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Phytochemical study of *Curcuma longa* and *Mentha spicata* powders for the management of the *Callosobruchus maculatus* (Chrysomelidae: Coleoptera) on the Pigeon pea *Cajanus cajan*

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ABSTRACT

Stored-product beetles, particularly *Callosobruchus maculatus* (Fabricius), are among the most destructive pests of stored legumes, causing significant quantitative and qualitative losses during storage. The widespread use of synthetic insecticides for bruchid management has led to concerns regarding insect resistance, pesticide residues, environmental contamination, and human health risks, thereby creating a need for safer and more sustainable alternatives. Botanical insecticides have emerged as promising eco-friendly options because of their biodegradability, availability, and diverse bioactive compounds with insecticidal, repellent, and fumigant properties. Pigeon pea (*Cajanus cajan* L. Millsp.) is an important pulse crop widely cultivated in tropical and subtropical regions, particularly in India, where it serves as a major source of dietary protein and contributes to soil fertility through biological nitrogen fixation. However, its storage is severely affected by *C. maculatus*, resulting in reduced seed quality, weight loss, and decreased market value. The present study was undertaken to evaluate the insecticidal potential of *Curcuma longa* (turmeric) and *Mentha spicata* (spearmint) against *C. maculatus* infesting stored pigeon pea. The study focuses on the efficacy of phytochemicals present in these botanicals as sustainable alternatives to conventional chemical insecticides. By assessing their potential in managing pulse beetle infestations, the research aims to contribute to the development of environmentally friendly and economically viable pest management strategies for the protection of stored legumes and the enhancement of food security.

Key Words: (Stored-product beetle *Callosobruchus maculatus* (Fabricius), Pigeon pea (*Cajanus cajan* L. Mill sp.), Botanical insecticides *Curcuma longa* (turmeric) and *Mentha spicata* (mint).

INTRODUCTION

Stored product pests, particularly beetles of the order *Coleoptera*, pose a major challenge in grain storage systems due to their high adaptability to dry conditions and ability to complete their life cycles within stored grain environments. Among these, the bruchid beetles, especially *Callosobruchus maculatus* (commonly known as the cowpea or pulse beetle), are recognized as one of the most economically damaging pests of stored legumes, including cowpeas and other pulses. These beetles not only infest a wide variety of stored crops such as cereals, pulses, and oilseeds, but also exhibit strong host preferences (Kumar *et al.,* 2022). (Nacoulma *et al.,* 2018) emphasize the significance of botanical insecticides in managing *C. maculatus* populations, particularly in resource-limited settings like Burkina Faso, where access to synthetic pesticides may be restricted. (Brhane *et al.,* 2023) further explore integrated pest management approaches, comparing the efficacy of plant-based extracts with carbaryl, a synthetic insecticide, in controlling bruchid infestations. These findings collectively highlight the persistent threat posed by *C. maculatus* and the importance of sustainable, locally adapted management strategies to safeguard stored legume crops.

The findings support the exploration of botanicals such as *Curcuma longa* (turmeric) and *Mentha spicata* (spearmint) as promising alternatives for controlling *Callosobruchus maculatus* in stored pigeon pea (*Cajanus cajan*). Pigeon pea (*Cajanus cajan* L. Millsp.), also known as red gram, tur or arhar, is one of the most important pulse crops cultivated across tropical and subtropical regions, particularly in India where it serves as a major dietary protein source in vegetarian populations (Kumar *et al.,* 2011). Belonging to the Fabaceae family, pigeon pea is highly valued for its rich nutritional profile containing 20-22 % protein along with vital minerals and vitamins making it essential for addressing protein-energy malnutrition in developing countries (Varshney *et al.,* 2013). Additionally, the crop is recognized for its nitrogen-fixing ability, contributing up to 60 kg N/ha, which enhances soil fertility and supports sustainable agriculture (Kumar *et al.,* 2011). Its adaptability to diverse agro-climatic conditions and its performance in rainfed and marginal lands further underscore its significance in food and nutritional security, especially in resource-limited farming systems (Varshney *et al.,* 2013). Essential oils and leaves extracted from *Mentha* species have demonstrated strong fumigant and deterrent effects on stored product insects (Tripathi *et al.,* 2009). The present study builds upon this foundation, aiming to evaluate the efficacy of the phytochemicals present in the two botanicals as part of a sustainable pest management strategy for stored legumes.

MATERIALS AND METHODS

The experiment was carried out at the laboratory of Zoology, Nirmala College for Women, Coimbatore.

Classification o the test insect

Kingdom : Animalia

Phylum : Arthropoda

Order : Coleoptera

Family : Chrysomelidae

Genus : *Callosobruchus* (Fabricius, 1775)

Species *: maculatus*

Rearing of Test Insect – *Callosobruchus maculatus*

Callosobruchus maculatus (pigeon pea weevil or pulse beetle) is a common storage pest of pulses and is widely reared in laboratories for research on insect biology and pest management. Clean and sterilize the cowpea seeds to eliminate any existing infestation. Placed approximately 200-300 grams of pigeon pea seeds into a clean rearing jar. Introduced ten freshly emerged adult *C. maculatus* into each jar. Covered the mouth of the jar with muslin cloth and secure it with a rubber band to allow ventilation while preventing insect escape. Kept the jars under controlled laboratory conditions: Temperature: 27 ± 2°C; Relative humidity: 65-75 %; Photoperiod: 12:12 hours (Light: Dark). Allowed the adults to mate and lay eggs for 5-7 days. Removed the adult beetles after the oviposition period to prevent overlapping generations. Maintained the jars until adult emergence, which usually occurs after 25-35 days, depending on environmental conditions. Collected freshly emerged adults daily for experimental use and transferred them to fresh pigeon pea seeds to maintain a continuous culture. Precautions were, used only clean, uninfected seeds; Maintained constant temperature and humidity throughout the rearing period; Avoided overcrowding of insects in the rearing containers; Removed adults after oviposition to obtain a uniform-age culture; Kept the culture free from contamination by mites, fungi or other insects; Labelled each culture with the date of initiation and generation number.

Medicinal plant powders

The plant powders shown in the following **Table -1** were collected and used against the pests of pigeon pea *Callosobruchus maculatus.*

Table :1- Medicinal Plant powders

S.No	Botanical Name	Common Name	Tamil Nadu	Family Name
1	*Curcumalonga*	Turmeric	Manjal	Lamiaceae
2	*Mentha pictata*	Mint	Puthina	Lamiaceae

Experimental Design

Two replications from each concentration and untreated control maintained simultaneously. From the residue, desired concentrations of 1gram, 2 grams, 3 grams, 4 grams and 5 grams of plant powders were prepared.

250 grams of infected *Cajanus cajan* gram was taken in a container in which different doses of plant powders were added. The containers were mixed well and dried. All the treatment and control were replicated

two times. 10 newly emerged adults were released into the container. The containers were tightly closed with lid.

Phytochemical Screening

Qualitative analysis

Preliminary phytochemical screening of leaf extracts of selected medicinal plant was carried out using the standard procedures.

Test for alkaloids

2 ml of plant extract was treated with Wagner's reagent. Brown or Red colour precipitate indicates the presence of alkaloids.

Test for flavonoids

0.5 g of plant powder was added with 10 ml of distilled water. 3-5 ml of dilute ammonia solution were added to side of the test tube, then add 1ml of con. Sulphuric acid. Yellow colour indicates the presence of flavonoids.

Test for tannins

2 ml of purified plant extract was taken in a test tube and add 2 drops of 5% ferric chloride solution and the presence was indicated by yellow colour.

Test for reducing sugar

To 2 ml of purified extract add 2 ml of Fehling's solution. The solution was kept in water bath for 40^{o} C. Formation of brick red precipitate at the bottom of the test tube indicates the presence of reducing sugar.

Test for steroids

1ml of purified extract was placed in a test tube, 2 ml of acetic anhydride followed by addition of 3-5 drops of chloroform. Then 2 drops of concentrated Sulphuric acid were added along the side portions of the test tube drop by drop. Formation of blue or green colour indicates the presence of steroids

Test for phenols

To 1ml of purified sample add 2 ml of distilled water. Then 2-3 drops of 10 % aqueous ferric chloride were added. The presence of phenol was indicated by the formation of blue or green colour.

Test for Saponins

2 ml of purified plant extract was taken and added with 5 ml of distilled water. The mixture was vigorously shaken. The presence of saponins was indicated by the formation of persistent form.

RESULT AND DISCUSSION

Major Bioactive Constituents of Turmeric powder

Turmeric, obtained from the rhizomes of Curcuma longa, contains several compounds associated with insect control: Curcumin, Demethoxy curcumin, Bisdemethoxycurcumin, Ar-turmerone, α-Turmerone, β-Turmerone, Zingiberene, Flavonoids, Sterols and Saponins. These compounds act individually and synergistically against storage insects.

The management of *Callosobruchus* insects by the phytochemicals in the Turmeric powder

The Repellent activity-The characteristic odor of turmeric masks host seed volatiles and interferes with insect chemoreceptors. This leads to: Reduced attraction to grains; Lower oviposition rates and Decreased infestation. Female beetles avoid laying eggs on turmeric-treated seeds. Contact toxicity- Curcuminoids and associated phytochemicals affect the insect cuticle and nervous system. Effects include: Reduced mobility; Feeding deterrence and mortality of larvae and adults. Antifeedant action- Flavonoids and saponins reduce feeding efficiency by: Altering taste perception; Inhibiting digestive enzymes and reducing nutrient absorption. As a result: Larval development slows;

Adult emergence decreases and reproductive capacity declines. Growth regulatory effects. Curcuminoids can interfere with: Molting processes; Hormonal regulation and Egg hatchability. This disrupts the life cycle of *Callosobruchus* species. Physical protection of grains. Turmeric powder forms a thin coating on seed surfaces that: Obstructs egg attachment; Limits larval penetration into grains and creates an unfavorable microenvironment. The powder may also block spiracles, contributing to insect mortality. These findings support the use of turmeric powder as an eco-friendly botanical protectant for stored pulses.

Results of the phytochemical screening of mint powder

The phytochemical screening of mint powder indicates that several classes of secondary metabolites with known insecticidal and repellent properties are present, while others are absent. These compounds may contribute individually or synergistically to the control of storage pests such as *Callosobruchus maculatus*. Phytochemicals detected in mint powder were revealed the presence of alkaloids, flavonoids, sterols, proteins, carbohydrates, saponins, and cardiac glycosides. Among these, alkaloids, flavonoids, saponins, and cardiac glycosides are known to possess insecticidal, repellent, antifeedant, and growth-regulating properties.

The absence of terpenoids, anthraquinones, anthocyanins, phenolics, quinones, tannins, coumarins, lignin, volatile oils and most glycosides suggests that these groups are either absent or present below detectable levels in the tested mint powder. Notably, mint plants are often rich in volatile compounds such as menthol and menthone; however, the negative fluorescence test indicates that drying, storage conditions, powder preparation or extraction procedures may have reduced detectable levels of volatile oils.

The management of *Callosobruchus* insects by the phytochemicals in the Mint powder

Species of *Callosobruchus* are serious storage pests of pulses and legumes. Adult females lay eggs on seeds and the developing larvae bore into the grains, causing weight loss and reduced seed viability. The phytochemicals detected in mint powder can affect different stages of the insect life cycle. Repellent action by Alkaloids, flavonoids, and residual aromatic compounds from mint can alter insect behavior by interfering with olfactory receptors.

The effects include: Reduced attraction to stored grains; Lower egg-laying activity and Avoidance of treated seeds. This decreases infestation rates during storage. Antifeedant activity by Saponins, flavonoids, and cardiac glycosides reduce feeding by: Producing bitter or toxic effects; Causing digestive discomfort and interfering with nutrient absorption. Larvae feeding inside the seeds consume less food, leading to slower growth and lower survival. Toxic effects on larvae and adults. Alkaloids- Alkaloids can disrupt the insect nervous system by interfering with neurotransmission.

Possible outcomes: Reduced mobility; Paralysis and Increased mortality. Cardiac glycosides- These compounds inhibit membrane ion transport mechanisms, resulting in: Impaired muscle function; Metabolic disruption and Death of susceptible insects. Saponins- Saponins interact with membrane sterols and increase membrane permeability, causing: Cell damage; Digestive tract disruption and reduced larval survival. Growth and developmental inhibition by Flavonoids and sterol-like compounds can interfere with insect hormones responsible for molting and metamorphosis.

Consequences include: Delayed larval development; Failure to pupate; Reduced adult emergence and Production of weak or sterile adults. Reduced reproductive performance- Exposure to mint phytochemicals may lead to: Fewer eggs laid per female; Lower egg hatchability; Reduced fecundity and shorter adult lifespan. These effects gradually suppress pest populations during storage.

Overall, the positive detection of alkaloids, flavonoids, sterols, saponins, and cardiac glycosides suggests that mint powder acts as a botanical protectant against *Callosobruchus* through multiple mechanisms: Repellency; Feeding deterrence; Direct toxicity; Growth regulation and Reproductive suppression. The combined action of these metabolites makes mint powder a promising eco-friendly alternative to synthetic fumigants and chemical insecticides for protecting stored pulses.

Table:2- Results of Phytochemical Screening of Turmeric powder

S. No.	Metabolite	Test performed	Observation	Result	Figure No.
1	Alkaloids	+ Mayer's reagent	Absence of Cream coloured precipitate	-	
		+ Dragendorff's reagent	Absence of reddish-brown precipitate	-	
2	Flavonoids	Alkaline test	Intense yellow colour with dil. NaOH that turns colourless on adding dil. HCl	+	**1**
		+ H_2SO_4	Absence of reddish orange colour	-	
		+ lead acetate	Presence of white precipitate	+	**2**
		Shinoda test	Absence of crimson pink colour	-	
3	Sterols (Libermann test)	+ $CHCl_3$+ Acetic anhydride + Conc.H_2SO_4	Presence of reddish-brown ring	+	**3**
4	Terpenoids (Libermann test)	+ $CHCl_3$+ Acetic anhydride + Conc. H_2SO_4	Absence of green colour	-	
5	Anthraquinone (Borntrager's test)	+ $FeCl_3$ + Conc. HCl + diethyl ether + Ammonia	Absence of reddish orange colour	-	
6	Anthocyanin	HCl Test	No Colour change	-	
7	Proteins	+ 2% Ninhydrin reagent	Absence of Purple colour	-	
		+ 2% $CuSO_4$ + 95% ethanol +KOH pellet	Absence of blue colour	-	
		+ conc. HNO_3	Absence of Yellow colouration	-	
8	Phenolic compounds	+ 5% neutral $FeCl_3$	Absence of bluishgreen coloured solution	-	
		Gelatin test	Absence of whiteprecipitate	-	
		+ Ellagic acid test	Absence of niggerbrown precipitate	-	
		Conc. HCl	Absence of yellow precipitate	-	

9	Quinones	Alcoholic KOH	Absence of reddish solution	-	
10	Carbohydrates	Molisch’s test	Presence of Violet ring	+	4
		Fehling’s test	Presence of Red precipitate	+	5
11	Tannin	Braymer’s test	Absence of bluish green colour	-	
		+ Gelatin test	Absence of white precipitate	-	
		10% NaOH test	Absence of emulsion	-	
12	Saponins	Shaken with water	Presence of foam	+	6
13	Cardiac glycosides	+ Baljet reagent	Absence of yellow orange colour	-	
		Bromine water test	Absence of yellowprecipitate	-	
		Keller-killani test	Absence of brown ring	-	
14	Glycoside’stest	Borntrager’s test	Absence of pink coloured solution	-	
		Aq. NaOH test	Absence of yellow coloured solution	-	
15	Lignin	+ Gallic acid	Absence of olive-green colour	-	
16	Coumarins	+ 10% NaOH + $CHCl_3$	Absence of yellow colour	-	
17	Volatile oils	Fluorescence test	No pinkish fluorescence	-	

Figure 1: Phytochemical Screening of Turmeric powder

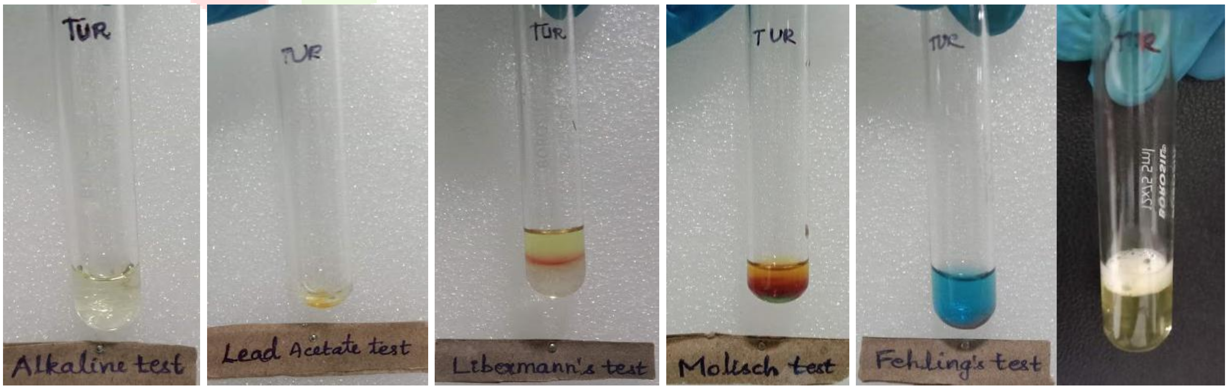

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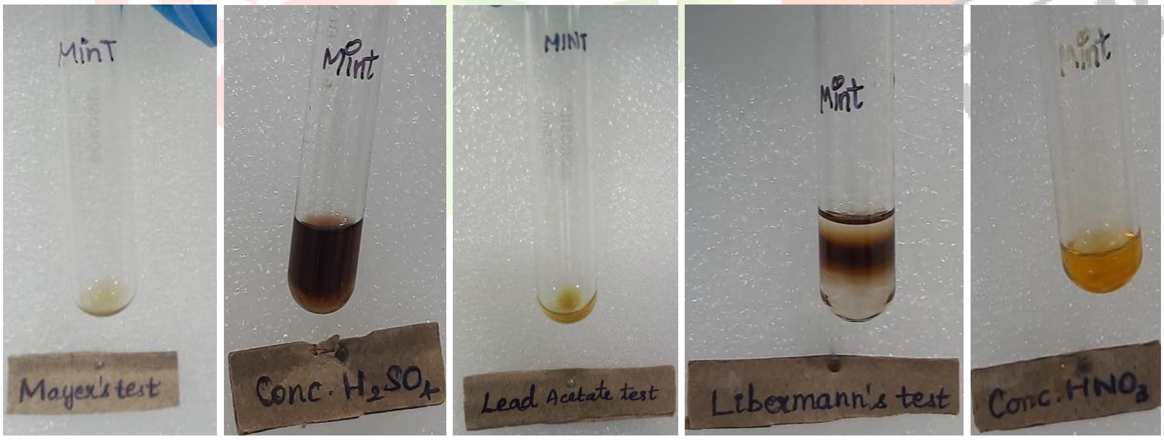
Table:3- Results of Phytochemical Screening of Mint

S. No.	Metabolite	Test performed	Observation	Result	Figure No.
1	Alkaloids	+ Mayer's reagent	Presence of Cream coloured precipitate	+	**1**
		+ Dragendorff's reagent	Absence of reddish brown precipitate	-	
2	Flavonoids	Alkaline test	No intense yellow colour with dil.NaOH	-	
		+ H_2SO_4	Presence of reddish orange colour	+	**2**
		+ lead acetate	Presence of white precipitate	+	**3**
		Shinoda test	Absence of crimson pink colour	-	
3	Sterols (Libermanntest)	+ $CHCl_3$+ Acetic anhydride + Conc.H_2SO_4	Presence of reddish brown ring	+	**4**
4	Terpenoids (Libermann test)	+ $CHCl_3$+ Acetic anhydride + Conc. H_2SO_4	Absence of greencolour	-	
5	Anthraquinone (Borntrager's test)	+ $FeCl_3$ + Conc. HCl + diethyl ether + Ammonia	Absence of reddish orange colour	-	
6	Anthocyanin	HCl Test	No Colour change	-	
7	Proteins	+ 2% Ninhydrin reagent	Absence of Purple colour	-	
		+ 2% $CuSO_4$ + 95% ethanol +KOH pellet	Absence of blue colour	-	
		+ conc. HNO_3	Presence of Yellow colouration	+	**5**
8	Phenolic compounds	+ 5% neutral $FeCl_3$	Absence of bluish green coloured solution	-	
		Gelatin test	Absence of whiteprecipitate	-	
		+ Ellagic acid test	Absence of niggerbrown precipitate	-	
9	Quinones	Conc. HCl	Absence of yellow precipitate	-	
		Alcoholic KOH	Absence of reddish solution	-	

10	Carbohydrates	Molisch’s test	Presence of Violet ring	+	**6**
		Fehling’s test	Presence of Red precipitate	+	**7**
11	Tannin	Braymer’s test	Absence of bluish green colour	-	
		+ Gelatin test	Absence of white precipitate	-	
		10% NaOH test	Absence of emulsion	-	
12	Saponins	Shaken with water	Presence of foam	+	**8**
13	Cardiac glycosides	+ Baljet reagent	Presence of yellow orange colour	+	**9**
		Bromine water test	Absence of yellowprecipitate	-	
		Keller-killani test	Absence of brown ring	-	
14	Glycoside’stest	Borntrager’s test	Absence of pink coloured solution	-	
		Aq. NaOH test	Absence of yellow coloured solution	-	
15	Lignin	+ Gallic acid	Absence of olive-green colour	-	
16	Coumarins	+ 10% NaOH + $CHCl_3$	Absence of yellow colour	-	
17	Volatile oils	Fluorescence test	No pinkish fluorescence	-	

Figure 2: Phytochemical Screening of Turmeric powder

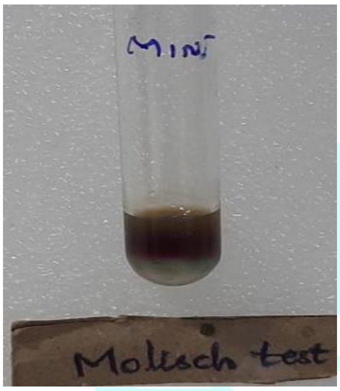


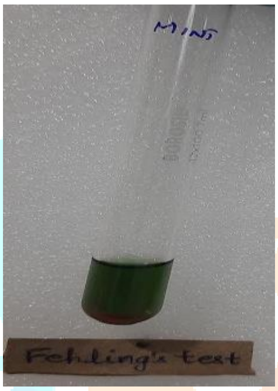
1 2 3 4 5

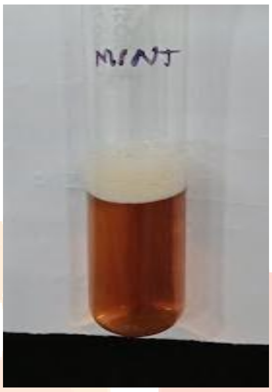
6 7 8 9

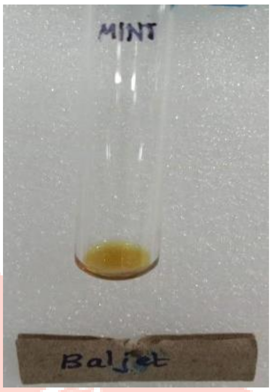
DISCUSSION

The pulse seeds suffer a great injury during packing due to insect occurrence, (Sherma,1989). Moreover, pulses stored exactly for feeding purpose should not be preserved with toxic chemicals since the remains of the chemicals may carriage serious risk on human health. On the other hand, certain plant measures and old methods are much safer than chemical insecticides, Weaver and Subramanyam, (2000). Effective use of plant extracts, ash, vegetable oils and plant leaf powders in insect pest regulator has been reported by many workers Bakkali *et al.,* 2008 and Isman and Machial, (2006). Pigeon pea (*Cajanus cajan* (L.) Millsp.), also









known as red gram, is an important food legume crop in semi-arid tropical and subtropical farming systems (Shanower *et al.,* 1997). The efficacy of *Piper nigrum* and *Curcuma longa* powders for the management of the *C. maculatus* (Chrysomellidae: Coleoptera) on the Pigeon pea was explained by Rosaline Mary *et al.,* (2024).

CONCLUSION

The present study demonstrates that turmeric powder and mint powder are effective botanical materials for the management of *Callosobruchus maculatus* in stored pulses. Both plant powders significantly reduced adult survival, oviposition, egg hatchability, and seed damage compared with the untreated control. Their insecticidal activity is attributed to the presence of bioactive phytochemicals such as alkaloids, flavonoids, tannins, phenolics, saponins, terpenoids, and essential oils, which exhibit repellent, antifeedant and toxic effects against the pulse beetle.

The phytochemical analysis confirmed that turmeric and mint contain several secondary metabolites responsible for their pesticidal properties. Turmeric, rich in curcuminoids and phenolic compounds, showed strong protective effects against infestation, while mint, containing menthol and other volatile compounds, provided effective repellency and reduced insect reproduction. The combined evidence from phytochemical screening and bioassays suggests that these botanicals can serve as eco-friendly alternatives to synthetic insecticides.

Overall, the use of turmeric and mint powders offers a safe, economical, biodegradable and environmentally sustainable approach for protecting stored grains from *C. maculatus*. Further studies under large-scale storage conditions and standardization of application rates are recommended to optimize their practical use in integrated pest management programs.

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