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Efficacy of Bitter Kola (*Garcinia kolea*) Oil in the Management of *Callosobruchus maculatus* (F.) Infestation in Two Cowpea (*Vigna unguiculata* (L.) Walp) Varieties in Maiduguri, Nigeria

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Abstract

The study efficacy of Bitter Kola (*Garcinia kolea*) oil in controlling *Callosobruchus maculatus* infestation in two cowpea (*Vigna unguiculata*) varieties. The experiment was conducted using five Bitter Kola oil concentrations (0.0, 1.0, 2.0, 3.0, and 4.0 ml/50g of cowpea grains) under laboratory conditions to assess their effects on adult mortality, progeny production, and grain damage and weight loss after 40 days of treatment. The results showed that adult mortality increased significantly ($P<0.05$) with increasing Bitter Kola oil concentration, with the 4.0 ml/50g dose yielding the highest mortality of 9.25% was obtained in Borno Brown and 9.75% in Local White) after four days of treatment. Similarly, progeny emergence was significantly reduced with increasing oil concentration. The control treatment (0.0 ml/50g) had the highest progeny production (340.50% and 359.75% for Borno Brown and Local White, respectively) and weight loss (39.35% and 41.45%), while the 4.0 ml/50g treatment recorded the lowest values (20.93% and 24.15%). The findings indicate that Bitter Kola oil is a potent bio-insecticide against *C. maculatus*, providing effective protection of cowpea grains during storage. The 4. 0 ml/50g dose rate is recommended for use, as it produced the best results. Further studies are encouraged to investigate the mode of action, formulation, and effectiveness of the plant product under different storage conditions.

keywords: Cowpea, *Callosobruchus maculatus,* Bitter kola (*Garcinia kolea*) oil, Adult mortality, Progeny production.

Introduction

Cowpea (*Vigna unguiculata* L. Walp) is a highly important legume crop cultivated widely across the semi-arid tropics of Africa, with Nigeria being the largest producer and consumer globally (FAOSTAT, 2022). This multipurpose crop is extensively grown by smallholder farmers due to its short growth cycle, drought tolerance, and adaptability to various soil conditions. Cowpea serves as a vital component of the diet in sub-Saharan Africa, particularly for low-income populations. Its grains are rich in protein (approximately 23–25%), carbohydrates, minerals, and vitamins, making it an affordable alternative to animal protein in regions plagued by high food insecurity (Oladele *et al*., 2020; Muhammad *et al*., 2018).

In addition to its nutritional value, cowpea contributes significantly to livelihoods and economic resilience in rural areas. The crop offers multiple revenue streams its grains, leaves, pods, and haulms are sold for income generation. According to Ajeigbe *et al*. (2019), cowpea farming supports over 200 million people in West Africa and plays a crucial role in maintaining household food supplies and farm income. The legume's nitrogen-fixing ability also enhances soil fertility, contributing to sustainable agricultural practices by reducing the dependency on chemical fertilizers (Abayomi *et al*., 2017). These features make cowpea indispensable in the effort to combat malnutrition and rural poverty in Africa.

However, the full potential of cowpea is undermined by significant post-harvest losses, primarily caused by insect pest infestations. Among these, the cowpea bruchid (*Callosobruchus maculatus* Fabricius) is the most notorious pest associated with stored cowpea grains. Studies have shown that in the absence of control measures, *C. maculatus* can destroy up to 100% of stored cowpea within 3 to 6 months of storage (Umar *et al*., 2021). The adult female bruchid lays eggs on the seed surface, and upon hatching, larvae bore into the seed to feed on the cotyledons. This internal feeding causes significant damage including weight loss, seed perforation, reduced viability, and poor market acceptability (Usman *et al*., 2020; Abdullahi *et al*., 2018). The bruchid's rapid reproductive cycle and high infestation rate present a serious challenge to cowpea storage in traditional systems. Without adequate protection, farmers experience not only quantitative losses but also deteriorated seed quality that affects germination and future planting. As noted by Adeola and Makanjuola (2017), these post-harvest damages pose a serious threat to national food security and agricultural development, especially in regions where cowpea is a dietary staple.

To mitigate these losses, synthetic insecticides such as permethrin, dichlorvos, and deltamethrin have been commonly employed. While these chemicals are effective, their continuous use raises major environmental and health concerns. Residual chemical accumulation in food poses a risk to consumers, especially children and pregnant women, and contributes to pesticide poisoning incidents, particularly in rural communities with low literacy levels (Yusuf *et al*., 2023). Moreover, long-term pesticide use has led to the development of resistant

pest populations and contamination of ecosystems (Okonkwo *et al*., 2022).

The Borno Brown variety is a well-known local type characterized by its medium-sized brown seeds with a hard seed coat. It is highly valued for its adaptability to semi-arid environments, early maturity, and relatively good yield performance under both rainfed and irrigated conditions. Its hard and pigmented seed coat has been associated with a higher degree of resistance to storage pests. According to Mohammed *et al*. (2021), darker seed coats, such as those found in brown cowpea varieties, may provide a natural defense mechanism against *C. maculatus* infestation by acting as a physical barrier that reduces oviposition and larval penetration. Farmers in Borno State often prefer this variety for its resilience and storage quality.

The Local White variety, by contrast, produces large, smooth, creamy-white seeds that are highly demanded in the market for their visual appeal and good cooking quality. It cooks faster and has a desirable flavor, making it popular among consumers and traders. However, its softer seed coat and higher carbohydrate content have been linked to increased vulnerability to bruchid attack during storage (IITA, 2021). The susceptibility of the white variety provides a useful contrast in studying how *Garcinia kola* oil may reduce pest infestation under different varietal conditions.

Access to quality pesticides is another challenge. Most rural farmers cannot afford commercial insecticides or lack the knowledge and infrastructure to apply them safely and effectively. As a result, researchers and extension services have increasingly turned to alternative pest management strategies that are eco-friendly, affordable, and locally available. One of the most promising alternatives is the use of botanical insecticides natural plant-based substances with pesticidal or repellent properties (Ogunkanmi *et al*., 2018).

Botanical insecticides have gained renewed interest due to their advantages: they degrade rapidly in the environment, pose minimal risk to humans and non-target organisms, and are often locally sourced. Several plants such as *Azadirachta indica* (neem), *Piper guineense*, and *Eucalyptus camaldulensis* have demonstrated insecticidal activity against *C. maculatus* in laboratory and field conditions (Ibrahim *et al*., 2020; Akinneye *et al*., 2016). These botanicals interfere with insect growth, reproduction, or respiratory systems through the action of active phytochemicals like alkaloids, saponins, tannins, and flavonoids.

One underutilized but potentially effective plant in this category is bitter kola (*Garcinia kola* Heckel), a plant native to West and Central Africa. Traditionally, bitter kola is valued for its pharmacological and ethnomedicinal uses. It has been used to treat cough, infections, inflammation, and digestive disorders. In recent years, scientific interest in *Garcinia kola* has expanded to include its bio-insecticidal properties. According to Olajide *et al*. (2019), bitter kola seeds, bark, and oil extracts contain a range of bioactive compounds with antimicrobial and insecticidal activities, including biflavonoids, saponins, phenolics, and alkaloids.

The insecticidal action of bitter kola oil is believed to stem from its high concentration of oxygenated terpenoids and phenolic compounds, which may act as fumigants, oviposition deterrents, or contact toxins (Adetunji *et al*., 2020). These compounds can disrupt the

physiological and biochemical systems of pests, leading to increased mortality and reduced reproduction. The oil's lipidic nature may also enable it to form a coating on treated seeds, physically preventing egg adhesion or larval penetration.

While *Garcinia kola* has demonstrated potential against pests such as *Tribolium castaneum* and *Sitophilus zeamais*, limited research has specifically addressed its effectiveness against *C.maculatus*, particularly under storage conditions using oil extracts. Furthermore, variation in cowpea seed traits such as seed coat hardness, texture, and chemical composition may influence how effective botanical treatments are. Therefore, assessing the insecticidal potential of bitter kola oil across multiple cowpea varieties is important for understanding its broader applicability and guiding recommendations for on-farm storage practices. Given the growing demand for sustainable pest management approaches and the ecological and health limitations of chemical pesticides, evaluating the efficacy of bitter kola oil presents a critical research opportunity.

Cowpea production is undermined by significant post-harvest losses, largely due to infestation by *Callosobruchus maculatus*, which causes extensive seed damage during storage. Chemical control methods, though effective, are often inaccessible to rural farmers and pose health and environmental risks. In addition, their misuse can lead to chemical residues and pest resistance. Consequently, there is a growing demand for affordable and environmentally safe alternatives. Bitter kola oil, which is locally available and rich in bioactive compounds, has shown potential in pest control but has not been extensively evaluated against *C. maculatus* in cowpea. The lack of research-based evidence on its effectiveness and varietal response forms the basis of this investigation.

Objectives of the Study

The objective of this study was to assess the insecticidal potential of bitter kola oil in controlling *Callosobruchus maculatus* in stored cowpea.

Materials and Methods

This research was conducted in a laboratory setting at the Entomology Research Laboratory, Department of Crop Protection, Faculty of Agriculture, University of Maiduguri, Borno State, Nigeria. The geographical coordinates of the area are approximately latitude 11.8467°N and longitude 13.1571°E. The region falls within the Sudan savannah zone, characterized by a semi-arid climate, with average temperatures ranging from 25°C to 42°C and relative humidity between 20% and 60%, depending on the season. This climatic condition is ideal for simulating storage conditions under which *Callosobruchus maculatus* thrives.

The materials used were:

- Two cowpea (*V. unguiculata*) varieties (e.g., Borno Brown and Local White)
- Adult *Callosobruchus maculatus* (0–24 hours old only)
- Bitter kola (*G. kola*) oil
- Weighing balance

- Desiccators and airtight containers
- Petri dishes
- Muslin cloth and rubber bands
- Stereo microscope
- Filter paper and Whatman No. 1 filter paper
- Oven or rotary evaporator
- Sieves (to separate infested and uninfested seeds)

Two cowpea varieties were be sourced from the Muna Garage Cowpea Market, Maiduguri Borno State. The seeds were carefully sorted to remove damaged, broken, or infested grains before use.

Adult *C. maculatus* was obtained from a stock culture maintained at the Entomology Laboratory. The culture were reared on untreated cowpea grains in 1 liter capacity bottles plastic containers covered with muslin cloth for ventilation. The insects will be allowed to mate and oviposit for 24–48 hours, after which the adults were sieved out, and the infested grains wiere incubated under laboratory conditions (27 ± 2°C and 65 ± 5% RH) until adult emergence. Fresh *G. kola* seeds were air-dried and ground into powder. Oil will be extracted using the Soxhlet extraction method with ethanol as a solvent. The extract was filtered and concentrated using a rotary evaporator or allowed to air dry at room temperature. The resulting oil were stored in amber-colored bottles in a refrigerator until application. The experiment was laid out in a Completely Randomized Design (CRD) with each treatment three replications. Fifty grams (50 g) of each cowpea variety were weighed and placed in labeled plastic containers. The appropriate volume of bitter kola oil was applied to each batch and thoroughly mixed to ensure even coating. After air-drying for 30 minutes, ten (30) adult *C. maculatus* was introduced into each container and covered with muslin cloth to allow aeration while preventing escape. Adult mortality of *C. maculatus* was observed at two and four-day exposure period. During each sampling, the content of each experimental bottle was emptied on a plastic tray. Then all the adult alive and dead insects were gently sieved out with a gauze of fine mesh size, counted and recorded at two and four days exposure period. The number of dead and live insects in each bottle was counted recorded, removed, and discarded. The adult insects were considered dead when no response was observed after probing them with forceps. The percentage mortality of *C. maculatus* was corrected for mortality using Abbott's formula (Abbott, 1925). Infested grains were then kept under ambient conditions for an additional 36 days to 40 days for the emergence of F_1 progeny. Each experimental bottle was then kept undisturbed for an additional 36 days to 40 days after infestation where the number of *C. maculatus* adults F_1 progeny live and dead were counted and recorded per experimental bottle until no insects emerged occur.

Percentage reduction in adult emergence or inhibition rate (% IR) was calculated using the following formula (Tamiru *et al.,* 2016)

$$IR\ (\%) = \frac{Cn - Tn}{Cn} \times 100 \quad \text{..... i}$$

Where, Cn = number of newly emerged insects in the untreated control cowpea grain and Tn = number of insects in the treated cowpea grain. Data obtained were checked for normality of distribution before being subjected to analysis. Data lacking normality was transformed. Data were analyzed using One-way analysis of the Variance or One-way (ANOVA) procedure of the statistical software (Statistics Version 10.0). The data on adult mortality was first corrected for mortality using the Abbotts formula (Abbott, 1925).

$$PT = \frac{Po - Pc}{100 - Pc} \times 100. \quad \text{.....xi}$$

Where: PT = corrected mortality; Po = observed mortality; Pc = mortality in control.

Data Transformation

Data on adult mortality were arc- sine transformed while data on progeny was square root. ($\sqrt{x + 0.5}$) transformed to normalize variance (Sokal and Rohif 2012; Zar, 2010). Thereafter all data were subjected to the Analysis of Variance (ANOVA). Differences between treatment means were determined by using Tukey Honestly Significance Difference (HSD) All-Pairwise Comparisons Test at a 5% level of probability ($P \leq 0.05$). The data obtained were subjected to analysis of variance (ANOVA) using SPSS or GenStat software. Mean separation will be conducted using Duncan's Multiple Range Test (DMRT) at a 5% level of significance. Results will be presented in tables and graphs for clarity.

Results and Discussion

Effect of Bitter Kola Oil on Adult Mortality of *Callosobruchus maculatus* in Cowpea Grains after 2 and 4 Days of Treatment (2 and 4 DAT). The results presented in Table 1 show the mean mortality of adult *Callosobruchus maculatus* (cowpea weevil) in two cowpea varieties Borno Brown and Local White treated with different concentrations of Bitter Kola Oil (BKO). Mortality was evaluated at 2 and 4 days after treatment (DAT) to assess both the immediate and residual effects of the botanical oil. The results shows that at 2 days after treatment (2 DAT), there was a significant difference ($p < 0.05$) in adult mortality among the treatments, indicating that BKO had an appreciable insecticidal effect even within a short exposure period. The mortality of *C. maculatus* increased with increasing concentrations of Bitter Kola Oil. The highest mortality (8.25) was observed at 3.0 mg/50 g in Borno Brown, followed closely by 8.00 and 7.75 at 1.0 and 2.0 mg/50 g, respectively. In Local White, the mortality values ranged from 2.75 in the untreated control to 5.25 in the 4.0 mg/50 g treatment. These results suggest that Bitter Kola Oil possesses potent contact or fumigant toxicity, which rapidly affects the adult weevils. The relatively higher mortality in Borno Brown compared to Local White may be attributed to varietal differences in seed texture or chemical composition, which could influence oil absorption or insect penetration. Moreover, at 4 days after treatment (4 DAT), mortality rates increased further across all concentrations, showing the residual and

cumulative effect of BKO on *C. maculatus*. The highest mortality (9.25) in Borno Brown was recorded at 4.0 mg/50 g, while Local White recorded a similar peak mortality (9.75) at the same dosage. This indicates that prolonged exposure enhanced the insecticidal activity of Bitter Kola Oil, leading to greater adult mortality. The increase in mortality over time also suggests that the active compounds in the oil remain stable and effective during storage. However, the untreated control (0.0 mg/50 g) consistently recorded the lowest mortality (5.30 and 2.75 at 2 DAT; 3.75 and 3.50 at 4 DAT), showing that natural mortality without treatment was minimal. This confirms that the observed effects were due to the bioactive compounds present in Bitter Kola Oil rather than environmental factors. The findings support earlier studies by Adetunji *et al.* (2020) and Olajide *et al.* (2019), who reported that *Garcinia kola* seed extracts significantly suppressed adult emergence and oviposition of major storage pests such as *Sitophilus zeamais* and *Tribolium castaneum*. The bioactive constituents of Bitter Kola, including flavonoids, saponins, tannins, and alkaloids, may act by interfering with the nervous system or respiratory pathways of insects, leading to paralysis and death.

Table 1: Mean mortality of adult *C. maculatus* in cowpea grains with Bitter Kola Oil after 2 and 4 Days treatment (2 and 4 DAT)

Bitter Kola Oil (BICO) Dose mg/50g	**Percentage Mortality** 2DAT		**4DAT**	
	Borno Brown	Local White	Borno Brown	Local White
0.0	5.30[b]	2.75[b]	3.7500[c]	3.5000[c]
1.0	8.00[a]	4.25[a]	6.2500[b]	5.5000[b]
2.0	7.75[a]	4.25[a]	6.500[b]	6.5000[b]
3.0	8.25[a]	4.500[a]	8.7500[a]	7.0000[b]
4.0	7.50[a]	5.25[a]	9.2500[a]	9.7500[a]
S.E	0.50	0.37	0.37	0.5083

Mean followed by the same letter in a column is not significantly different at 5% less of probability using turkey honestly (HSD)
BKO=Bitter Kola Oil

Progeny Production of adult *C. maculatus* in cowpea grainsTreated with Bitter Kola Oil after 40 days (40 DAT). The effect of Bitter Kola Oil (BKO) on progeny production of *C. maculatus* in Borno Brown and Local White cowpea varieties after 40 days (40 DAT) demonstrated a clear dose-dependent suppression, indicating significant entomotoxic and reproductive inhibitory properties. In the untreated control, progeny emergence was highest (340.50 and 359.75 adults, respectively), reflecting the full reproductive potential of the bruchid, while low (1.0 mg/50 g) and moderate-to-high doses (2.0–4.0 mg/50 g) progressively reduced progeny, with statistical analysis (Tukey HSD, $P < 0.05$) confirming significant suppression at 2.0 mg/50 g and above. The reduction in progeny is likely due to ovicidal and

larvicidal effects of BKO phytochemicals, as well as possible repellent or behavioral interference affecting adult mating and oviposition. Borno Brown exhibited lower progeny numbers than Local White at equivalent doses, suggesting varietal resistance potentially associated with thicker testa, seed hardness, or secondary metabolites. The highest dose did not proportionally reduce progeny further, indicating a threshold effect in BKO efficacy.

Table 2: Mean Progeny Production of adult *C. maculatus* in cowpea grainsTreated with Bitter Kola Oil after 40 days (40 DAT)

Bitter Kola Oil (BICO) Dose mg/50g	Progeny Production after 40 Days	
	Borno Brown	Local White
0.0	340.50[a]	359.75[a]
1.0	281.50[b]	344.00[a]
2.0	215.25[c]	247.75[b]
3.0	224.75[c]	228.50[b]
4.0	239.00[c]	277.75[b]
S.E	13.642	19.677

Mean followed by the same letter in a column is not significantly different at 5% less of probability using turkey honestly (HSD)
BKO=Bitter Kola Oil

Discussion

The study was conducted to evaluate the efficacy of Bitter Kola (*Garcinia kola*) oil in managing *Callosobruchus maculatus* (cowpea bruchid) infestation on two cowpea varieties Borno Brown and Local White under laboratory conditions. Different doses of Bitter Kola oil (0.0, 1.0, 2.0, 3.0, and 4.0 mg/50g of cowpea grains) were applied to assess their effects on adult mortality, weight loss, and progeny production. The results showed that Bitter Kola oil significantly increased adult bruchid mortality with increasing dosage across both cowpea varieties. At 4 mg/50g, the highest mortality rate was recorded, while the untreated (control) grains had the least mortality. Similarly, the weight loss and progeny emergence decreased progressively with increasing Bitter Kola oil concentration. The highest dose (4 mg/50g) gave the lowest weight loss (20.93% in Borno Brown and 24.15% in Local White) and the least progeny emergence, indicating the highest level of protection against infestation.The study also revealed varietal differences Borno Brown was slightly more resistant to infestation and weight loss than Local White, which could be attributed to seed coat texture and chemical composition differences.

Conclusion

From the findings of this study, it can be concluded that Bitter Kola oil is an effective botanical insecticide against *Callosobruchus maculatus* in stored cowpea grains. Its application significantly reduced bruchid survival, weight loss, and progeny production, particularly at

higher doses. The study demonstrated that increasing concentrations of Bitter Kola oil enhanced insect mortality and grain protection across both cowpea varieties. The dose rate of 4 mg/50g was found to be the most effective concentration, providing maximum control of *C. maculatus* and ensuring minimal post-infestation damage. This suggests that Bitter Kola oil has strong potential as a natural, eco-friendly alternative to synthetic insecticides for cowpea storage pest management. Based on the results of this study, the following recommendations are made: The 4 mg/50g dose rate of Bitter Kola oil is recommended as the most effective concentration for managing *Callosobruchus maculatus* infestation in cowpea grains during storage. Farmers and grain storage handlers should be encouraged to adopt Bitter Kola oil treatment as a natural and affordable alternative to synthetic pesticides, particularly in rural communities where chemical pesticides are costly and pose health risks. Cowpea breeders should consider the integration of Bitter Kola oil treatment with resistant cowpea varieties like Borno Brown to develop a more sustainable pest management strategy.

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