THE EFFICACY OF *Moringa oleifera* ON MAIZE WEEVILS (*Sitophilus Zeamais*)

BY

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CERTIFCATION

This is to certify that this research was conducted by ADENIJI MAMUDAT DIGIOLA (ND/23/AGT/FT/0008) and has been read, certified and approved as meeting part of the requirements for the award of National Diploma (ND) in Agricultural Technology. Department of Agricultural Technology, Institute of Applied Sciences, Kwara State Polytechnic, Ilorin.

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DEDICATION

This project is dedicated to Almighty Allah. The beginning and the end, who have mercy upon me throughout the course of my studies. I also dedicate the project to my parents Mr. and Mrs. ADENIJI.

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ABSTRACT

This study investigates the efficacy of Moringa oleifera leaf powder as a botanical insecticide in the control of maize weevils (*Sitophilus zeamais*), a major pest responsible for significant post-harvest losses in stored maize. The research aimed to evaluate the insecticidal properties of Moringa oleifera through controlled laboratory experiments, focusing on adult mortality, grain damage, and weight loss. Different concentrations of Moringa oleifera powder were applied to infested maize samples and monitored over a specified period. The results revealed that Moringa oleifera exhibited significant insecticidal activity, with higher concentrations leading to increased weevil mortality and reduced seed damage when compared to untreated control samples. The findings suggest that Moringa oleifera can serve as a cost-effective, eco-friendly alternative to synthetic insecticides for smallholder farmers, offering a sustainable method for mitigating post-harvest losses. This study contributes to the growing body of research advocating for the use of plant-based pest management strategies in grain storage systems.

Keywords: Moringa oleifera, *Sitophilus zeamais*, maize weevil, botanical insecticide, post-harvest loss, grain protection, sustainable agriculture.

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CHAPTER ONE

INTRODUCTION

Maize (*Zea mays*) is one of the most important cereal crops globally, serving as a staple food for millions of people, particularly in sub-Saharan Africa, Latin America, and parts of Asia (FAO 2020). It is a major source of carbohydrates, proteins, and essential nutrients. However, post-harvest losses due to insect pests, especially the maize weevil (*Sitophilus zeamais*), pose a significant threat to food security and economic stability and resilience. Maize weevils cause severe damage to stored grains by boring into kernels, leading to a loss of weight, diminished nutritional value, and reduced market quality.

The maize weevil, *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) is a major pest of stored maize grains in the tropics and temperate regions of the world (Adedire, 2021). Its infestation causes severe postharvest losses of maize in storage (Oni and IIeke, 2018). The pest also infests other stored cereal grains as alternative hosts (Adedire et al., 2021). Notable among its secondary hosts is wheat that has becomes one of the staple foods in Africa for combating malnutrition. The destructive activities of maize weevil has been subdued by chemical control. Farmers and grain traders often rely on synthetic insecticides to mitigate storage losses. However, the excessive use of chemical pesticides raises concerns about human health risks, environmental pollution, and the development of pesticide resistance in pests (Ogunwolu and Idowu, 2021).

The problems of many synthetic insecticides which include high persistence, poor knowledge of application, increasing costs of application, pest resurgence, genetic resistance by the insect and lethal effects on non-target organisms in addition to direct toxicity to users (Berger, 2023; Okonkwo and Okoye, 2016; Akinkurolere et al., 2016; Oni and Ileke, 2018). As a result, there is an increasing need for alternative, eco-friendly, and sustainable pest control methods that are effective and safe for both consumers and the environment (ref). *Moringa oleifera* is widely known for its medicinal, nutritional, and pesticidal properties. Studies have shown that its leaves contain bioactive compounds such as alkaloids, flavonoids, tannins, and saponins, which have insecticidal and repellent effects. Using *Moringa oleifera* leaf powder as a natural protectant against maize weevils could provide an environmentally friendly alternative to synthetic insecticides. This could enhance grain storage practices, reduce post-harvest losses and improve food security.

STATEMENT OF THE STUDY

The infestation of maize grains by *Sitophilus zeamais* remains a significant challenge in maize production. Many smallholder farmers lack access to effective pest control measures, leading to increased post-harvest losses. The use of chemical pesticides is often costly and is associated with adverse effects such as toxicity, residue accumulation, and environmental contamination. This has necessitated research into plant-based insecticides, such as *Moringa oleifera* leaf powder, which may offer a safer and more affordable solution.

RESEARCH QUESTIONS

This study aims to evaluate the efficacy of *Moringa oleifera* leaf powder in controlling maize weevil (*Sitophilus zeamais*) infestation in stored maize. To achieve this, the following research questions will be addressed:

1. What is the percentage mortality rate of maize weevils (*Sitophilus zeamais*) exposed to different concentrations of *Moringa oleifera* leaf powder?
2. How does *Moringa oleifera* leaf powder affect maize grain damage and weight loss during storage?
3. What is the potential impact of using *Moringa oleifera* as a natural grain protectant for smallholder farmers?

OBJECTIVES OF THE STUDY

The objectives of this study are

1. Investigate the effects of *Moringa oleifera* leaf powder on the eggs laid on maize.
2. Evaluate the impact of *Moringa oleifera* leaf powder on adult maize weevil.
3. Elucidate the effect of *Moringa oleifera* leaf powder on weight loss of maize due to maize weevil infestation.

CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of Maize (*Zea mays*)

Maize (Zea mays), commonly known as corn, is one of the most widely cultivated cereal crops in the world. Its significance spans across food security, livestock feed, economic development, industrial applications, and climate resilience, making it a cornerstone of agricultural systems in both developing and developed countries.

2.1.1 Contribution to Food Security

Maize serves as a staple food for over 300 million people, especially in sub-Saharan Africa and parts of Latin America and Asia. It is rich in carbohydrates and provides essential nutrients such as vitamin B, magnesium, and dietary fiber. In many developing countries, maize constitutes more than 30% of daily caloric intake, making it crucial for food and nutritional security. According to Meyers and Johnston (2020), the crop's versatility in cooking and processing methods, as well as its adaptability to local farming systems, enhances its role in ensuring food availability and accessibility.

2.1.2 Role in Livestock Feed

Globally, approximately 60–70% of maize produced is used for animal feed, making it a fundamental component of the livestock industry. Its high energy content and digestibility make it suitable for feeding poultry, pigs, and cattle. The Food and Agriculture Organization (FAO, 2021) emphasizes that maize-based feeds support higher yields in meat and milk production, thereby contributing to both food supply and income generation for farmers.

2.1.3 Economic Importance

Maize plays a significant economic role by providing income for millions of smallholder farmers. It is a major cash crop in several countries and contributes notably to national GDPs, especially in sub-Saharan Africa. Akudugu et al. (2020) reported that maize production in Ghana alone supports thousands of farming households and is a key driver of rural development and poverty alleviation.

2.1.4 Industrial Applications

Beyond food and feed, maize is a vital raw material for various industries. It is processed into ethanol for biofuel, high-fructose corn syrup for sweeteners, cornstarch, biodegradable plastics, and even pharmaceuticals. These industrial uses enhance value addition and create employment opportunities in agro-processing sectors. Rajendran et al. (2021) highlighted recent biotechnological advancements that have improved the efficiency of maize-based bioethanol production, making it a cleaner energy alternative (Prasanna et al. 2022).

2.2 Biology of maize weevil

Maize weevils are small, dark brown beetles typically measuring 2.5–4 mm in length. They possess a distinctive elongated snout and are capable of flight, which facilitates their spread in storage environments. Female maize weevils bore holes into maize kernels to deposit their eggs, typically laying 50 to 250 eggs in their lifetime. Each egg is sealed within the grain, where the larva hatches and feeds internally on the endosperm. The complete life cycle includes egg, larva, pupa, and adult stages—all occurring inside the kernel. Under optimal conditions (27–30°C and 70–90% relative humidity), the life cycle completes in about 25–35 days. This short development time allows rapid population buildup, especially in poorly managed or traditional storage systems. Kassie et al. (2021) explain that the weevil's biological efficiency and reproductive capacity make it a persistent threat in grain storage systems, especially where hermetic or modern control methods are lacking.

2.3 Infestation of maize weevil on stored maize

2.3.1 Quantitative Losses

The maize weevil is responsible for considerable quantitative losses due to grain consumption by larvae and adults. Infestation can lead to weight losses exceeding 30% during storage, especially when proper storage conditions are not maintained. Ojo and Omoloye (2020) conducted studies in

Nigeria and reported significant postharvest losses in smallholder maize storage, attributing more than 35% grain loss to maize weevil infestation.

2.3.2 Quality and Nutritional Degradation

Infestation affects grain quality through internal feeding, which reduces starch and protein content. The damage also lowers the economic and market value of maize due to contamination with frass, exuviae (shed skins), and dead insects. Nboyine et al. (2019) highlighted that maize damaged by *S. zeamais* shows reduced protein and carbohydrate content, resulting in poor acceptability among consumers and processors.

2.3.3 Facilitation of Secondary Contamination

Weevil-infested maize becomes more susceptible to fungal invasion, particularly by *Aspergillus flavus*, which produces aflatoxins—dangerous mycotoxins that are harmful to humans and livestock. Midega et al. (2022) observed that physical damage by maize weevil increases the risk of aflatoxin contamination by facilitating fungal entry, especially in humid storage environments.

2.3.4 Seed Viability and Germination

Maize weevil infestation also affects seed viability, as the developing larvae often destroy the embryo, leading to poor germination and seedling vigor. This undermines seed quality and the success of future cropping cycles. Opit and Campbell (2020) reported significant reductions in seed germination and vigor in maize infested by *S. zeamais*, posing a threat to food security in subsistence farming systems.

2.4 *Moringa oleifera* as a Botanical Insecticide

The increased awareness of the environmental and health concerns associated with synthetic insecticides has intensified global efforts to find sustainable alternatives. Among the most promising botanical options is *Moringa oleifera*, a fast-growing, drought-tolerant tree widely cultivated across tropical and subtropical regions. Beyond its nutritional and medicinal uses, *M.*

oleifera has been found to possess significant insecticidal properties, making it an effective, eco-friendly alternative for managing insect pests in both field and storage systems.

2.5 Phytochemical Properties and Mode of Action

Moringa oleifera exhibits insecticidal activity primarily due to its rich content of bioactive compounds such as alkaloids, tannins, flavonoids, saponins, and glucosinolates. These phytochemicals act through various mechanisms such as repellency, antifeedant activity, growth inhibition, and direct toxicity against target insect species (Okoro & Ezekiel, 2021). The leaves and seeds are especially potent, with the extracts disrupting the physiological processes of pests either upon contact or ingestion.

2.6 Advantages of Moringa-Based Insecticides include

Environmental Safety: It is biodegradable and non-toxic to non-target organisms.

Human and Animal Safety: Unlike many synthetic pesticides, *Moringa* extracts are safe for humans and livestock when used properly.

Cost-Effectiveness and Availability: The tree is widely available and inexpensive to cultivate, making it accessible for smallholder farmers in low-income regions.

Resistance Management: The use of complex phytochemical mixtures reduces the likelihood of pest resistance, a growing problem with synthetic insecticides.

2.7 Synthetic Insecticides

Synthetic insecticides used in maize storage primarily include organophosphates, pyrethroids, carbamates, and insect growth regulators. Among these, **pirimiphos-methyl** (organophosphate) and **deltamethrin** (pyrethroid) are widely applied either directly on maize grains or on storage surfaces. These chemicals act by disrupting the insect's nervous system, causing paralysis and death. The formulation and method of application significantly affect their residual efficacy and safety. Fleurat-Lessard et al. (2020) reported that modern formulations such as emulsifiable concentrates and dusts allow better coverage and persistence on stored grains. In many countries, such treatments are used as part of approved postharvest practices to extend the shelf life of stored maize by several months.

2.8 Challenges of using synthetic insecticides

Synthetic insecticides have long been central to pest control strategies in both agricultural and storage systems due to their fast-acting, broad-spectrum effectiveness. However, overreliance on these chemicals has revealed numerous disadvantages that impact human health, the environment, pest resistance dynamics, and the sustainability of farming systems—particularly among smallholder farmers.

2.8.1 Development of Insect Resistance

One of the major drawbacks of synthetic insecticides is the development of resistance among target insect populations. Continuous and unregulated use of insecticides leads to the selection of resistant genotypes, rendering chemical treatments ineffective over time. In storage systems, pests like *Sitophilus zeamais* (maize weevil) and *Tribolium castaneum* (red flour beetle) have shown increased resistance to pyrethroids and organophosphates. According to Opit, Morrison, and Arthur (2022), insecticide resistance is now widespread among stored-product insects globally, largely due to poor rotation practices and the overuse of a limited range of active ingredients. This phenomenon not only increases control costs but also drives pest resurgence.

2.8.2 Human Health Hazards

Exposure to synthetic insecticides—through inhalation, ingestion, or skin contact—poses serious health risks to farmers, grain handlers, and consumers. These risks range from acute symptoms like headaches and respiratory irritation to chronic conditions including neurological damage and cancer. Ngowi, Mbise, and Ijumba (2020) documented increased incidence of pesticide-related illnesses among rural grain handlers in Tanzania, attributing the problem to a lack of proper protective equipment and inadequate training in safe pesticide application. Furthermore, unsafe storage and handling practices amplify exposure risks, especially in low-resource settings.

2.8.3 Environmental Pollution

The environmental impact of synthetic insecticides is significant. Runoff from treated fields can contaminate nearby water bodies, affecting aquatic life and reducing biodiversity. Residues in the soil may also disrupt microbial communities essential for nutrient cycling. Aslam, Akbar, and Shahzad (2021) found that pesticide contamination in water sources near agricultural fields led to the bioaccumulation of harmful residues in aquatic organisms, thus threatening entire ecosystems and public water supplies.

2.8.4 Harm to Non-Target Organisms

Synthetic insecticides often lack selectivity, harming not only target pests but also beneficial insects such as pollinators and natural enemies (e.g., parasitoids and predators). The death of these non-target organisms disrupts natural pest control mechanisms and may lead to secondary pest outbreaks. Khan, Razaq, and Majeed (2022) emphasized that synthetic insecticides applied in vegetable fields significantly reduced populations of bees and predatory insects, which play vital roles in pollination and integrated pest management systems.

2.8.5 Residue Problems and Food Safety

Improper or excessive application of synthetic insecticides may leave residues on harvested crops that exceed internationally accepted maximum residue limits (MRLs), raising serious food safety concerns. These residues can persist in storage and pose chronic health risks to consumers. Shindano, Phiri, and Musonda (2020) revealed that maize samples from informal markets in Zambia contained residues of banned or restricted pesticides, with many samples exceeding safe consumption thresholds.

2.8.6 Economic Unsustainability for Smallholders

Synthetic insecticides can be prohibitively expensive for small-scale farmers, especially when repeated applications are required. The rising cost of chemicals, coupled with reduced efficacy due to resistance, makes long-term reliance on synthetic products economically unsustainable. Fagbohungbe and Sosan (2020) noted that many Nigerian farmers struggle with the high costs of synthetic insecticides and are increasingly exploring low-cost alternatives such as botanicals. This highlights the need for accessible, safer pest control strategies.

CHAPTER THREE
MATERIALS AND METHODS

3.2 Study Area

The study was conducted at the Entomology Laboratory, Department of Agricultural technology, Kwara State Polytechnic, Ilorin, Kwara State. The laboratory provides controlled environmental conditions for insect rearing and bioassay experiments, with temperature ranging between 25°C and 30°C and relative humidity between 65% and 75%.

3.3 Materials

The materials used in the study include:

- **Maize weevils (*Sitophilus zeamais*)** – Adult weevils were obtained from *S. zeamais* culture maintained in the laboratory.
- **Plastic storage containers (3.4 x 2.8 cm)** were used for storing maize samples during the experiment.
- **Digital weighing balance** – For precise measurement of Moringa powder and maize grains.
- **Maize grains (*Zea mays*)** – Obtained from local markets and sieved to remove debris and previously infested seeds.
- **Moringa leaves (***Azadirachta indica***)** – Fresh leaves were collected from Moringa trees within Ilorin, Kwara State and processed into powder.
- **Hand grinder and sieve** – For processing Moringa leaves into fine powder.
- **Magnifying lens and microscope** – For examining seed perforation and weevil activity.

3.4 Experimental Design

A completely randomized design (CRD) was used to evaluate the effect of Moringa leaf powder on *S. zeamais* infestation. The experiment consisted of five treatments with three replicates each:

1. **T1** – 1.0 g Moringa leaf powder
2. **T2** – 2.0 g Moringa leaf powder
3. **T3** – 3.0 g Moringa leaf powder
4. **T4 (Positive control)** – Synthetic insecticide
5. **T5 (Negative control)** – Untreated maize grains

Each treatment was stored in labeled plastic containers under laboratory conditions for 30 days (Gopalakrishnan et al., 2022).

3.5 Preparation of Moringa Leaf Powder

Fresh Moringa leaves were collected, washed, and shade-dried for 7–10 days to retain bioactive compounds. The dried leaves were ground using a hand grinder and sieved to obtain a fine powder. The powder was stored in airtight containers until use (Adedire *et al*., 2019).

3.6 Insect Rearing and Infestation

Adult *S. zeamais* weevils were reared on untreated maize grains in plastic containers to ensure a uniform source of test insects. Newly emerged adults (0–48 hours old) were collected for infestation trials (Ofuya & Lale, 2020).

For the experiment, 20 unsexed adult weevils were introduced into each container containing 100 g of maize and left for 48 hours for oviposition before removal (Akinneye *et al*., 2022).

3.7 Data Collection

The following parameters were recorded to assess powder's efficacy:

3.7.1 Adult Mortality

- Dead weevils were counted at 24, 48, and 72 hours after treatment application.
- Mortality rates were calculated as:

$$\text{Mortality (\%)} = \frac{\text{Number of dead beetles}}{\text{Total beetles introduced}} \times 100$$

(Baidoo & Mochiah, 2021).

3.7.2 Oviposition and Egg Hatchability

i. The number of eggs laid on maize seeds was recorded using a magnifying lens.
ii. After 7 days, hatched eggs were counted to determine hatchability rate (Ogendo *et al.*, 2018).

3.7.3 Seed Damage and Weight Loss

- After 30 days of storage, the percentage of perforated seeds was determined by visual inspection:

$$\text{Seed Damage (\%)} = \frac{\text{Number of perforated seeds}}{\text{Total seeds}} \times 100$$

- Seed weight loss due to infestation was measured using a digital balance:

$$\text{Weight Loss (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

(Abdullahi et al., 2020).

3.7.4 Seed Viability (Germination Test)

- Maize seeds from each treatment were subjected to a germination test using the paper towel method.
- Germination percentage was calculated as:

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total seeds tested}} \times 100$$

(Gopalakrishnan et al., 2022).

3.8 Data Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0. One-way Analysis of Variance (ANOVA) was used to compare treatment means. Duncan's Multiple Range Test (DMRT) was applied to separate significant differences at a 5% confidence level ($p < 0.05$) (Mbata *et al*., 2021).

CHAPTER FOUR

RESULTS

The Table 1 below is showing the results of maize treated with *Moringa oleifera* an experiment conducted at the Crop garden of the Department of Agricultural Technology, Kwara State Polytechnic, Ilorin

Table 1: Number of eggs and holes in maize treated with *Moringa oleifera* at the Crop Garden of the Department of Agricultural Technology, Kwara State Polytechnic, Ilorin

Treatment	Number of Eggs	No of Holes
1.0g	20.42c	20.45b
2.0g	14.51b	16.54b
3.0g	8.92a	8.54a
Control	27.91d	18.33b
Syn	4.91a	4.54a

Means in a column followed by the same letter(s) are not significantly different at $p > 0.05$ using Duncan Multiple Range Test (DMRT). Values are means ± S. E. of 3 replicates

The Table 2 is showing the percentage of mortality and weight loss of maize treated with *Moringa oleifera* an experiment conducted at the Crop garden of the Department of Agricultural Technology, Kwara State Polytechnic, Ilorin.

Table 2: Percentage mortality and weight loss in maize treated with *Moringa oleifera* at the Crop Gardenof the Department of Agricultural Technology, Kwara State Polytechnic, Ilorin

Treatment	Mortality (%)	Weight loss (%)
1.0g	17.08a	61.34c
2.0g	76.06b	51.3b
3.0g	87.98c	10.2a
Control	12.2a	76.43c
Syn	92.16c	9.2a

Means in a column followed by the same letter(s) are not significantly different at $p > 0.05$ using Duncan Multiple Range Test (DMRT). Values are means ± S. E. of 3 replicates

Chapter 5

Discussion

The data presented in Table 1 reflect the efficacy of different concentrations of *Moringa oleifera* leaf powder in controlling insect infestation in stored maize, as measured by the number of eggs laid and the number of exit holes created by emerging adult insects. These indicators are commonly used to assess the reproductive activity and damage potential of storage pests such as the maize weevil (*Sitophilus zeamais*).

The number of eggs laid varied significantly across treatments. The highest egg count was recorded in the control group (27.91 eggs), which had no insecticidal treatment, indicating a conducive environment for pest reproduction. This was followed by the 1.0 g treatment (20.42), while the lowest numbers were recorded in the synthetic insecticide (4.91) and 3.0 g Moringa (8.92) treatments.This trend suggests that higher concentrations of *Moringa oleifera* significantly suppress oviposition by adult weevils. The 3.0 g dosage showed effectiveness comparable to the synthetic insecticide in deterring egg laying, possibly due to the presence of bioactive compounds such as flavonoids, tannins, alkaloids, and saponins, which act as oviposition deterrents and repellents (Okoro & Ezekiel, 2021; Akinneye & Ayanlola, 2020).

The number of exit holes reflects the successful development and emergence of adult weevils. Treatments with 3.0 g of Moringa (8.54) and synthetic insecticide (4.54) recorded significantly fewer holes than the 1.0 g (20.45), 2.0 g (16.54), and control (18.33) treatments. This further supports the efficacy of higher *Moringa oleifera* concentrations in reducing larval survival and adult emergence, possibly due to the growth-inhibitory and toxic effects of phytochemicals in the plant (Adebayo et al., 2021; Mbailao & Faye, 2022).

Interestingly, the control group recorded fewer holes than 1.0 g and 2.0 g, despite having the highest egg count. This might be due to higher larval mortality or cannibalism in the untreated group, or possibly delayed development stages not captured within the observation period.

According to Duncan’s Multiple Range Test (DMRT), values sharing the same letter in a column are not significantly different at $p > 0.05$. In both columns, the 3.0 g Moringa and synthetic insecticide treatments are statistically similar (denoted with “a”), indicating they are equally effective in controlling pest infestation. This validates *Moringa oleifera* as a viable alternative to synthetic chemicals for managing stored-product pests.

The percentage mortality increased significantly with increasing concentrations of Moringa oleifera. The synthetic insecticide (92.16%) recorded the highest mortality, closely followed by the 3.0 g Moringa treatment (87.98%), with no significant difference between them. The 2.0 g treatment resulted in 76.06% mortality, while 1.0 g (17.08%) and control (12.2%) showed the lowest and statistically similar mortality rates..

These findings demonstrate that Moringa oleifera exhibits a strong insecticidal effect at higher concentrations, effectively comparable to synthetic insecticides. This is consistent with findings by Okoro and Ezekiel (2021), who reported that phytochemicals in Moringa such as alkaloids, saponins, and tannins disrupt insect physiological processes, leading to mortality. Similarly, Akinneye and Ayanlola (2020) observed that Moringa leaf powder significantly increased mortality of Sitophilus zeamais, the maize weevil, in a dose-dependent manner.

Weight loss, an indicator of the level of insect feeding and damage, also showed a clear reduction with increasing Moringa dosage. The control (76.43%) and 1.0 g (61.34%) treatments experienced the highest levels of grain damage and were statistically similar. The 2.0 g treatment moderately reduced weight loss to 51.3%. Remarkably, the 3.0 g Moringa (10.2%) and synthetic insecticide (9.2%) treatments achieved the lowest and statistically indistinguishable grain weight losses..

These results suggest that Moringa oleifera not only kills storage pests but also limits the extent of damage by reducing feeding and development, thereby preserving grain quality. The low weight loss observed at 3.0 g Moringa confirms the findings of Mbailao and Faye (2022), who emphasized its traditional use and efficacy in protecting stored grains in West Africa. Adebayo et al. (2021) also highlighted that Moringa extracts possess growth inhibition and antifeedant properties, which contribute to reduced damage.

Conclusion

The results from Table 1 and Table 2 clearly show that *Moringa oleifera* leaf powder is effective in reducing insect infestation and damage in stored maize. Higher concentrations, particularly at 3.0 g, significantly reduced the number of eggs laid, the number of exit holes, and the weight loss of maize grains, while increasing insect mortality. The performance of the 3.0 g *Moringa oleifera* treatment was comparable to that of synthetic insecticides in terms of pest control and grain protection. In contrast, lower concentrations (1.0 g and 2.0 g) were less effective, indicating a dose-dependent response. These findings demonstrate the potential of *Moringa oleifera* as a safe and natural alternative to synthetic insecticides in post-harvest pest management.

Recommendation

Based on the observed results:

(1) The use of *Moringa oleifera* powder at 3.0 g is recommended for effective protection of stored maize against insect pests.

(2) Farmers and grain handlers, especially in rural and low-resource areas, should consider adopting *Moringa oleifera* as a botanical insecticide due to its affordability, accessibility, and safety.

(3) Further promotion and awareness campaigns should be encouraged to educate local communities on the proper preparation and application of *Moringa oleifera* for pest control.

(4) Future research should focus on developing standardized formulations and exploring its long-term effectiveness under different storage conditions.

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