decreased by plant derivatives. Plant compounds also prevented the growth of eggs and immature stages inside grain kernels. the crude extract slowed down development, killed off larvae, melanized their cuticles, and significantly increased adult mortality rates.

**Table 1. List of plant species reported to show insecticidal activity.**

| Plant species | Family | Plant part |
|---|---|---|
| *Acorus calamus* | Acoraceae | O, RO |
| *Allium sativum* | Alliaceae | P |
| *Annona squamosa* | Annonaceae | L |
| *Aphanamixis polystachya* | Meliaceae | SC, SE |
| *Azadirachta indica* | Meliaceae | O, SP, LP |
| *Baccharis salicifolia* | Asteraceae | O |

| | | |
|---|---|---|
| *Bassia longifolia* | Sapotaceae | E |
| *Brassica* spp. | Cruciferae | L, ZE |
| *Cajanus cajan* | Fabaceae | O |
| *Calophyllum inophyllum* | Clusiaceae | O |
| *Calotropis procera* | Apocynaceae | LP |
| *Carum carvi* | Apiaceae | FE |
| *Cinnamomum aromaticum* | Lauraceae | B |
| *Citrus* | Rutaceae | O |
| *Curcuma longa* | Zingiberaceae | P |
| *Chenopodium ambrosioides* | Amaranthaceae | FE, O |
| *Cocos nucifera* | Arecaceae | O |
| *Convolvulus arvensis* | Convolvulaceae | LE |
| *Conyza dio scoridis* | Asteraceae | ZE |
| *Coriandrum sativum* | Apiaceae | SE, O |
| *Datura alba* | Solanaceae | LP |
| *Decalepis hamiltonii* | Asclepiadaceae | XP |
| *Eichhornia crassipes* | Pontederiaceae | LE |
| *Elae is guineensis* | Arecaceae | O |
| *Elae is guineensis* | Palmaceae | O |
| *Embelia ribes* | Myrsinaceae | FE, O |
| *Eucalyptus globules* | Myrtaceae | LP, M |
| *Foeniculum vulgare* | Apiaceae | FE |
| *Glycine max* | Fabaceae | O |
| *Jatropha gossypifolia* | Euphorbiaceae | SE |
| *Juniperus vi rginiana* | Cupressaceae | O |
| *Lantana camara* | Verbenaceae | TE |
| *Lonchocarpus* spp. | Leguminosae | O |
| *Lupinus albus* | Fabaceae | SE |

| | | |
|---|---|---|
| *Lupinus termis* | Leguminosae | SE |
| *Melia azedarach* | Meliaceae | O, E |
| *Mentha citrate* | Lamiaceae | O |
| *Nicotiana tabacum* | Solanaceae | E |
| *Ocimum canum* | Lamiaceae | LP |
| *Ocimum kilimands charicum* | Lamiaceae | O |
| *Piper nigrum* | Piperaceae | O, E |
| *Polygonum hydropiper* | Polygonaceae | L |
| *Pongamia glabra* | Fabaceae | O, E |
| *Psidium guajava* | Myrtaceae | L, LP |
| *Ryania speciosa* | Flacourtiaceae | YE |
| *Sapindus trifoliatus* | Sapindaceae | SP |
| *Schleichera trijuga* | Sapindaceae | O |
| *Sesamum orientale* | Pedaliaceae | O |
| *Sesamum indicum* | Pedaliaceae | O |
| *Syzy gium aromaticum* | Myrtaceae | O |
| *Tagetes erec ta* | — | X, Y |
| *Tanacetum cinerariaefolium* | Asteraceae | O, P |
| *Thujopsis dolabrata* | Cupressaceae | E |
| *Trigonella foenumgraecum* | Fabaceae | SE |
| *Vitex negundo* | Lamiaceae | L |

Note. L: leaves, B: bark, F: fruits, S: seeds, O: oil, P: powder, E: extract, M: vapour, R: Rhizome, T: plant, V: flower, X: root, and Y: stem,

**Challenges to the Utilization of Botanicals Pesticides:**

Metabolites found in a variety of plant species are effective against several pest species. Some of the plants, like neem trees, are also highly sought-after sources of phytochemicals for more environmentally friendly grain and crop protection. Phytochemical products can boost rural farmers' incomes, improve food safety and quality, and improve people's quality of life in general.

In addition to reducing erosion, desertification, deforestation, and possibly even reducing human population by acting as spermaticicide (although this will be viewed as a major negative effect by many cultures and religions), the effective use of botanicals can help control many of the destructive pests and diseases that plague the world. Although there are seemingly countless applications for employing botanical pesticides, there are also a lot of unanswered questions. Before their promise can be completely realized, several challenges need to be solved and many ambiguities need to be clarified. These restrictions appear to be overcomeable, but they confront the scientific and economic development communities with fascinating difficulties. By overcoming the ensuing challenges and doubts, it's possible to create a significant new resource that will help most of the world. These challenges consist of:

1. Lack of understanding and experience with the effectiveness of botanicals for pest control. Due to their gradual action and lack of a rapid knockdown effect, there are still questions regarding the efficacy of plant-derived products (both commercial and "homemade" products).
2. Genetic diversity of plant species across different environments.
3. Natural product registration and patenting challenges as well as a lack of standards for botanical pesticide products.
4. Due to geographical restrictions, the perennial nature of the majority of botanical trees, the seasonal availability of seeds, and the change in potency with place and time, there are economic risks.
5. Handling challenges due to the lack of a mechanized method for gathering, storing, or managing seeds, leaves, or blooms from several perennial trees.
6. Exposure to direct sunlight causes the active components to become unstable.
7. Commercial pesticide dealers aggressively advertise their products to compete with synthetic pesticides and commercially produced botanical insecticides are more expensive and less accessible than synthetic insecticides.

8. Although in some ways advantageous, rapid degradation necessitates more exact timing or frequent applications.
9. Some botanicals lack information on their efficacy and long-term (chronic) mammalian toxicity, and some still lack defined tolerances.

**Safety:**

The safety of botanical pesticides for human use and consumption should not be taken for granted just because they are naturally derived; rather, some sort of safety evaluation should be taken into account. Some of the most promising plant species were examined for harmful effects on vertebrates to gauge their mammalian toxicity (Belmain et al., 2001).
To evaluate the practical applicability of the botanical insecticides, field tests are necessary. It is important to do biosafety studies to determine how dangerous they are to people, animals, and crop plants.
Small-scale farmers have shown evidence that they prefer using pesticidal plant materials for storage over other pest management strategies. Individual farmers' understanding of various plants and the best ways to use them, however, differs greatly. The creation of new commercial goods for the benefit of humanity as a whole and the place of origin may result from the identification of novel compounds or modes of action identified in the botanicals. It is important to make scientific efforts to catalogue pesticidal plants and look into the effectiveness of plant diseases for biocontrol. To evaluate the practical applicability of the botanical insecticides, field tests are necessary. It is important to do biosafety studies to determine how dangerous they are to people, animals, and crop plants.

**Conclusion:**

Numerous writers have examined the insecticidal (grain-protectant) effects of plant products on different species of pest insects that attack stored goods. The findings unequivocally demonstrate that techniques for grain protectants can be developed with a lesser utilization of synthetic chemical pesticides. The key benefits of natural insecticides are that they are non-toxic to organisms other than the target species, easily biodegradable, and may be made from locally accessible raw materials. Numerous plant-based insecticides have been investigated in laboratories. Apart from their effectiveness, research should concentrate on the compound's stability, mammalian toxicity, mode of action in insects, seed germination, impact on nutritional quality, and method of action in insects. The insecticides with plant origins could be used to create new compounds with very specific targets for long-term insect pest control in stored grains. Synthetic insecticides have been used in crop protection programs recently, which has led to environmental disruptions, pesticide residues, pest resurgence, pest resistance, etc. This results in a greater emphasis being placed on naturally occurring plants linked to a wealth of traditional knowledge held by India's extremely diversified indigenous groups, which is the environmentally friendly agricultural technique for guaranteeing food safety and security. Green pesticides, botanical pesticides, plant pesticides, or botanical ecological pesticides, which are eco-friendly, biodegradable, natural, have no residual effects, etc., may be preferred by modern society's current trends towards Green Consumerism, which seeks fewer synthetic ingredients. As a result, modern science fields like Indigenous Integrated Pest Management and EthnoBotanical Crop Protection should be established using this rich heritage of botanical knowledge.

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