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Repellent Properties of Ackee (*Blighia sapida* K.) Pulp and Seed Oil in the Control of Beans Weevils(*Callosobruschus maculatus F*.)

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ABSTRACT

Agriculture is fundamental to human survival, but pests, diseases, and weeds pose significant challenges to crop production. Synthetic pesticides were initially adopted to address these challenges, yet their negative impacts on human health and the environment, along with the emergence of pesticide-resistant strains, have necessitated alternative pest management approaches. Sustainable agricultural practices, emphasizing the use of botanicals, are gaining popularity, particularly in organic farming**.** This study focuses on the control of *Callosobruschus maculatus*, a major pest of beans, using Ackee pulp/seed oil as a botanical pesticide. The insecticidal properties of Ackee (*Bligha sapida* Koenig) pulp and seed oil in the control of C*allosobruschus maculatus* (beans weevils) were investigated in the Biochemistry Department of Ambrose Alli University, Ekpoma. Edo State, Nigeria. The experiment consisted of five treatments including control, laid out in complete randomized design (CRD). Each treatment was replicated thrice. The pulp and seed oil was applied at the rate of 0 as control, then at 10, 25, 50, and 100g/kg. Data collected were subjected to Analysis of Variance (ANOVA). Means were separated using Turkey's Honest Significant difference. The findings in the study revealed that Ackee pulp/seed oil at 25g/kg to 100g/kg most effectively controlled *Callosobruschus maculatus* at a 0.01% level of significance. Increasing concentration of the oil 25g/kg to 100g/kg recorded mortality values after 24 hrs than 0g/kg at ($p<0.01$) 18.00, 15.23, and 8.50 while 0g/kg recorded 3.32 respectively However, an increase in the concentration of the Ackee pulp and seed oil with 100g/kg gave the highest mortality rate, residual action, and egg hatchability. Preliminary findings suggest that Ackee pulp/seed oil has significant insecticidal properties against *C. maculatus*, offering a sustainable solution to protect bean crops, a staple food in Nigeria. The preliminary findings suggest that Ackee seed oil extract has promising insecticidal properties against C. *maculatus*, providing a potentially eco-friendly solution to this pest problem. Ackee pulp and seed oil is safe to apply, affordable, environmentally friendly, and less harmful to human health.

Keywords: Sustainability; Botanicals; Ackee Pulp/Seed Oil; *Callosobruschus* maculatus

Introduction

Agriculture is the hub of man's continued existence on earth, but diseases, weeds, and pests are some of the chief challenges to crop production (FAO, 2021).Synthetic pesticides were created and adopted as a rapid and efficient method of managing agricultural pests and illnesses due to the increased demand for food to feed the world's constantly expanding population. However, these synthetic pesticides like some organo-chlorine pesticides have led to negative impacts on human health and the emergence of pest and pathogen strains that are resistant to these pesticides. (Lengai *et al.*, 2020). These pesticides have been banned in many countries because their exposure has led to brutal health effects on living things (Odion *et al*., 2020). According to the United Nations Environmental Programme, between 2005 and 2020, the cost of diseases caused by pesticides in Sub-Saharan Africa could amount to USD 90 billion (Tudi *et al*., 2022; Ngegba *et al.*, 2023).

Alternative methods of pest management are now required due to the negative effects associated with the incorrect and excessive use of synthetic pesticides. Globally and locally, sustainable agricultural practices are now required to avoid the potential negative environmental impacts of the use of pesticides (Bouri *et al.*, 2022). The use of botanicals as a sustainable pest management strategy is gaining fame in organic farming due to their safety profile on crop utilization, soil, and the environment. Before the development of synthetic pesticides, botanical pesticides were generally used for millennia in both subsistence and commercial crop production. (Ngegba *et al.*, 2023).Crop production is, nevertheless, at peril as a result of damages that arise due to high infestation in stored grains (Wayne and Wendy, 2015). Pest damage to stored grains always resulted in key economic losses for crop production to meet food security. Grain loss caused by insect pests in the store reduces the quantity, quality, nutritive value and viability of crops such as beans which is a serious issue.(Bouri *et al.*, 2022).Legume crops especially beans are widely known to be attacked by grain weevils (C*allosobruschus maculatus)* causing 25-100% post-harvest losses (Moura *et al.*, 2020 and Mansouri *et al.*, 2022). Beans are a staple, leguminous, and most accepted food grain consumed by a high number of the populace in Nigeria, (IFPRI, 2017).Presently, beans constitute an essential part of the food basket of over 16% of the population in West Africa as legumes play key roles in food and nutritional security, health, and income generation.(AFDB/FAO, 2015 and Akah *et al*., 2021).

Callosobruschus maculates is a species of beetle known normally as cowpea weevil or beans seed beetle which majorly attacks bean storage in Nigeria. Their dangerous feeding habit is often hidden until damage has occurred. Farmers in Nigeria record losses due to their feeding activities of this weevil so necessary control measures must be put in place (Kumar and Kalita, 2017). Pest control in the field and stored food products depend heavily on the use of herbicides and lasting contact insecticides. Akhideno *et al*., (2017) and Sakar *et al.*, (2021) stated that the European Union has criticized the use of chemicals in the control of pests both in the farm especially stored products, resulting in residual effects on humans and the environment. Thus, this

problem has created the need to find plant materials that will effectively protect the fields and stored grains, which are readily accessible, inexpensive, less noxious, and environmentally friendly.

Bligha Sapida K.D. (Koenig) belongs to the family *Sapindaceae* and is commonly known as Ackee. It is a timber, medicinal plant, fuel plant, and vegetable oil and it is marketed as Ukpe, Ukpe-aghaba in Edo, Kwanja Kusa in Hausa, Okpu in Igbo, Isiri-jeje, Isin in Yoruba (Aigbokhan, 2014). Ackee which is in abundance in rainforest vegetation belts has been inferred from literature to possess bio-pesticide potential. The timber is defiant to termites and the pounded fruit and the stem bark are used as fish poison (Famuyiwa*et al*., 2018). The methanol extract of the stem bark was reported to be active against the instar larvae. Powdered Ackee leaves proved to be a botanical insecticide in removing *Dinoderin porcellus* insects in dried yam chips (Loko*et al*., 2017). Studies by Khan and Gumbs (2003) showed that pulp of Ackee extracted with either organic solvents such as acetone or ethanol against stored insect pests yielded better repellent activity than when extracted with water. Thus, this experiment was aimed are establishing the efficiency of Ackee pulp and seed oil in the control of insect pests especially (*C. maculatus*) weevils in storage without extracting with any organic solvent or water.

Materials and Methods

Experimental Sites

The experiment was carried out in the Biochemistry Laboratory Department of Ambrose Alli University, Ekpoma of Edo State, Nigeria. It is geo-positioned between latitudes 6°44'34" and 6°03'16" N and longitudes 6°08'25" and 5°58'25".E. This area has weather factors such as mean air temperature of 29°C, relative humidity of 70 %, sunshine of about 5-7 hours/day, and mean rainfall of 1200-1500 mm. It shares general boundaries with Owan West and Etsako West local government areas (Siloko and Siloko, 2023). Th'e traditional livelihood of the people is farming but small-scale industries are fast springing up around Ekpoma due to the university in the town.

Plant Collection

The fruits of Ackee were collected from a mature tree in Ogbona central market which lies between Latitude 7°10'.23" and 7°06'33"N and Longitude 6°46'03" and 6°28'.58"E in Fugar, Etsako Central, Local Government Area in Edo State, Nigeria. The plant part was authenticated and identified by the Herbarium of Forestry Research Institute of Nigeria, Ibadan, Oyo State with a voucher number No. FHI 113859.

Nurturing of Beans Weevils

Adult *C.maculatus* was obtained from naturally infected bean grains from Ekpoma Market in Esan West Local Government Area of Edo State. They were raised in 2-kilner jars containing 200 g of bean grains capped with muslin fabric and kept at an ambient temperature of 20°C and relative humidity of 50 %. The muslin fabric allows for aeration but barred entry or exit of the weevil.

Oil Extraction

The fruit pulp/seed was oven-dried to 60°C constant weight and the dry plant matter was pulverized to a fine powder using a Victoria Milling machine. Little water was added to form a feasible paste which forms an almost

solid ball that was knead for several minutes over a bowl until oil collected on the surface of the ball. Then ball was manually pressed firmly using a Mexican elbow squeeze to extract the oil (Paquot.,1979).

Beans Treatment and Experimental Design

The bean grains were obtained from the ADP office at Irrua Esan Central Local Government Area of Edo State. They were fumigated for 48 hours to ensure that any developing larva/pupa within the grains was killed as suggested by (Ivbijaro, 1984). The oil was mixed with the beans at different rates (0, 10, 25, 50, and 100g/kg) for 24 hrs, 48 hrs, 72 hrs, 96 hrs and 120 hrs exposure. 20 bean weevils (10 males and 10 females) were introduced into the treated bean grains and mortality counts were taken. For each experiment, three replicates were set up using a completely randomized design (CRD).

Mortality

For mortality studies, the bean grains were treated with the pulp seed oil of Ackee at different rates (0, 10, 25, 50, and 100g/kg) before the introduction of bean weevils. The jar was covered with a Muslin cloth and held with a rubber band. Mortality of *C. maculatus* was determined from daily counts of dead adults for 15 days after which all surviving adults were removed. The effect of Ackee pulp/seed oil on the reproductive capacity of adult bean weevils were also investigated 25 days after infestation by treating Jars set aside with gentian violet as suggested by (Ivbijaro, 1984) to reveal egg plugs of the weevils. Progeny emergence was recorded from 25 days after infestation till 60 days after infestation. The contaminated beans with the test weevils were put in Ackee-treated Jars for 10, 25, 50, and 100 days after treatment. The daily mortality counts of the 20 bean weevils (10 males and 10 females) used in the test were used to calculate weevil mortality rates in the formula below:

$$Adult\ Mortality = Number\ of\ dead\ \frac{insects}{Total}\ number\ of\ in$$

The percentage of eggs hatched from the 10 males and females

$$\frac{NN}{NE}\ X\ 100/1$$

Where NN= Number of Nymphs
NE= Total number of Eggs

Data was subjected to Analysis of Variance (ANOVA), and means were separated using Tukey's Honest Significant difference at a 1% significance level.

Results and Discussions

Table 1: Effects of Ackee pulp/Seed Oil on Adult *C.maculatus mortality*Ackee g/kg^{-+}

TREATMENTS	24HRS	48HRS	72HRS	96HRS	120HRS
0 (CONTROL)	0.08^{a}	0.20^{e}	1.35^{e}	2.60^{e}	3.32^{e}
10	0.00^{d}	1.00^{d}	2.20^{d}	3.00^{d}	4.06^{d}
25	1.24^{c}	2.60^{c}	5.00^{e}	6.78^{c}	8.50^{c}
50	3.00^{b}	4.54^{b}	10.01^{b}	13.50^{b}	15.23^{b}
100	4.56^{a}	5.04^{a}	11.56^{a}	14.68^{a}	18.00^{a}
MEANS	1.76	2.68	6.02	8.11	9.82
LSD	0.20	0.80	1.86	0.49	1.28

CV(%)	18.2	15.2	17.00	3.40	8.00

LSD= Least significant difference; CV= Coefficient of Variation,letters ABCDE*means values with different superscripts are statistically different* at 1% level.

The effect of Ackee pulp/seed oil on the mortality of *C.maculatus* in Table 1 showed that 24 hours after infestation, the jar treated with 100g/kg recorded the uppermost mortality value. I8, 72, 96, and 120 hours after infestation. A similar trend was recorded at ($p<0.01$) significant. Increasingly concentration of the seed oil 25g/kg to 100g/kg recorded mortality values than 0g/kg at ($p<0.01$) 18.00, 15.23, and 8.50 while 0g/kg recorded 3.32 respectively. Ackee seed soil exhibited insecticidal properties that had a great effect on *C.maculatus*. This conforms to Khan *and Gimbs*, (2002) that powder seeds/oil of Ackee were toxic to three store product pests – cowpea beetle C.*maculatus* f_1 (Coleoptera: Bruchidea). Rusty grain beetle *Cryptolestesferrugineus* (Stephens) (Coleoptera: Cucujidae) and maize weevil (*Sitophiluszeamais*motschulsky).

Table 2: Residual Effect of Ackee Seed Oil on Adult *C.maculatus*

Treatments	10days	20days	40days	60days	50days	100days
0	0.00^{e}	0.00^{e}	0.00^{d}	0.00^{d}	0.00^{c}	0.00^{c}
10	4.50^{d}	3.60^{d}	2.14^{c}	1.56^{c}	0.00^{c}	0.00^{c}
25	6.32^{c}	5.36^{c}	3.01^{b}	1.10^{c}	0.30^{b}	0.00^{c}
50	7.00^{b}	6.46^{b}	3.01^{b}	2.82^{b}	1.38^{b}	0.35^{b}
100	15.71^{a}	10.48^{a}	9.52^{a}	6.81^{a}	3.13^{a}	1.56^{a}
Means	6.71	5.18	3.54	2.46	0.96	0.38
LSD	1.06	0.87	0.36	0.57	1.13	0.63
CV(%)	8.10	9.01	6.00	2.43	6.36	8.53

LSD= Least significant difference; CV= Coefficient of Variation; Abcde*means values with different superscripts are statistically different* at 1% level**.**

The insecticidal trait from the plant shows a significant difference at ($p<0.01$) among the treatments tested with 100g/kg. Ackee seed oil recorded the highest value of mortality. The control (0g/kg) recorded the lowest value 3.32. The result of the study further showed that mortality on the bean weevil was up to 60% at 60 days after treatment in 50g/kg treated pulp/seed oil. Thus the insecticidal effects of Ackee pulp/seed oil are supported by previous reports that extracts from fruit have been shown to possess repellent properties against insect pests (Khan and Gumbs, 2003). The life cycle of the beans weevil was significantly ($P < 0.01$) affected by Ackee seed oil. It shows that Ackee pulp/seed oil was very effective in the control of the egg plug of the weevils. The results showed that Ackee pulp/seed oil impaired not only the ovipositor but also affected the length of the cycle. This is in confirmation with the report of Khan and Gimbs, (2003) and Moura et *al.*, (2020) where Ackee fruit was extracted using ethanol and acetone, and the repellent activity of *C.maculatus* amplified by raising the concentration of the Ackee pulp/seed oil at 100g/kg resulting in the highest mortality rate, residual act and egg hatchability.

Table 3: Effects of Ackee pulp/seed oil on the reproductive capacity of *C. maculatus*.

ACKEE PULP/SEED OIL	NO EGG PLUS	NO EMERGENT ADULTS	LENGTH OF CYCLE
0	28	25	30.0[a]
10	17	10	30.8[a]
25	10	6	35.2[a]
50	2	1	40.6[a]
100	0	0	0.00[b]
MEANS			27.32
LSD			4.50
CV (%)			3.30

LSD= Least significant difference; CV=Coefficient of Variation;Letters ABCDE*means values with different superscripts are statistically different* at 1% level.

The hypoglycin A which is a stable toxin found in the Ackee fruit is sufficient to stifle the bean weevils over some time, thus indicating the very strong insecticidal properties of the Ackee pulp/seed oil (Surmatis and Hamilton, 2023). This finding was similar to Mohamed and Abbas (2017) which examined the fumigant toxicity of essential oils of *Eucalyptus camaldulensis* and *Artemisia herbalba* against third instar larvae and adults of *Trogoderma granarium*. They concluded that adult mortality rates were higher than those of larvae after different durations of exposure. This result conformed to the study of the efficacy of *Anogeissus seiocarpus* and *Amona senegalensis* extracts in the control of stored Cowpea Weevil (Adamu *et al*, 2021). There were significant differences between the study periods on the bean weevil. (*C. maculatus*) Essential oils are well known to have insecticidal bioactivities due to their chemical constituents. (Zoghroban *et al.*, 2023).

Conclusion

Ackee pulp and seed oil demonstrated strong insecticidal properties against C. maculatus. The study underscores the pressing need for sustainable pest management in agriculture, as synthetic pesticides have brought about various environmental and health concerns. It also highlights the specific challenge of *Callosobruschus maculatus* infestation in beans, a critical staple in Nigeria, and the potential of Ackee pulp/seed oil as a botanical pesticide to address this issue, emphasizing its environmental friendliness. The study suggests the potential use of Ackee pulp/seed oil as an eco-friendly and sustainable solution for protecting beans. Ackee tree is safe to apply, affordable, environmentally friendly, and less harmful to human health.

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