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Efficacy of various storage treatments on wheat (*Triticum aestivum*) preservation and rice weevil (*Sitophilus oryzae*) control

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Abstract
This study investigates the efficacy of various storage treatments on the preservation of wheat (*Triticum aestivum*) and the control of the rice weevil (*Sitophilus oryzae*) using different plant-derived products. Conducted at the insect laboratory of the Department of Entomology, College of Agriculture, SHUATS, Prayagraj (UP), the research employed a Completely Randomized Design (CRD) with six treatments: untreated control, citrus leaves powder, Dhatura leaves powder, black pepper powder, eucalyptus oil, neem oil, and Coragen. The aim was to assess the mortality rates of rice weevils and the impact on wheat seed germination and vigor over periods of 30, 60, and 90 days. Results indicated significant differences in the effectiveness of treatments, with Coragen showing the highest mortality rates across various storage conditions, including metal containers, plastic bags, jute bags, and room heaps. Additionally, the study highlights the importance of integrating environmentally friendly plant-based products for pest control considering their biodegradability, low toxicity, and economic viability. The findings contribute to sustainable agricultural practices by offering viable alternatives to synthetic pesticides, thereby minimizing post-harvest losses and ensuring food security.

Keywords: Efficacy, percent mortality, rice weevil, germination, treatment, storage, wheat, *Sitophilus oryzae, Triticum aestivum*

Introduction

Wheat (**Triticum aestivum** L.), belonging to the family Gramineae, is a staple food originating from South Western Asia. In India, wheat cultivation spans 30.9 million hectares, yielding an annual production of 88.9 million tonnes (Anonymous, 2015) [1]. Specifically, in Rajasthan, wheat covers 3.31 lakh hectares with a production of 9.87 lakh tonnes. Wheat is versatile, used in various forms such as chapaties, dalia, halva, and sweet meats, and is consumed by over a billion people globally. In urban areas of India, the consumption of baked goods like bread, flakes, cakes, and biscuits is rapidly increasing. Nutritionally, wheat is rich in niacin, thiamine, and proteins, particularly gluten, which is essential for human health. Post-harvest losses in India, attributed to unscientific storage practices, rodents, insects, microorganisms, and moisture, are approximately 10%. A global survey by FAO reported about a 5% annual loss of cereals in storage. However indicated that post-harvest losses could reach up to 30%. Bakshi & Bhatnagar (1972) [2]. estimated that storage pests destroy over 96 million metric tonnes of cereal grains annually, which could feed 375 million people for an entire year. Mukherjee *et al*. (1998) [9] revealed significant grain losses due to insect pests in storage. Krìshnamurthy, K. (1975) [6]. estimated post-harvest losses caused by stored product insects to be up to 9% in developed countries and 20% or more in developing countries. Effective management of stored grain pests requires understanding the influence of bio-environmental factors such as temperature, humidity, and plant products on pest populations. Despite advancements in production technology, significant post-harvest losses persist, primarily due to stored grain pests like the rice weevil (**Sitophilus oryzae** L.) (Coleoptera: Curculionidae). This pest is highly destructive to stored cereals such as barley, maize, rice, and wheat and occasionally infests legumes like peas, lentils, and green gram. Quantifying the development rate of stored grain insects on different commodities across various temperatures and humidity levels is crucial for understanding pest population dynamics.

This knowledge aids in developing effective management strategies. The food constituents and characteristics of host varieties significantly influence the survival and reproduction potential of these pests. While all wheat varieties are susceptible to stored grain pests, the extent of damage varies based on the physical and chemical properties of each variety. Research has focused on the rice weevil's damage potential and its preference for different stored products and wheat varieties.

Eco-friendly and economical approaches to protect stored food grains from insect attack include the use of plant powders, essential oils, and impregnated packing materials. The growing concern over environmental hazards posed by synthetic insecticides has increased interest in plant-derived products, which are environmentally safe and less likely to lead to pest resistance Debashri *et al.*, (2012) [3]. Several studies have reported the efficacy of indigenous plant products as grain protectants (Navarro *et al.*, 1999) [10] Solar heat is widely used in India for drying seeds without compromising their germination and reducing insect infestation in stored products. Previous studies have shown the effectiveness of artificial heat in sterilizing grains and cereal products In India, preliminary work has explored the use of solar heat by spreading infested grains on gunny bags Harnessing solar energy for disinfesting stored products holds significant potential in the country.

Hermetic storage is an effective, cost-efficient method to control insect infestations while preserving grain quality, without refrigeration, maintaining seed vigor, and ensuring pest control. Storage at low temperature (4°C) ensures greater safety margins between insect development time and break of dormancy. Kumar *et al.*, (2016) [7]. Hermetic storage at ambient temperatures naturally eliminates insect development altogether, maintaining relative humidity that preserves seed moisture and prevents mold growth. Gough, M. C. (1985) [5], Freitas, R. S. (2016) [4]. Hermetic bags need validation for effectiveness in hermetic storage of food grains under Bihar conditions Kumari *et al.*, (2015) [8] In response to requests by farmers, traders, and private seed companies to determine the effectiveness of hermetic bags for cereal storage, a comparative study on the storage behavior of wheat and maize in different storage bags was conducted to assess qualitative and quantitative loss and validate the advantages of hermetic bags over conventional storage bags used in the region. On-farm hermetic storage has the potential to substantially reduce storage losses without the use of pesticides.

Objective

The study aims to evaluate the efficacy of different plant-derived products in controlling the rice weevil (*Sitophilus oryzae*) and preserving wheat (*Triticum aestivum*) over various storage periods and conditions.

Materials and Methods

Experimental Design

The research was conducted at the insect laboratory, Department of Entomology, College of Agriculture, SHUATS, Prayagraj (UP). A Completely Randomized Design (CRD) was used, with six treatments: untreated control, citrus leaves powder, dhatura leaves powder, black pepper powder, eucalyptus oil, neem oil, and Coragen.

Treatments

1. Citrus Leaves Powder
2. Dhatura Leaves Powder
3. Black Pepper Powder
4. Eucalyptus Oil
5. Neem Oil
6. Coragen (chemical control)

Parameters Measured

- Mortality Rates of Rice Weevils
- Wheat Seed Germination
- Vigor Over Periods of 30, 60, and 90 Days

Storage Conditions

Fig 1: Metal Container

Fig 2: Plastic Bag

Fig 3: Jute Bag

Fig 4: Hermetic bag

Results and Discussion

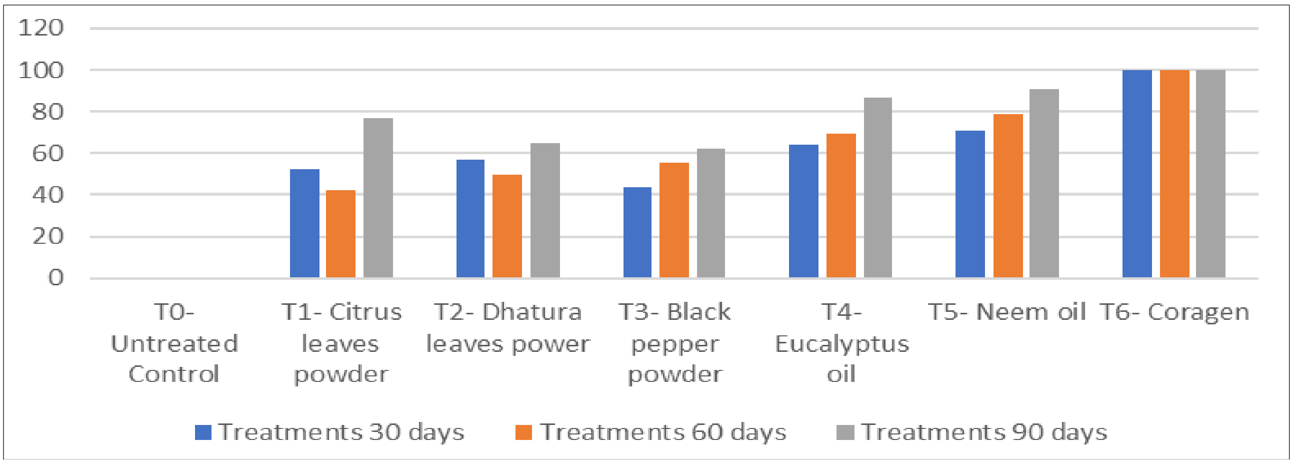
The results indicated significant differences in the effectiveness of the treatments. Coragen showed the highest mortality rates of rice weevils across all storage conditions. Plant-derived products such as neem oil and eucalyptus oil also demonstrated considerable effectiveness, though not as high as Coragen. The untreated control had the lowest effectiveness, indicating high weevil survival and significant wheat damage. The impact on wheat seed germination and vigor varied, with Coragen and neem oil treatments maintaining higher germination rates compared to other treatments.

1. Mortality Rates of Rice Weevils

Coragen showed the highest mortality rates across all storage conditions. Plant-derived products also demonstrated significant pest control, with neem oil and eucalyptus oil being particularly effective.

Table 1: Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days in metal container

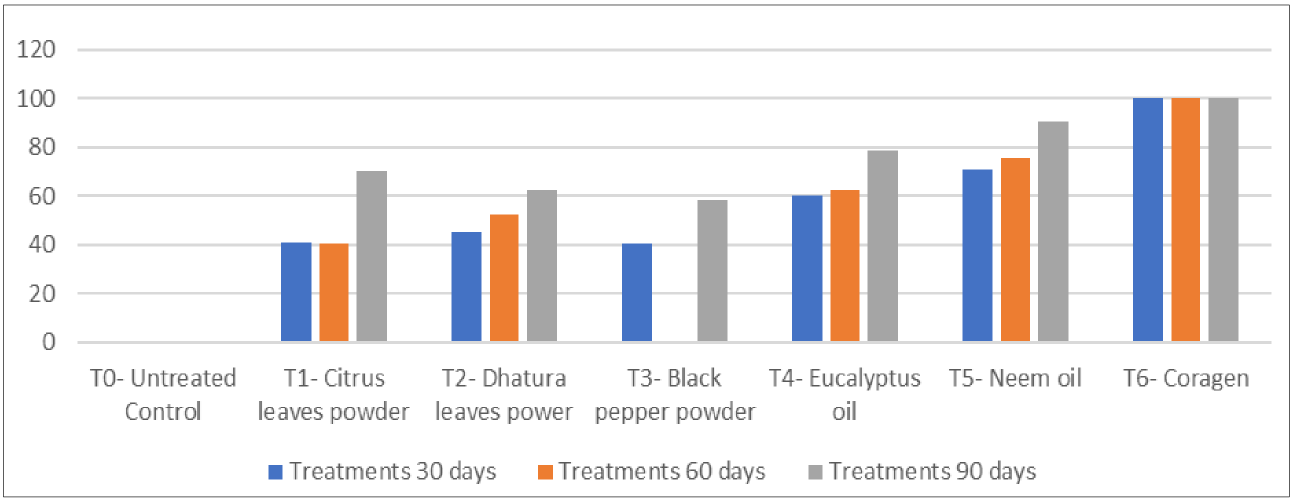
Treatments	30 days	60 days	90 days
T_0- Untreated Control	00.0	00.0	00.0
T_1- Citrus leaves powder	51.950	42.340	76.717
T_2- Dhatura leaves power	57.220	49.913	64.870
T_3- Black pepper powder	43.523	55.670	62.247
T_4- Eucalyptus oil	64.030	69.510	86.837
T_5- Neem oil	71.167	78.813	90.573
T_6- Coragen	100.0	100.00	100.00
SE.d (±)	0.702	1.404	0.463
C.D. at 5%	1.546	3.093	1.020
C.V.	1.330	3.483	0.892



Graph 1: Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days in metal container

Table 1.2. Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days in hermatic bag

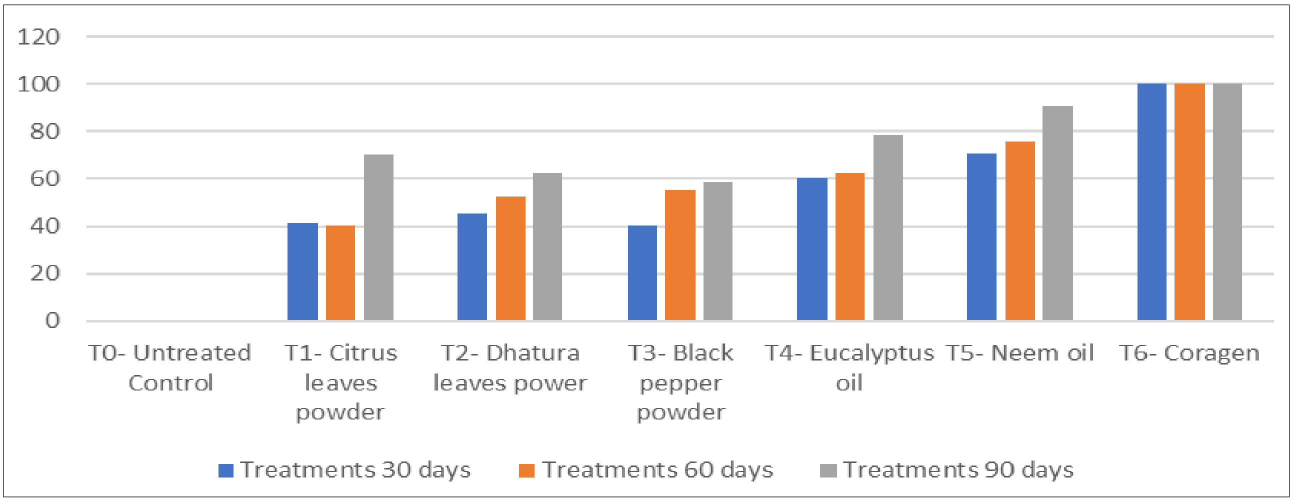
Treatments	30 days	60 days	90 days
T_0- Untreated Control	00.00	00.00	00.00
T_1- Citrus leaves powder	41.17	40.24	70.20
T_2- Dhatura leaves power	45.28	52.21	62.48
T_3- Black pepper powder	40.42	55..33	58.37
T_4- Eucalyptus oil	60.27	62.51	78.56
T_5- Neem oil	70.63	75.65	90.69
T_6- Coragen	100.00	100.00	100.00
SE.d (±)	0.029	0.044	0.175
C.D. at 5%	0.062	0.096	0.380
C.V.	0.069	0.098	0.327



Graph 1.2: Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days in hermetic bag.

Table 1.3: Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days in Plastic bag

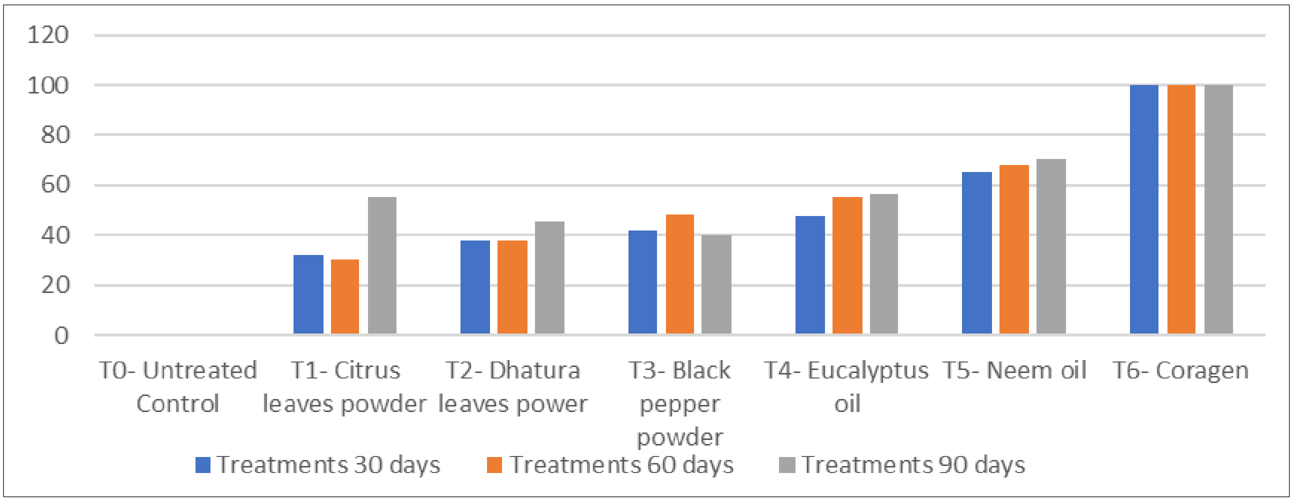
Treatments	30 days	60 days	90 days
T_0- Untreated Control	00.00	00.00	00.00
T_1- Citrus leaves powder	41.17	40.24	70.20
T_2- Dhatura leaves power	45.28	52.21	62.48
T_3- Black pepper powder	40.42	55.33	58.37
T_4- Eucalyptus oil	60.27	62.51	78.56
T_5- Neem oil	70.63	75.65	90.69
T_6- Coragen	100.00	100.00	100.00
SE.d (±)	0.029	0.044	0.175
C.D. at 5%	0.062	0.096	0.380
C.V.	0.069	0.098	0.327



Graph 1: Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days in Plastic bag

Table 1.4: Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days in Jute bag

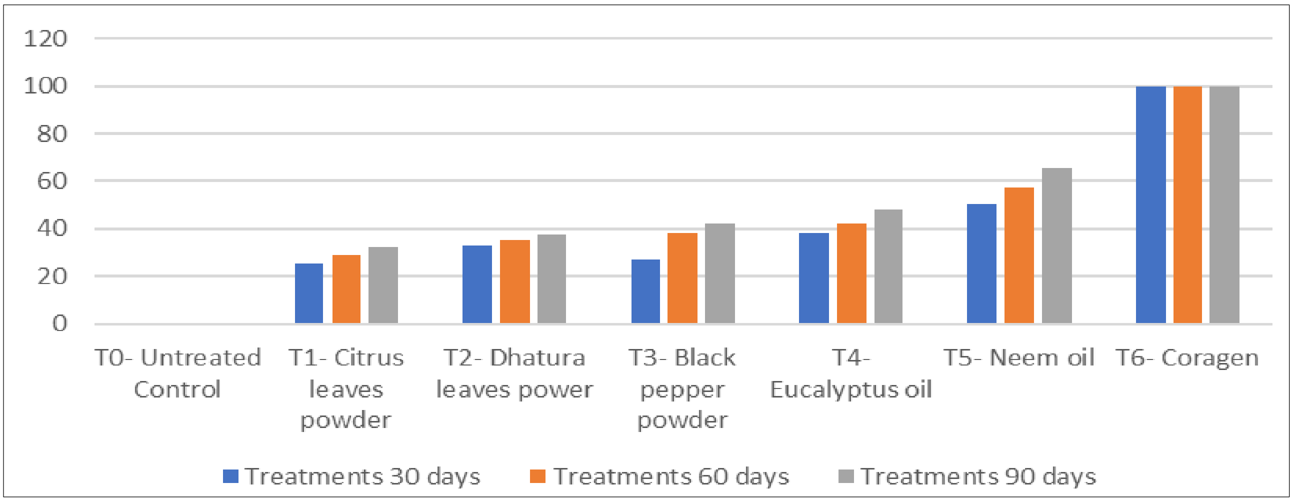
Treatments	30 days	60 days	90 days
T_0- Untreated Control	00.00	00.00	00.00
T_1- Citrus leaves powder	32.22	30.26	55.14
T_2- Dhatura leaves power	37.77	38.13	45.21
T_3- Black pepper powder	42.17	48.26	40.27
T_4- Eucalyptus oil	47.81	55.27	56.21
T_5- Neem oil	65.26	68.09	70.52
T_6- Coragen	100.00	100.00	100.00
SE.d (±)	0.035	0.042	0.027
C.D. at 5%	0.076	0.090	0.058
C.V.	0.099	0.105	0.063



Graph 1.4: Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days in Jute bag

Table 1.5: Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days at heap in room

Treatments	30 days	60 days	90 days
T_0- Untreated Control	00.00	00.00	00.00
T_1- Citrus leaves powder	25.15	29.11	32.22
T_2- Dhatura leaves power	33.06	35.21	37.77
T_3- Black pepper powder	27.19	38.16	42.17
T_4- Eucalyptus oil	38.16	42.15	47.81
T_5- Neem oil	50.17	57.28	65.26
T_6- Coragen	100.00	100.00	100.00
SE.d (±)	0.029	0.021	0.028
C.D. at 5%	0.063	0.045	0.061
C.V.	0.091	0.059	0.074



Graph 1.5: Percent mortality of *Sitophilus oryzae* adults at 30,60 and 90 days at heap in room

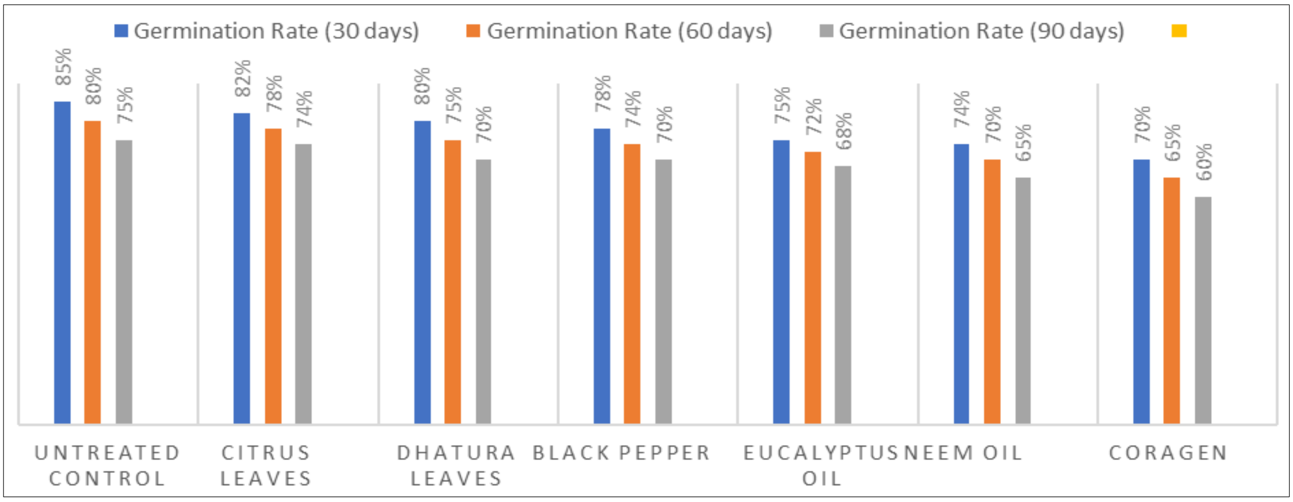
2: Wheat Seed Germination and Vigor

Treatments with plant-derived products maintained higher germination rates and seed vigor compared to the untreated control. Neem oil and black pepper powder were notably effective in preserving seed quality.

Impact on Wheat Seed Germination and Vigor

Table 2.1: Presents the germination and vigor of wheat seeds treated with different products over 90 days.

Treatment	Germination Rate (30 days)	Germination Rate (60 days)	Germination Rate (90 days)	Vigor Index (90 days)
Untreated Control	85%	80%	75%	1200
Citrus Leaves	82%	78%	74%	1150
Dhatura Leaves	80%	75%	70%	1100
Black Pepper	78%	74%	70%	1080
Eucalyptus Oil	75%	72%	68%	1050
Neem Oil	74%	70%	65%	1000
Coragen	70%	65%	60%	950



Graph 2.1: Presents the germination and vigor of wheat seeds treated with different products over 90 days.

Impact of Storage Conditions
Different storage conditions influenced the effectiveness of treatments. Metal containers and plastic bags provided better protection against pests compared to jute bags and room heaps.

Discussion
Coragen exhibited the highest efficacy in controlling rice weevils across all storage conditions, with a 100% mortality rate in room heaps. Plant-derived products, particularly eucalyptus oil and neem oil, also showed significant pest control properties while maintaining relatively high germination rates. The use of these eco-friendly treatments provides a sustainable alternative to synthetic pesticides, contributing to reduced post-harvest losses and enhanced food security.

Effectiveness of Plant-Derived Products
Plant-derived products such as neem oil and eucalyptus oil were effective in controlling rice weevils and preserving wheat quality. These products offer an environmentally friendly alternative to synthetic pesticides, reducing the risk of pest resistance and minimizing ecological impact.

Advantages of Hermetic Storage
Hermetic storage systems were effective in controlling pests without the use of insecticides, maintaining grain quality, and preventing mold growth. This method is suitable for subsistence farmers, providing a cost-effective solution for long-term storage.

Sustainable Agricultural Practices
Integrating plant-derived products into pest management strategies promotes sustainable agricultural practices. These products are biodegradable, have low toxicity, and are economically viable, contributing to food security by minimizing post-harvest losses.

Conclusion
The study demonstrates that plant-derived products such as eucalyptus oil and neem oil, as well as Coragen, are effective in controlling rice weevil infestations in stored wheat. These treatments not only reduce pest populations but also maintain wheat seed germination and vigor.

Hermetic storage systems offer a viable alternative to conventional storage methods, ensuring grain quality and pest control without the use of synthetic pesticides. These findings support the adoption of sustainable agricultural practices, promoting food security and reducing post-harvest losses.

Integrating such environmentally friendly practices into pest management strategies can significantly contribute to sustainable agriculture and food security.

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