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Repellent efficacy of oil, powder and extracts of garlic (*Allium sativum*) against *Callosobruchus chinensis* (L.) in chickpea seeds

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Abstract
Chickpea *Cicer arietinum* (L.) is the major pulse crop grown in India. During storage, the pulse beetle *Callosobruchus chinensis* (L.) causes immense quantitative and qualitative losses in the seeds. The use of botanicals against storage pests is gaining importance because of safety concerns. Therefore, repellent potential of various garlic (*Allium sativum* L.) products including oil, powder, and solvent-based extracts was investigated against the pulse beetle in stored chickpea seeds at CCS HAU, Hisar. Treatments were assessed based on adult mortality and oviposition repellence over a 7-day exposure period. Among the tested formulations, garlic oil exhibited the highest adult mortality (36%) and greatest reduction (36.42%) in egg laying. Methanol extract showed moderate repellence, while other extracts and garlic powder were less effective. The findings support the potential use of garlic-based botanicals as eco-friendly alternatives in pulse beetle management.

Keywords: *Allium sativum*, pulse beetle, garlic oil, oviposition deterrent, stored grain pest, chickpea, botanical repellent

Introduction
Spices have long been used in traditional pest control practices due to their insecticidal, fumigant, and repellent properties (Jood, S., *et al.*, 1996; Koul, O., *et al*., 2014; Kale, R.B., *et al.*, 2023; Yadav, S.D., *et al.*, 2025) [5, 7, 6, 15]. Garlic (*Allium sativum* L.) is one such spice with documented bioactivity against stored grain pests, particularly for its fumigant and repellent actions (Shaaya, E., *et al.*, 1997; Reena, *et al*., 2003; Denloye, A.A, *et al*., 2003; Yang, F., *et al*., 2010; Alla, M.I, *et al.*, 2015) [14, 12, 2, 16, 1]. In the present investigation, garlic oil, powder, and solvent extracts were evaluated for their repellent efficacy against *Callosobruchus chinensis* (L.), a key pest of stored pulses, using chickpea as the test substrate.

Materials and Methods
Insect Culture
A stock culture of *C. chinensis* was maintained in cylindrical plastic containers (20 × 10 cm) containing 250 g of chickpea seeds. A pair of adult beetles was introduced and allowed to oviposit for 5 days, after which the adults were removed. The culture was maintained in a BOD incubator at 29 ± 1°C and 80 ± 5% relative humidity. Newly emerged adults were used for bioassays.

Preparation of Test Materials
Certified seeds of chickpea variety 'HC-5' were obtained from the Directorate of Farms, CCSHAU, Hisar. Fresh garlic bulbs were sourced from the Department of Vegetable Science, CCSHAU. For extract preparation, 1 kg of crushed garlic bulbs was refluxed in 2.5 L of methanol for 6 h. The extract was filtered and concentrated by distillation. This process was repeated three times. Additionally, 5 kg each of garlic bulbs were extracted using methanol, hexane, chloroform, and acetone, yielding 20 g of each extract. Commercially available garlic oil and garlic powder were procured locally.

Repellency Bioassay
Glass jars (20 × 10 cm) were vertically divided using wire mesh. One side was treated with 1 mL of garlic oil or extract, or 1 g of garlic powder, while the other half side remained untreated and provided with untreated chickpea seeds for oviposition. Five pairs of adult *C. chinensis* were released into each jar, and observations were recorded for adult mortality and egg laying on days 1, 3, 5, and 7 post-exposures.

Statistical Analysis
Data were subjected to analysis of variance (ANOVA) using a completely randomized design. Significant differences among treatments were determined at the 5% probability level. Data on mortality and egg count were transformed using angular (arcsine √x) or square root transformations where necessary (Snedecor, G.N, *et al.*, 1996) [13].

Results and Discussion
Adult Mortality
No mortality was recorded during the first three days of exposure in any treatment (Table 1). By the fifth day, garlic oil caused 20% mortality, increasing to 36% by day seven. Methanol extract resulted in 20% mortality by day seven, while the other extracts showed only 10–13% mortality. The control recorded no mortality throughout the experiment. These results demonstrate the superior effects of garlic oil compared to other formulations. Repellency and toxicity properties of garlic extract were very effective in killing larvae and adults of red flour beetle (Mobki, M., *et al*., 2014) [8] corroborating present studies. Rahman, G.K., *et al*., (2000) [11] reported good repellent effect of intact garlic cloves, grated garlic and its volatile extract applied on brown rice against maize weevil and red flour beetle which is in line with the present studies.

Table 1: Repellent action of garlic oil, extracts and garlic powder on adult mortality *Callosobruchus chinensis* (L.) at different days intervals

Treatment	% mortality of pulse beetle days after release				
	1	3	5	7	Mean
Garlic oil	0.0 (5.7)	0.0 (5.7)	20.0 (26.0)	36.0 (36.9)	14.0(18.6)
Methanol extract	0.0 (5.7)	0.0 (5.7)	13.3 (17.4)	20.0 (26.0)	8.3 (14.4)
Hexane extract	0.0 (5.7)	0.0 (5.7)	10.0 (18.4)	13.0 (17.4)	5.7 (11.9)
Chloroform extract	0.0 (5.7)	0.0 (5.7)	10.0 (18.4)	10.0 (18.4)	5.0 (11.2)
Acetone extract	0.0 (5.7)	0.0 (5.7)	6.6 (12.5)	10.0 (18.4)	4.1 (9.6)
Garlic powder	0.0 (5.7)	0.0 (5.7)	3.0 (6.1)	10.0 (18.4)	3.2 (8.91)
Control (acetone treated)	0.0 (5.7)	0.0 (5.7)	0.0 (5.7)	0.0 (5.7)	0.0 (5.7)
Mean	0.0 (5.7)	0.0 (5.7)	8.9 (15.4)	14.1 (19.2)	
SE(m) ±	(0.01)	(0.01)	(5.7)	(5.8)	
C.D. at 5%	(NS)	(NS)	(NS)	(17.8)	
Factors	DF	SE(m) ±	C.D. at 5%		
Period (days)	3	(1.1)	(3.1)		
Treatment	6	(1.4)	(4.2)		
Period (days) x Treatment	18	(2.9)	(8.4)		

Surce: in the parentheses are angular transformation (X+1) values NS= Non-significant

Oviposition Repellency

On day one, the lowest egg count (52.6) was observed in garlic oil-treated jars, followed by methanol extract (58.6) (Table 2). By day seven, garlic oil again proved most effective in reducing oviposition (245.6 eggs), with methanol extract (320.3 eggs) performing moderately well. The highest egg counts were recorded in garlic powder, acetone extract, and control treatments. These findings corroborate earlier reports on the repellent action of garlic formulations against stored product pests (Ho, S.H., *et al.*, 1996; Ofuya, T.I., *et al*.,2010; Onu, F.M., *et al*., 2015; Jahromi, M.G., *et al*., 2012) [3, 9, 10, 4]. Ho, S.H., *et al*. (1996) [3] observed 95% repellency against *Tribolium castaneum* and *Sitophilus zeamais* which support the present findings. Repellent activity of garlic powder treated beans was encouraging in the management of pulse beetles (Onu, F.M., *et al.*, 2015) [10].

Table 2: Repellent action of garlic oil, extract, garlic powder on oviposition of *Callosobruchus chinensis* (L.) at different days intervals

Treatment	Mean number of eggs laid by pulse beetle days after release				
	1	3	5	7	Mean
Garlic oil	52.6 (7.3)	144.6 (12.0)	204.6 (14.3)	245.6 (15.7)	161.7 (12.3)
Methanol extract	58.6 (7.7)	161.3 (12.7)	258.0 (16.0)	320.3 (17.9)	199.5 (13.6)
Hexane extract	64.3 (8.0)	176.3 (13.3)	285.0 (26.9)	369.6 (19.2)	223.8 (14.3)
Chloroform extract	61.3 (7.8)	169.6 (13.0)	270.0 (16.4)	356.6 (18.9)	214.3 (14.0)
Acetone extract	66.3 (8.2)	180.3 (13.4)	279.6 (16.7)	383.0 (19.5)	227.3 (14.6)
Garlic powder	65.6 (8.1)	185.3 (13.6)	283.0 (16.8)	386.6 (19.6)	230.1 (14.5)
Control (acetone treated)	71.3 (8.5)	189.6 (13.8)	293.0 (17.1)	386.3 (19.6)	235.0 (14.6)
Mean	62.8(7.9)	172.4 (13.1)	267.5 (16.3)	349.7 (18.6)	
SE(m) ±	(0.12)	(0.18)	(0.18)	(0.17)	
C.D. at 5%	(0.39)	(0.56)	(0.58)	(0.52)	
Factors	DF	SE(m) ±	C.D. at 5%		
Period (days)	3	(0.06)	(0.18)		
Treatment	6	(0.08)	(0.24)		
Period (days) x Treatment	18	(0.17)	(0.48)		

Surce: in the parentheses are square root transformation values

Conclusion

The present study demonstrated that among different formulations of garlic, garlic oil exhibited the highest efficacy in reducing both adult survival and oviposition of *Callosobruchus chinensis* on stored chickpea seeds through repellency, followed by methanol extract. Other solvent extracts and garlic powder were comparatively less effective. These findings highlight garlic oil as a promising botanical repellent with potential application in the eco-friendly management of pulse beetles in stored grain systems. Since garlic-based products are biodegradable, locally available, and safe for human health, their incorporation into integrated pest management strategies could reduce dependence on synthetic chemical insecticides.

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