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Effect of Rice Husk and Melon Shell Wastes as Possible Grain Protectants in Cowpea Storage

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RTO and TIO designed the study. Author RTO carried-out the research practicals, wrote the protocols and managed the literature searches. Author BAO performed the statistical analysis, managed the analysis and wrote the manuscript. Authors TIO and JEI supervised the research. Authors RTO and BAO read and approved the final manuscript.

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ABSTRACT

Aims: This study sought to determine the effect of rice husk and melon shell powders and ashes in the control of *Callosobruchus maculatus*- a storage pest of cowpea.
Study Design: Completely Randomized Design (CRD).
Place and Duration of Study: Entomology Section, Cocoa Research Institute of Nigeria; year 2015.
Methodology: Clean cowpea samples were inoculated with five pairs (male and female) of newly emerged *Callosobruchus maculatus* (a major constraint in the storage of cowpea in the tropics) and treated with powders and ashes of rice husk and melon shell at different levels. Data obtained were subjected to statistical analysis.
Results: Samples treated with rice husk ash (RHA) recorded 100% pest mortality at 1.0-2.0 g/20 g cowpea just like the standard, and followed by melon shell ash (MSA) and rice husk powder (RHP)

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which gave 93.33 and 70% mortality respectively at 2.0 g/20 g. RHA showed significantly highest percentage oviposition inhibition ($P \leq .05$), followed by MSA and RHP.

Conclusion: While the viability of the cowpea seeds was preserved by powders and ashes of melon shell and rice husk used, RHA showed a distinctive protection against *C. maculatus.* Ashes and powders of agricultural wastes like rice husk and melon shell can therefore be employed as safer alternatives to synthetic insecticides in the control of *C. maculatus* in cowpea storage.

Keywords: Cowpea; rice husk; melon shell; Callosobruchus; oviposition; germination.

1. INTRODUCTION

Vigna unguiculata (cowpea) is a pulse mainly grown and consumed by subsistence farmers in the semi-arid and sub-humid regions of Africa. The crop is important to the incomes of resource poor farmers as well as to the nutritional status and diets of people in Africa, Latin America and the Carribean basin. The seed is high in protein contents which are either consumed directly, make flour sprouts, weaning foods for small children thereby ameliorating mal-nourishment and stunting. It is a good supplement in diets comprised mainly of roots, tubers or cereals [1,2].

A major constraint in the storage of cowpea in the tropics is infestation and damage by bruchids, particularly *Callosobruchus maculatus* F. [3]. During storage, these pests cause deterioration in the quality and quantity of the grains; about 30-50% annual loss was reported for tropical Africa [4]. However, grain yield losses due to insect pests and diseases are estimated to be up to 100% in the tropical region [5]. Losses are characterized by the direct consumption of kernels and accumulation of exuviate, webbing, and cadavers which may result in grain that is unfit for human consumption and loss of the food commodities, both in terms of quality and quantity [6].

Chemical control of stored products insect pests being the most efficient and effective means in the protection of stored produce is associated with many human, technical, environmental, non-target organisms and even insect pest management problems such as resistance, resurgence and replacement of insect pests, food and food product contamination with toxic residues, increased cost of application, handling hazards, environmental contamination, and other negative impacts of incredible magnitude on human health [7,8,9]. Most often, problem of insect damage is over-emphasized to the exclusion of natural products capable of protecting grains and pulses without damage to them, the consumer or the environment. Thus the search for botanical insecticides which are safe and biodegradable alternatives, against expensive (and hazardous) petroleum-based chemicals from the pool of chemical substances in plants needs to be continuous. In majority of the rice producing countries, most of the husks produced from the processing of rice is either burnt or dumped as a waste [10]. Also, applicable in Nigeria, the melon shell produced after removing the melon seed is equally burnt or dumped as a waste. Therefore, it will be promising to investigate the possibility of controlling cowpea beetle in storage using these ‘wastes’. In Nigeria, the efficacies of most botanical preparations have been investigated by some researchers [11,12]. However, the possibility of using agricultural waste for the control of storage pest has not been observed. Therefore this study seeks to investigate the possibility of controlling the cosmopolitan storage insect pest of cowpea using powders and ashes from rice husk and melon shell.

2. MATERIALS AND METHODS

The research work was carried out at the Entomology laboratory of the Cocoa Research Institute of Nigeria (CRIN), Ibadan, Nigeria located at an approximate geographical coordinate 07°10’N, 03° 52’E, 122 m ASL. The ambient laboratory conditions during the period of study were 28 ± 4°C temperature, 68 ± 10% relative humidity and an average daily twelve hour light/darkness exposure.

2.1 Cowpea Variety Used for the Experiment

Five kilogrammes of clean, non-infested cowpea, *Vignia unguiculata* (Ife BPC variety) was obtained from the seeds store of the Institute of Agricultural Research and Training (IAR&T), Ibadan, Nigeria. The seeds were kept in an air-tight container in the deep-freezer for two weeks for further dis-infestation. The seeds were taken out when needed and returned after use.

2.2 Culturing of Insect

The *C. maculatus* used to set up the culture was obtained from already infested cowpea seeds purchased from Bodija market in Ibadan. Fifty unsexed adults of *C. maculatus* were introduced into two hundred and fifty grams of sterilized un-infested cowpea in a plastic container and removed a week after. The cultures were maintained in the laboratory and the daily emerging adult weevils were used for the bio-assay.

2.3 Collection and Preparation of Plant Materials

Rice husks and melon shells used for the experiment were obtained from a market in Ibadan. They were grinded separately into fine powders using Nulux mills (Model RPM SR 400-061, Bombay India). The resulting powders: rice husk powder (RHP) and melon shell powder (MSP) were kept separately in plastic containers with firm cover and stored in the refrigerator until when needed. Some of the RHP and MSP were ashed in the furnace to produce rice husk ash (RHA) and melon shell ash (MSA) respectively, 24 hours before needed.

2.4 Experimental Design

The experiment was laid out in a Completely Randomized Design (CRD) and each treatment was applied at eight levels of 0, 0.2, 0.4, 0.6, 0.8, 1.0, 1.5 and 2.0 g per 20 g of uninfested cowpea in plastic containers with firm covers replicated three times. A standard check was set up with 0.4 g of *Piper guinensis* in three replicates. The plastic contents (treatments and grains) were manually shaken for about five minutes to ensure uniform distribution of the botanical powders and ashes. Then early emerged five pairs (male and female) of *C. maculatus* of the same age were collected from the previously reared culture of insects in the laboratory and introduced at the same time into each plastic container with cowpea.

After introduction of the adult weevils into each experimental container, adult mortality at 24 and 48 hours recordings were taken during the day when weevils were most active. Seeds were examined for adult emergence at 21 days after weevil infestation. The emerged adults were counted and recorded. The weevil counts data were given as percentages to compound averages on the mortalities. Weevil perforation index (WPI) and germination percentage (GP) were also calculated as follows [13]:

$$\%\,mortality = \frac{Number of dead insects}{Total number of insects introduced} x\ 100$$

$$WPI = \frac{\%\text{ treated seeds perforated}}{\%\text{ treated seeds perforated} + \%\text{control seeds perforated}} X\ 100$$

$$\%\text{Germination} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sampled}} X\ 100 \quad [14]$$

2.5 Data Analysis

All data obtained were transformed and analyzed using two-way Analysis of Variance (ANOVA) with the aid of SAS version 9.1 software package. Mean values were separated using Duncan's Multiple Range Test at 5% level of significance. Line graph was used in the presentation of some data.

3. RESULTS AND DISCUSSION

3.1 Results

At 24 hours post treatment, adult mortality of *C. maculatus* differed significantly ($P \le .05$). Cowpea seeds treated with 0.2-2.0 g RHA and MSA recorded higher mortality of *C. maculatus* than in cowpea seeds treated with RHP and MSP. At 0.6 g and above, RHA caused mortality of more than 50% of *C. maculatus.* The result from Table 1 also shows that high mortality of *C. maculatus* (86.67%) was recorded on cowpea seeds treated with 2.0 g of RHA, which was significantly higher ($P \le .05$) than the mortality recorded on standard treatment of *P. guinensis* (73.33%). Generally, insect mortality increased as application rate of powders and ashes increased.

At 48 hours post treatment percentage adult mortality of *C. maculatus* was significantly higher ($P \le .05$) in cowpea seeds treated with RHA and MSA than their respective powders (Table 1). There was a significant kill (100%) of *C. maculatus* at 1.0 g of ash and above in cowpea seeds treated with RHA, and this is similar to the 100% recorded on the standard treatment of *P. guinensis.*

The percentage efficacy of ashes and powders of rice husk and melon shell on mean oviposition of *C. maculatus* at different application rates is illustrated in Fig. 1. Irrespective of the treatment application rate of ashes and powders of rice husk and melon shell, percentage efficacy of the treatment on oviposition of *C. maculatus* was highest in RHA followed by MSA, RHP and MSP. At 0.2 g of ash, RHA treated cowpea recorded close to 100% efficacy against *C. maculatus.* Also, the result showed that the efficacy of the plant powder was dosage dependent. As the application rate increased, efficacy of the ash and powder also increased.

Mean adult emergence from cowpea treated with powders and ashes of rice husk and melon shell was significantly lower ($P \leq .05$) than the untreated control (Table 2). There was no adult emergence in cowpea treated with rice husk ash from application rate of 0.4 g and above which is similar to the standard treatment. Also, adult emergence from cowpea treated with MSA was significantly lower ($P \leq .05$) than those from RHP and MSP. Generally, cowpea seeds treated with RHA recorded insignificant number of adult emergence only at 0.2 g, followed by MSA, RHP and MSP. Similarly, mean percentage seed weight loss in the untreated control cowpea was significantly higher ($P \leq .05$) than treated seeds at all levels (Table 3). Cowpea seeds treated with RHA at all levels recorded zero loss in weight which was significantly similar ($P \leq .05$) to the seeds treated with the standard control (*P. guinensis*). The seeds treated with MSA had a mean percentage seed weight loss which was significantly lower ($P \leq .05$) than the MSP and RHP treatments at all levels.

Cowpea seeds treated with RHA had a significantly low ($p \leq 0.05$) weevil perforation index (WPI), in contrast with other treatments at all application rates (Table 4). RHA treated seeds recorded zero mean WPI (i.e. no seed was holed) from 0.6 g to 2.0 g application levels. This was similar to that obtained in the standard treatment. Significantly higher numbers of seeds were holed in cowpea seed treated with RHP and MSP.

Mean percentage germination of randomly selected cowpea seeds treated with different application rates of powders and ashes of rice husk and melon shell after adult emergence is presented in Table 5. Mean percentage germination differs significantly ($P \leq .05$) among treated cowpea seeds, control and the standard treatment. Mean percentage germination of 100% was recorded at 0.6 g and above for rice husk ash treated cowpea seeds. This was similar to that obtained in the standard treatment. One hundred percent germination was equally recorded at 2.0 g MSA application.

Generally, seeds treated with RHA had significantly higher percentage germination ($P \leq .05$) than seeds treated with powders of rice husk and melon shell.

3.2 Discussion

Findings from this experiment demonstrated that rice husk and melon shell powders and their ashes tested against cowpea weevil, *C maculatus* showed insecticidal activity. This was confirmed in all the treatments with the results showing variations in their effectiveness against the insect pest. This study also reveals the toxicity and reproduction inhibitory effects of the two powders - rice husk and melon shell (RHP and MSP) and their ashes (RHA and MSA) on *C. maculatus.* Also discovered is the great capacity of RHA and MSA in protecting cowpea against weevil in storage under laboratory conditions.

Table 1. Effect of rice husk and melon shell treatments on mean % mortality of *C. maculatus*

Application rates of powder/ASH (g)	RHP		RHA		MSP		MSA	
	24 hrs	48 hrs	24 hrs	48 hrs	24 hrs	48 hrs	24 hrs	48 hrs
0.0	0.00^{n}	0.00^{m}	0.00^{n}	0.00^{m}	0.00^{n}	0.00^{m}	0.00^{n}	0.00^{m}
0.2	0.00^{n}	0.00^{m}	20.00^{jk}	43.33^{hi}	0.00^{n}	0.00^{m}	20.00^{jk}	43.33^{hi}
0.4	6.67^{mn}	16.67^{l}	20.00^{jk}	56.67^{fg}	0.00^{n}	13.33^{l}	26.67^{ij}	50.00^{gh}
0.6	10.00^{ml}	30.00^{k}	50.00^{f}	86.67^{bc}	3.33^{mn}	16.67^{l}	30.00^{hi}	60.00^{ef}
0.8	20.00^{jk}	43.33^{hi}	60.00^{de}	96.67^{a}	6.67^{mn}	30.00^{k}	36.67^{gh}	66.67^{de}
1.0	23.33^{ijk}	60.00^{ef}	66.67^{cd}	100.00^{a}	10.00^{ml}	33.33^{jk}	40.00^{g}	73.33^{d}
1.5	40.00^{g}	66.67^{de}	76.67^{b}	100.00^{a}	16.67^{kl}	33.33^{jk}	56.67^{ef}	83.33^{c}
2.0	40.00^{g}	70.00^{d}	86.67^{a}	100.00^{a}	20.00^{jk}	40.00^{ij}	66.67^{cd}	93.33^{ab}
P. guinensis	73.33^{bc}	96.67^{a}	73.33^{bc}	100.00^{a}	66.67^{cd}	93.33ab	73.33^{bc}	100.00^{a}

Means with the same superscripts are not significantly different at ($P \leq .05$) using DMRT
RHP- Rice husk powder, RHA- Rice husk ash, MSP- Melon shell powder
MSA- Melon shell ash

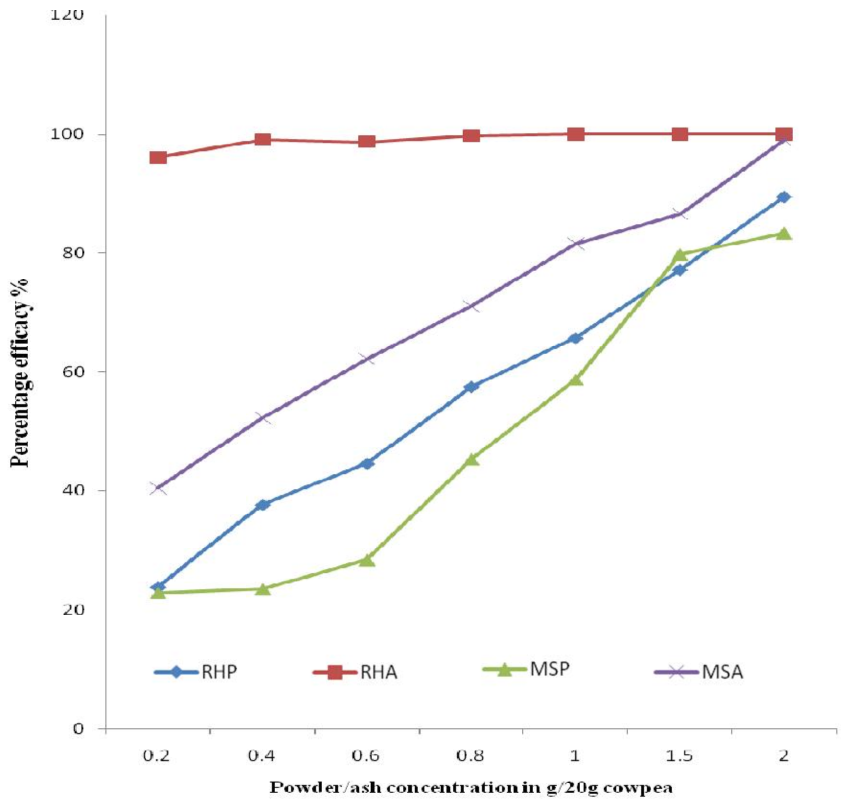

Fig. 1. Efficacy of different application rates of powders and ashes of rice husk and melon shell on oviposition of *C. maculatus*

RHP: Rice husk powder, RHA: Rice husk ash, MSP: Melon shell powder
MSA: Melon shell ash

Table 2. Effect of rice husk and melon shell treatments on total adult emergence of *C. maculatus* 21 days after infestation

Application rates of powder/ASH (g)	RHP	RHA	MSP	MSA
0.0	79.67^{a}	77.00^{a}	76.33^{a}	81.00^{a}
0.2	61.67^{b}	2.33^{kl}	57.33^{bc}	54.67^{cd}
0.4	50.00^{d}	0.00^{l}	53,67^{cd}	42.67^{e}
0.6	42.67^{e}	0.00^{l}	51.67^{cd}	32.00^{gh}
0.8	36.00^{fg}	0.00^{l}	41.33ef	26.67^{h}
1.0	28.33^{h}	0.00^{l}	38.33ef	12.00^{ij}
1.5	15.00^{i}	0.00^{l}	15.33^{i}	7.00^{jk}
2.0	7.33^{jk}	0.00^{l}	10.00^{ij}	0.00^{l}
P. guinensis	0.00^{l}	0.00^{l}	0.33^{l}	0.00^{l}

Means with the same superscripts are not significantly different at (P ≤ .05) using DMRT
RHP- Rice husk powder, RHA- Rice husk ash,MSP- Melon shell powder
MSA- Melon shell ash

The high percentage mortality recorded for RHA and MSA in *C. maculatus* may be due to the occlusion of the spiracles of the weevils, thus preventing respiration through the trachea which consolidated the report of De lima [15] and Golob [16] that the traditional use of inert materials, including dust from clays, wood ash, silicates sand, botanical powders and diamaceous earths (diatomite) reduced insect population.

Cowpea treated with RHA showed a very high oviposition inhibition capacity with the efficacy close to 100% even at 0.2 g of ash. Other treatments (MSA, RHP and MSP) also recorded incomparably low number of eggs than the untreated control. Many authors have reported reduced life span and oviposition in cowpea treated with botanical powders [17,18]. This oviposition inhibitory capacity of RHA can be adduced to the report of Naito [19] that RHA is abrasive and this, according to Wolfson et al. [20], can hinder movement of male weevil from locating female weevil for mating and gaining access to the grain.

Table 3. Comparative mean % seed weight loss in cowpea after adult emergence

Application rates of powder/ash (g)	RHP	RHA	MSP	MSA
0.0	0.93^{bc}	1.37^{a}	1.07^{b}	1.32^{a}
0.2	0.75^{cd}	0.00^{k}	0.68^{de}	0.45^{f}
0.4	0.58^{def}	0.00^{k}	0.53^{ef}	0.23^{g}
0.6	0.22^{gh}	0.00^{k}	0.47^{f}	0.25^{g}
0.8	0.23^{g}	0.00^{k}	0.22^{g}	0.23^{g}
1.0	0.23^{g}	0.00^{k}	0.27^{g}	0.10^{ij}
1.5	0.20^{gh}	0.00^{k}	0.13^{hi}	0.02^{k}
2.0	0.05j	0.00^{k}	0.08^{ij}	0.00^{k}
P. guinensis	0.00^{k}	0.00^{k}	0.00^{k}	0.00^{k}

Means with the same superscripts are not significantly different at (P ≤ .05) using DMRT
RHP- Rice husk powder, RHA- Rice husk ash, MSP- Melon shell powder
MSA- Melon shell ash

Table 4. Mean weevil perforation index in cowpea treated with powders and ashes of rice husk and melon shell

Application rates of powder/ash(g)	RHP	RHA	MSP	MSA
0.2	45.86^{a}	3.93^{ij}	44.27^{ab}	42.60^{ab}
0.4	40.98^{abc}	1.66^{ij}	40.39^{bc}	39.73^{bc}
0.6	39.71^{bc}	0.00^{j}	44.46^{ab}	31.99^{de}
0.8	36.22^{cd}	0.00^{j}	40.00^{bc}	29.72^{e}
1.0	41.55^{ab}	0.00^{j}	34.48^{d}	16.93^{g}
1.5	23.22^{f}	0.00^{j}	19.79^{fg}	6.15^{i}
2.0	11.56^{h}	0.00^{j}	16.99^{g}	0.00^{j}
P. guinensis	0.00^{j}	0.00^{j}	0.80^{j}	0.00^{j}

Means with the same superscripts are not significantly different at (P ≤ .05) using DMRT
RHP- Rice husk powder, RHA- Rice husk ash, MSP- Melon shell powder
MSA- Melon shell ash

Table 5. Mean % germination of cowpea treated with powders and ashes of rice husk and melon shell after F1 adult emergence

Application rates of powder/ash (g)	RHP	RHA	MSP	MSA
0.0	23.33^{l}	33.33^{l}	23.33^{l}	23.33^{l}
0.2	53.33^{fghi}	36.67^{hijkl}	43.33^{hijk}	36.67^{hijkl}
0.4	36.67^{hijkl}	56.67^{efgh}	36.67^{hijkl}	56.67^{efgh}
0.6	26.67^{jk}	100.00^{a}	30.00^{jk}	53.33^{fghi}
0.8	33.33^{ijk}	100.00^{a}	40.00^{hijkl}	76.67^{cd}
1.0	50.00^{ghij}	100.00^{a}	53.33^{fghi}	86.67^{bc}
1.5	30.00^{jk}	100.00^{a}	66.67^{defg}	90.00^{b}
2.0	50.00^{ghij}	100.00^{a}	73.33^{cde}	100.00^{a}
P. guinensis	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{a}

Means with the same superscripts are not significantly different at (P ≤ .05) using DMRT
RHP- Rice husk powder, RHA- Rice husk ash, MSP- Melon shell powder
MSA- Melon shell ash

Consequently, no F_1 adult of *C. maculatus* emerged from cowpea seed treated with rice husk ash (RHA) at 0.4 g dose of ash and above, which is exactly what was obtained in the standard control. F_1 adult emergence of *C. maculatus* was exceptionally high in the untreated control cowpea. The treatments with rice husk and melon shell powders generated some adult weevils. This shows that mating actually took place but their mean adult emergence was low when compared with the controls. The act of weakening of adults by botanical powders may make them lay fewer eggs than expected, leading to limited hatchability to larvae and final metamorphosis to adults [21].

Different botanicals' effectiveness at higher dosage to various storage insect pests has been reported by several authors [21,22]. The reproduction inhibitory ability of RHA and MSA and reduction in adult emergence in RHP and MSP treatments could be due to egg mortality or even reduction in the hatching of the eggs. This study can be related to the findings of Ofuya [23], Wolfson et al. [20], and Chinwada and Giga [24], that mixing cowpea seeds with inert materials like wood ash and sand cause physical impediments to beetle movement, thus inhibiting mating and oviposition.

It has been reported that the larvae which hatch from the eggs of *Callosobruchus* species must penetrate the seeds to survive [25]. The larvae are unable to do so unless the eggs are firmly glued to the seed surface. It was however observed in this study that larvae were found loosely in the treatment where they hatched. This finding is supported by Golob [16], who reported that inert materials induced egg mortality of *C. maculatus* by desiccation.

In this study, the percentage seed weight loss was relatively low in the treatments compared with the control. A distinctive protection ability of RHA was significantly great with no loss in weight of cowpea treated with RHA. Reduced cowpea bruchid oviposition, adult emergence as well as reduced seed weight loss in contrast to controls had also been reported by several workers [26,27].

Weevil perforation index obtained in this study for cowpea treated with RHA was zero at all levels. This can be related to the zero value recorded for the standard treatment of *P. guinensis*. Rice husk ash (RHA) completely inhibited movement growth and development of *C. maculatus*. This however was contrary to cowpea treated with MSA, as perforation was recorded at all levels except at 2.0 g dose of ash. This implies that *C. maculatus* laid and hatched into larvae within the cowpea seeds but the low adult emergence recorded shows that larva mortality took place. Perforation index in cowpea treated with MSA was however lower than those treated with RHP, MSP and control.

The germination test demonstrated that the powders and ashes tested against *C. maculatus* did not show any visible adverse effects on germination capacity of the pulse. Contrary to this finding, Paranagama et al. [28] reported that *C. citratus* oil treatment reduced the germination capacity of rice paddy as compared to the control. Mean percentage germination of cowpea recorded in all treatments was far greater than the untreated control.

RHA showed total protection for cowpea when adult mortality, oviposition adult emergence, seed weight loss, weevil perforation index is considered with insignificant effect on percentage seed germination especially in cowpea seeds. Treatment efficacy following RHA is MSA, RHP then MSP.

4. CONCLUSION

It is evident in this research that powders and ashes of rice husks and melon shells are effective plant materials for the control of cowpea bruchid as they impact significant insecticidal action/contact toxicity on *C. maculatus*. The use of these agricultural wastes as contact insecticides/seed protectants in stored grains would be a safer, economical and environmentally-friendly alternative to poisonous/ harmful synthetic insecticides.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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