

Assessment of Allelopathic Potentiality of Vimraj (*Wedelia chinensis*) Against Some Stored Grain Insect Pests

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Abstract

Vimraj (*Wedelia chinensis*) possesses potential bioactive compounds that may offer an eco-friendly alternative to synthetic insecticides for managing major storage pests. This investigation was conducted at the Department of Entomology, Bangladesh Agricultural University, Mymensingh, to assess the allelopathic potentiality of vimraj leaf extracts against rice weevil. A single-factor experiment was carried out following a completely randomized design (CRD) with three replications. Three treatments were applied viz. 100% methanol extract of vimraj leaf, 70% aqueous methanol extract of vimraj leaf, and 50% aqueous methanol extract of vimraj leaf. Each treatment was tested at three doses: D1 – 2.0 ml extract/20 g grain, D2 – 1.5 ml extract/20 g grain, and D3 – 1.0 ml extract/20 g grain. The results revealed significant effects of these treatments on adult mortality of the tested insect pests. Both 100% methanol extract and 70% extract at higher doses showed 100% mortality for all three pests, indicating strong allelopathic activity. In contrast, 50% methanol extract showed statistically insignificant effects on red flour beetle and pulse beetle mortality across all doses. The effectiveness of the extracts increased proportionally with higher doses, and 100% methanol extract at the lowest dose was least effective against rice weevil. Overall, the results suggest that methanol extracts of vimraj (*Wedelia chinensis*) leaf may be used as effective and eco-friendly bioinsecticides, provided proper concentrations and doses are maintained for managing storage insect pests.

Keywords: Vimraj, *Wedelia chinensis*, Bioinsecticide, Storage pests, Adult mortality

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INTRODUCTION

Wedelia chinensis (Osbeck) Merr., also referred to as Vimraj or Vringaraj, is a small, highly branched annual plant indigenous to India, China, and Japan (Farooq et al. 2011; Akter et al., 2025). It is prevalent throughout Bangladesh, thriving in a variety of soil types and climates, and grows well in both sunny and partially shaded areas. Typically found in gardens, along roadsides, and as ground cover, *W. chinensis* is characterized by its fine-haired leaves and bright yellow, tubular flowers that bloom abundantly during the summer and rainy seasons (Jabran et al., 2012; Hasan et al., 2025a).

Wedelia chinensis is highly regarded for its cultural and medicinal significance, being an essential component in Ayurveda, Siddha, and Unani practices due to its healing properties. The plant's leaves and extracts are noted for their antioxidant and antimicrobial effects (Nawaz et al., 2020), making it a common choice in herbal remedies. In addition to its medicinal applications, it has attracted interest in agricultural studies for its potential role in sustainable pest control, especially against insects that infest stored grains. Its anti-inflammatory qualities are advantageous for ailments such as

arthritis, while its antioxidant elements aid in reducing oxidative stress. Traditionally, it is employed for healing wounds, treating skin infections, and enhancing kidney function (Nikson et al., 2024; Laboni et al., 2024; Hasan et al., 2025c).

Beyond its roles in medicine and agriculture, *W. chinensis* is also utilized in cosmetic applications, such as for dyeing hair and encouraging hair growth (Wato et al. 2020; Ali et al., 2025; Yesmin et al., 2023; Ahsan et al., 2025). This plant's adaptability is further demonstrated by its use in treating conditions like toothaches, headaches, and even cancer, highlighting its wide range of traditional medicinal uses (Adimas et al., 2024; Rahman et al., 2024). The widespread destruction caused by insect pests in stored grains presents a major agricultural issue globally, resulting in significant losses in both the quantity and quality of grain products. In tropical areas such as Bangladesh, favorable environmental conditions exacerbate the risk of insect infestations in stored grains. Present pest control methods predominantly depend on chemical insecticides, despite their negative effects on the environment and human health. The unrestrained application of these chemicals leads to environmental contamination, the emergence of insecticide resistance, and health hazards for humans (Makoi et al., 2012; Howlader et al., 2024a; Shumon et al., 2025).

The rice weevil (*Sitophilus oryzae*), red flour beetle (*Tribolium castaneum*), and pulse beetle (*Callosobruchus chinensis*) were selected for this study due to their widespread occurrence and economic importance as major pests of stored grains and pulses. These insects are responsible for significant postharvest losses in both quantity and quality of stored food products, particularly in tropical regions like Bangladesh (Hasan et al., 2025b). The rice weevil is a primary pest of whole cereal grains, while the red flour beetle infests processed products such as flour, and the pulse beetle targets legumes, causing internal damage that reduces both market and seed value. Their ability to survive under storage conditions, reproduce rapidly, and develop resistance to conventional insecticides makes them critical targets for eco-friendly pest management strategies such as botanical bioinsecticides.

Conversely, using plant extracts for pest management presents a promising alternative by utilizing natural compounds with bioactive characteristics. Plant-derived solutions are beneficial due to their decreased environmental persistence and a lower likelihood of insects developing resistance to them. Additionally, they are in line with sustainable farming practices, promoting eco-friendly pest control systems (Navarro et al., 2020; Karim et al., 2024). Research into allelopathy, where plants release biochemicals that affect the growth and behavior of other organisms, highlights the potential of botanical extracts as insecticides and antimicrobial agents in crop protection (Singano et al., 2019; Mia et al., 2025; Howlader et al., 2024a). Understanding the allelopathic effects of plants like *W. chinensis* on stored grain insect pests—such as the rice weevil, red flour beetle, and pulse beetle—is essential for creating effective, safe, and environmentally friendly alternatives to safeguard stored grain products. In summary, tapping into the allelopathic potential of *W. chinensis* leaf extracts offers a promising path for sustainable pest management in agriculture. By decreasing dependence on chemical insecticides and exploring natural options, we can reduce the economic losses and environmental impacts caused by insect infestations in stored grains, thereby ensuring food security and agricultural sustainability.

MATERIALS AND METHODS

Experimental site

In this study, the test insects (*Sitophilus oryzae*, *Tribolium castaneum*, and *Callosobruchus chinensis*) were initially collected from the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. After collection, they were allowed to mate under controlled laboratory conditions at the Entomology Department, Bangladesh Agricultural University, to produce a sufficient number of individuals. The first-generation progeny from these cultures were used for the experiments.

Design of the experiment

The study employed four treatments, including a control, using Vimraj leaf extract mixed with wheat flour, rice, and pulse seeds at concentrations of 10%, 7.5%, and 5.0% of grain weight (100 ml/kg, 75 ml/kg, and 50 ml/kg grain weight). Each treatment and the control were replicated three times following the Completely Randomized Design (CRD). To prepare the treatments, three concentrations (100%, 70%, and 50%) of each plant extract were created using appropriate solvents. Then, 1.0 ml, 1.5 ml, and 2.0 ml of each prepared solution were applied using a micropipette onto petri dishes containing 20 g each of wheat flour, pulse seeds, and rice. Ten insects per replication were treated, and each treatment was replicated three times. Additionally, an equal number of insects were treated with solvent only as a control. Following treatment, the insects were transferred into 9 cm diameter petri dishes (10 insects per dish) containing the respective food (grain) for further observation (Fig. 1). For this experiment, Vimraj (*W. chinensis*) was selected and its leaf extract was used, and leaves were collected from various locations in the Mymensingh District.

The experiment focused on three major stored grain insect pests: rice weevil (*Sitophilus oryzae*), pulse beetle (*Callosobruchus chinensis*), and red flour beetle (*Tribolium castaneum* Herbst), all of which belong to the order Coleoptera. The test insects were collected from a food godown and Bangladesh Institute of Nuclear Agriculture (BINA) in Mymensingh town and maintained in the Entomology Department laboratory at Bangladesh Agricultural University (BAU) under controlled conditions (27–30°C, 70–75% RH). The rice weevil, red flour beetle, and pulse beetle were reared separately on rice, wheat flour, and pulses, respectively, in rectangular plastic jars (9.5 cm × 7.5 cm), each containing 10 pairs of adults (10 males and 10 females). After seven days of oviposition, the adults were removed, and the jars were maintained under controlled laboratory conditions. First-generation adults that emerged within 28 days were collected and used for the experimental trials.

Methanol was used as the extraction solvent in this study due to its high polarity and efficiency in extracting a wide range of bioactive compounds, including phenolics, flavonoids, and alkaloids, from plant materials. These compounds are often responsible for insecticidal and allelopathic activities. Methanol is also widely reported in literature as an effective solvent

for botanical pesticide studies because of its ability to penetrate plant tissues and solubilize both polar and moderately non-polar constituents. No preliminary study using ethanol was conducted in this research.

Preparation of the treatment

The plant extract was produced using leaf powder that had been previously prepared. A 100 ml solution was prepared by combining ten grams of powder with methanol and distilled water as solvents. The mixture was subsequently agitated for 15 minutes using a stirrer and allowed to stand for the subsequent 24 hours. The stirrer was then used to agitate the mixture that had been concocted for 24 hours. The mixture was again filtered through filter paper (Whatman No. 1) and a fine gauze. The filtered materials were transferred to a round-bottomed flask and securely sealed with plastic and foil paper before being stored at room temperature. Extracts are generated in three alternatives: 50% aqueous methanol (50% water and 50% methanol), 70% aqueous methanol (30% water and 70% methanol), and 100% solution (100% methanol) (Fig. 1, 2).

Data collection

Insect mortalities were recorded at 24, 48 and 72 hours after treatment (HAT), and measured following formula (Fahim et al., 2025).

$$\text{Mortality (\%)} = \frac{\text{Total number of dead insects}}{\text{Total number of insects released}} \times 100\%$$

2.5 Statistical analysis

The data were statistically analyzed using a Completely Randomized Design (CRD) with one- and two-factor analyses. Treatment means were compared using the LSD test, and all analyses were conducted using R Statistical Software (version 3.5.3) on a computer (Bashir et al., 2025; Hasan et al., 2025b).



Figure 1. Collection and rearing of insects.

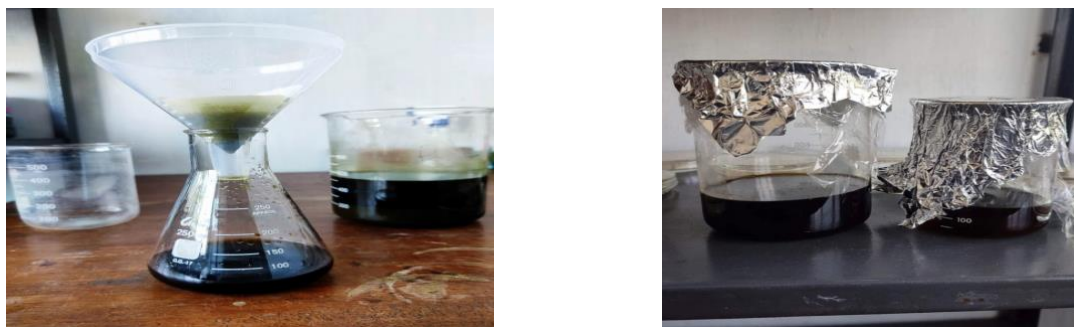


Figure 2. Preparation and filtration of plant extracts



Figure 3. Experiment on petri dishes

RESULTS

The study examined the allelopathic effects of Vimraj plant extract on rice weevils (*S. oryzae*), red flour beetles (*T. castaneum*), and pulse beetles (*C. chinensis*). The findings from multiple experiments conducted throughout the study duration are detailed below.

Effect of 100% methanol extract of Vimraj leaf on the adult mortality of rice weevil

The adult mortality percentage of rice weevils (*S. oryzae*) exposed to various concentrations of 100% methanol extract from Vimraj leaves was analyzed. Mortality rates recorded at 24, 48, and 72 hours after treatment (HAT) indicated that dose-1 exhibited the highest toxicity (100%), while dose-3 had the lowest. The mortality observed at dose-1 (2.0 ml extract/20 g grain) and dose-2 (1.5 ml extract/20 g grain) was significantly higher than that of the control (0%); conversely, dose-3 (1.0 ml extract/20 g grain) showed no significant difference. Therefore, doses 1 and 2 were statistically significant, whereas dose 3 was statistically insignificant (Table 1).

Effect of 100% methanol extract of vimraj leaf on the adult mortality of red flour beetle

The adult mortality percentage of red flour beetles (*Tribolium castaneum*) exposed to various concentrations of 100% methanol extract from Vimraj leaves was analyzed. Mortality rates recorded at 24, 48, and 72 HAT indicated that both dose-1 and dose-2 exhibited the highest toxicity (100%), while dose-3 had the lowest (20%). The mortality observed at dose-1 (2.0 ml extract/20 g grain), dose-2 (1.5 ml extract/20 g grain), and dose-3 (1.0 ml extract/20 g grain) was significantly higher than that of the control (0%). Therefore, all tested doses were statistically significant (Table 1).

Effect of 100% methanol extract of vimraj leaf on the adult mortality of pulse beetle

The adult mortality percentage of pulse beetles (*Callosobruchus chinensis*) treated with different concentrations of 100% methanol extract from Vimraj leaves was evaluated. Mortality rates recorded at 24, 48, and 72 hours after treatment revealed that both dose-1 and dose-2 caused the highest mortality (100%), while dose-3 resulted in the lowest (20%). The mortality observed at dose-1 (2.0 ml extract/20 g grain), dose-2 (1.5 ml extract/20 g grain), and dose-3 (1.0 ml extract/20 g grain) was significantly greater than the control (0%). Hence, all tested doses were found to be statistically significant (Table 1).

Effect of 70% aqueous methanol extract of vimraj leaf on the adult mortality of rice weevil

The mortality rate of *Callosobruchus chinensis* treated with varying concentrations of 100% methanol extract from Vimraj leaves was significantly assessed. Mortality percentages recorded at 24, 48, and 72 hours after treatment indicated that both dose-1 and dose-2 resulted in the highest mortality rate (100%), while dose-3 showed the lowest (20%). The mortality observed at dose-1 (2.0 ml extract/20 g grain), dose-2 (1.5 ml extract/20 g grain), and dose-3 (1.0 ml extract/20 g grain) was significantly higher compared to the control (0%). Consequently, all tested doses exhibited statistically significant effects (Table 2).

Effect of 70% aqueous methanol extract of vimraj leaf on the adult mortality of red flour beetle

The mortality rate of *Tribolium castaneum* (red flour beetle) treated with varying doses of 70% aqueous methanol extract from Vimraj leaves was significantly assessed under laboratory conditions. Mortality percentages recorded at 24, 48, and 72 hours after treatment revealed that both dose-1 (2.0 ml extract/20 g grain or 100 ml/kg grain) and dose-2 (1.5 ml extract/20 g grain or 75 ml/kg grain) induced the highest mortality rate (100%); in contrast, dose-3 (1.0 ml extract/20 g grain or 50 ml/kg grain) resulted in the lowest mortality rate (40%). All treatments exhibited significantly higher mortality compared to the control (0%), indicating that each dose had a statistically significant toxic effect (Table 2).

Effect of 70% vimraj leaf extract on the adult mortality of pulse beetle

The mortality rate of *Callosobruchus chinensis* (pulse beetle) treated with varying doses of 70% aqueous methanol extract from Vimraj leaves was significantly assessed under laboratory conditions. Mortality percentages recorded at 24, 48, and 72 hours after treatment indicated that dose-1 (2.0 ml extract/20 g grain or 100 ml/kg grain) exhibited the highest mortality rate (100%), while dose-3 (1.0 ml extract/20 g grain or 50 ml/kg grain) resulted in the lowest (40%). All treatments produced significantly higher mortality compared to the control (0%), confirming that each dose had a statistically significant toxic effect (Table 2).

Effect of 50% aqueous methanol extract of vimraj leaf on the adult mortality of rice weevil

The mortality rate of *Sitophilus oryzae* (rice weevil) treated with varying doses of 50% aqueous methanol extract from Vimraj leaves was significantly assessed under laboratory conditions, as shown in Table 4. The mortality percentages recorded at 24, 48, and 72 hours after treatment (HAT) demonstrated that dose-1 (2.0 ml extract/20 g grain or 100 ml/kg grain) resulted in the highest mortality rate (100%), while dose-3 (1.0 ml extract/20 g grain or 50 ml/kg grain) showed the lowest. All treatments exhibited significantly higher mortality than the control (0%), indicating that each dose had a statistically significant toxic effect (Table 3).

Effect of 50% aqueous methanol extract of vimraj leaf on the adult mortality of red flour beetle

The mortality rate of *Tribolium castaneum* (red flour beetle) treated with 50% aqueous methanol extract from Vimraj leaves was also evaluated under laboratory conditions, as presented in Table 5. All doses—dose-1 (2.0 ml/20 g grain), dose-2 (1.5 ml/20 g grain), and dose-3 (1.0 ml/20 g grain)—resulted in a consistently low mortality rate (10%) across 24, 48, and 72 HAT. These values were only slightly higher than the control (0%) and were statistically significant, suggesting a minimal toxic effect at all tested concentrations (Table 3).

Effect of 50% aqueous methanol extract of vimraj leaf on the adult mortality of pulse beetle

Similarly, the mortality rate of *Callosobruchus chinensis* (pulse beetle) exposed to varying doses of 50% aqueous methanol extract of *Wedelia chinensis* leaves was examined under laboratory conditions. The 50% aqueous methanol extract of Vimraj leaf showed a dose- and time-dependent effect on adult mortality of pulse beetle. The highest mortality (mean 5.47 beetles) was observed at 2.0 ml extract/20 g grain, with 8.64 beetles dead at 72 hours. Lower concentrations (1.5 ml

and 1.0 ml) caused moderate mortality (mean 0.55), while no mortality occurred in the control. The results indicate significant insecticidal activity of the extract, especially at higher doses and longer exposure (Table 3).

Table 1. Effect of 100% aqueous methanol extract of vimraj leaf on the adult mortality of rice weevil, red flour beetle and pulse beetle.

Treatments	Rice weevil						Red flour beetle						Pulse beetle					
	No. of adults died at different time interval				Total dead	% adult mortality of rice weevil	No. of adults died at different time interval				% adult mortality of red flour beetle	No. of adults died at different time interval				Total dead	% adult mortality of pulse beetle	
	24 hr	48 hr	72 hr	Mean			24 hr	48 hr	72 hr	Mean		24 hr	48 hr	72 hr	Mean			
2.0 ml extract/20g grain (dose 1)	10.0a	10.0a	10.0a	10.0a		100%	10.0a	10.0a	10.0a	10.0a	10.0	100%	10.0a	10.0a	10.0a	10.0a	10.0	100%
1.5 ml extract/20g grain (dose 2)	7.0b	7.33b	7.66b	7.33b		80%	10.0a	10.0a	10.0a	10.0a	10.0	100%	10.0a	10.0a	10.0a	10.0a	10.0	100%
1.0 ml extract/20g grain (dose 3)	0.0c	0.0c	0.33c	0.11c		10%	0.66b	1.33b	2.0b	1.33b	2.00	20%	0.0b	1.66b	1.66b	1.10b	2.00	20%
Control	0.0c	0.0c	0.0c	0.0d		0.0%	0.00b	0.00c	0.0c	0.0c	0.00	0.0%	0.0b	0.00c	0.00c	0.0c	0.00	0.0%
LS	***	*	**	*			***	***	*	*			**	*	*	**		
CV (%)	9.37	6.64	7.00	5.12			10.17	5.41	6.74	6.23			4.54	5.32	5.32	6.76		
SE (±)	1.23	1.33	1.16	0.63			1.41	1.09	1.15	0.75			0.69	1.12	1.12	1.02		

Table 2. Effect of 70% aqueous methanol extract of vimraj leaf on the adult mortality of rice weevil, red flour beetle and pulse beetle.

Treatments	Rice weevil							Red flour beetle						Pulse beetle						
	No. of adults died at different time interval				Total dead	% adult mortality of red flour beetle	No. of adults died at different time interval				Total dead	% adult mortality of red flour beetle	No. of adults died at different time interval				Total dead	% adult mortality of pulse beetle		
	24 hr	48 hr	72 hr	Mean			24 hr	48 hr	72 hr	Mean			24 hr	48 hr	72 hr	Mean				
2.0 ml extract/20g grain	10.0a	10.0a	10.0a	10.0a	10.0	100%	10.0a	10.0a	10.0a	10.0a	10.0	100%	10.0a	10.0a	10.0a	10.0a	10.0	100%		
1.5 ml extract/20g grain	10.0a	10.0a	10.0a	10.0a	10.0	100%	10.0a	10.0a	10.0a	10.0a	10.0	100%	8.0b	8.0a	8.30a	8.10ab	8.00	80%		
1.0 ml extract/20g grain	10.0a	10.0a	10.0a	10.0a	10.0	100%	1.33b	3.66b	4.00b	2.99b	4.00	40%	3.33c	3.66b	4.00b	3.66b	4.00	40%		
Control	0.0b	0.0b	0.0b	0.0b	0.00	0.0%	0.00b	0.00c	0.00c	0.00c	0.00	0.0%	0.00d	0.00c	0.00c	0.0c	0.00	0.0%		
LS	***	***	*	*			**	*	***	*			**	***	*	*				
CV (%)	10.17	5.41	6.74	6.23			14.32	9.51	10.43	5.48			9.51	7.31	6.34	7.66				
SE (±)	1.41	1.09	1.15	0.75			1.22	1.08	1.17	1.29			1.05	1.14	0.96	1.28				

In column, means followed by different letters are significantly different, *means at 5% level of probability, **means at 1% level of probability and ***means at 0.1% level of probability; LS = Least significant, CV = Co-efficient of variation, SE = Standard error

Table 3. Effect of 50% aqueous methanol extract of vimraj leaf on the adult mortality of rice weevil, red flour beetle and pulse beetle.

Treatments	Rice weevil							Red flour beetle						Pulse beetle					
	No. of adults died at different time interval				Total dead	% adult mortality of red flour beetle	No. of adults died at different time interval				Total dead	% adult mortality of red flour beetle	No. of adults died at different time interval				Total dead	% adult mortality of pulse beetle	
	24 hr	48 hr	72 hr	Mean			24 hr	48 hr	72 hr	Mean			24 hr	48 hr	72 hr	Mean			
2.0 ml extract/20g grain	10.0a	10.0a	10.0a	10.0a	10.0	100%	0.00a	0.33b	0.33ab	0.22b	1.00	10%	0.00a	0.33b	0.33ab	0.22b	1.00	10%	
1.5 ml extract/20g grain	9.00a	9.00a	9.33a	9.11ab	9.00	90%	0.33b	0.66a	0.66ab	0.55a	1.00	10%	0.33b	0.66a	0.66ab	0.55a	1.00	10%	
1.0 ml extract/20g grain	1.00b	2.33b	2.66b	1.99b	3.00	30%	0.00a	0.66a	1.00a	0.55a	1.00	10%	0.00a	0.66a	1.00a	0.55a	1.00	10%	
Control	0.00b	0.00b	0.00c	0.00c	0.00	0.0%	0.00a	0.00c	0.00b	0.0c	0.00	0.0%	0.00a	0.00c	0.00b	0.0c	0.00	0.0%	
LS	***	***	***	*			*	**	**	*			*	**	**	*			
CV (%)	7.30	6.64	8.64	6.58			6.41	5.30	8.64	5.47			6.41	5.30	8.64	5.47			
SE (±)	1.14	0.96	1.05	1.14			1.10	1.24	0.66	1.14			1.10	1.24	0.66	1.14			

In column, means followed by different letters are significantly different, *means at 5% level of probability, **means at 1% level of probability and ***means at 0.1% level of probability; LS = Least significant, CV = Co-efficient of variation, SE = Standard error

DISCUSSION

The present study evaluated the insecticidal efficacy of Vimraj leaf extracts against three common storage pests: *Sitophilus oryzae* (rice weevil), *Tribolium castaneum* (red flour beetle), and *Callosobruchus chinensis* (pulse beetle) under laboratory conditions. The mortality responses were assessed following treatment with different concentrations (100%, 70%, and 50%) of methanolic and aqueous methanolic leaf extracts.

The 100% methanol extract of *W. chinensis* demonstrated strong toxic effects on all three test insects, with *S. oryzae* and *C. chinensis* exhibiting complete mortality (100%) at the higher doses (dose-1 and dose-2) and moderate mortality at the lowest dose. This high level of toxicity is likely due to the presence of potent phytochemicals such as flavonoids, alkaloids, saponins, and terpenoids, which have been widely reported to possess insecticidal and antifeedant

properties (Sultana et al., 2025, Mohapatra et al., 2015; Zhang et al., 2020; Haque et al., 2025; Rahman et al., 2025). These compounds may disrupt normal physiological processes in insects, including respiration and nervous system function, ultimately leading to death (Hou et al., 2025; Şimşek et al., 2025; Uluçay et al., 2025). In the case of *T. castaneum*, all three doses of the 100% methanol extract caused significant mortality, although the lowest dose (20%) was less effective. This variation may be attributed to species-specific tolerance levels or cuticular differences that affect the absorption and penetration of the bioactive compounds (Kumar et al., 2022; Hossen et al., 2020). Similar to the 100% methanol extract, the 70% aqueous methanol extract also showed high efficacy against all three insect species. Both *S. oryzae* and *C. chinensis* reached 100% mortality at the highest doses, while *T. castaneum* responded slightly less (40% at the lowest dose). Aqueous methanol likely enhances the solubility and extraction of polar and semi-polar bioactive compounds, improving insecticidal action at moderate concentrations (Huang et al., 2022; Unver et al., 2025; Aydın et al., 2025; Bashir et al., 2025). However, the reduced mortality at lower doses may suggest that the concentration of active compounds was insufficient to exert strong toxic effects. The 50% extract displayed a marked reduction in toxicity compared to higher concentrations. In *S. oryzae* and *C. chinensis*, mortality remained significant at higher doses but was noticeably lower than that observed with the 100% and 70% extracts. Notably, *T. castaneum* exhibited minimal susceptibility, with only 10% mortality across all doses, indicating potential resistance or lower sensitivity to the diluted extract. This trend of decreased mortality with decreasing extract concentration is consistent with previous findings, which suggest that the potency of plant-derived insecticides is dose-dependent and closely correlated with the concentration of phytochemicals present (Azeem et al., 2023). At lower solvent concentrations, the extract may lack sufficient quantities of bioactive molecules necessary to cause physiological disruption or mortality in more resilient insect species. Across all treatments, *C. chinensis* and *S. oryzae* consistently showed greater sensitivity to *W. chinensis* extracts compared to *T. castaneum*. This may be attributed to interspecific differences in cuticle composition, detoxification enzymes, or metabolic rates, which can affect susceptibility to phytochemicals (Hu et al., 2023; Şahin et al., 2025). Pulse beetles, in particular, have been found to be highly vulnerable to botanical insecticides due to their thinner cuticle and higher respiration rates, which increase exposure to toxicants (Thao et al., 2018; Howlader et al., 2024b; Al Masum et al., 2025). The results underscore the potential of *W. chinensis* leaf extract as a bioinsecticide in the management of stored grain pests. The strong insecticidal activity at higher extract concentrations, especially in 100% and 70% methanol-based formulations, highlights its promise as a sustainable alternative to synthetic pesticides. However, the variation in efficacy across insect species and extract concentrations suggests that further formulation optimization and active compound isolation are warranted for consistent field application.

CONCLUSION

This study demonstrated the promising allelopathic potential of Vimraj leaf extracts in controlling major stored grain pests, including *Sitophilus oryzae*, *Tribolium castaneum*, and *Callosobruchus chinensis*. The bioactivity of the extracts was found to be dose-dependent, with higher concentrations exhibiting greater insecticidal effects. These findings suggest that *Wedelia chinensis* could be a valuable natural alternative to synthetic pesticides in integrated pest management strategies for stored grains. However, this study primarily focused on assessing mortality rates and did not explore the underlying biochemical or molecular mechanisms responsible for the observed toxic effects. Future research should aim to elucidate the mode of action of these extracts, including their impact on insect enzyme activities, hormonal balance, and gene expression. Additionally, evaluation of extract stability, safety, and efficacy under field conditions would be essential to advance practical applications. Addressing these gaps will enhance understanding of the potential and limitations of *Wedelia chinensis* as a botanical pesticide, ultimately contributing to sustainable and eco-friendly pest control solutions.

Compliance with Ethical Standards

Peer Review

This article has been reviewed by independent experts in the field using a rigorous double-blind peer review process.

Conflict of Interest

The authors declare no conflicts of interest.

Author Contributions

Ayrin Akanda Mou: Investigation and Methodology; **Md. Abdullah Al Masum:** Investigation and Methodology; **Nayan Chandra Howlader:** Formal Analysis, Writing - Original draft, Visualization, Resource, Data Curation and Software; **Md. A Hadi Pk:** Software and Writing – Review & Editing; **Krishna Rany Das:** Conceptualization, Supervision, Resource and Writing – Review & Editing; **Abdullah Al Amin** and **Isfak Tanvir:** Writing – Review & Editing; **Loukik Mehjabin & Israt Jahan:** Writing – Review & Editing; **Md Arman Ullah:** Writing – Review & Editing and Data Curation.

Ethics Committee Approval

Ethical approval was not required for this study.

Consent to Participate / Publish

Not applicable.

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Data Availability

Data will be made accessible upon demand via the corresponding email address.

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