



Plantain and banana peels as sources of insecticidal materials against *callosobruchus maculatus* (fabricius) and *sitophilus zeamais* (motschulsky).

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Abstract

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The effect of plantain and banana peels extracts and powders as sources of insecticidal materials against *Callosobruchus maculatus* and *Sitophilus zeamais* was investigated under ambient laboratory conditions. Ife Brown variety of cowpea and yellow maize (DMR) were used. The effect of different rates of application of extracts (0, 1.0, 0.5, 10.0ml/ 20g of seed) and powders (0, 0.4, 0.8, 2.0g/ 20g of seed) of the two plants was tested for insecticidal action against *C. maculatus* and *S. zeamais*. Hexane extracts and powders made from ripe and unripe banana and plantain peels were found to have insecticidal effect on *C. maculatus* in stored cowpea and *S. zeamais* in stored maize. At the highest concentration of application (10ml/kg) each hexane peel extract always caused significant mortality of both *C. maculatus* and *S. zeamais* adults in comparison with the control. Significantly reduced oviposition by *C. maculatus* and *F₁* adult emergence in *C. maculatus* and *S. zeamais* was also observed in treatments involving the highest concentration of each hexane peel extract. The insecticidal effect of hexane extract from unripe peels was generally greater than extracts from ripe peels. Except for powder obtained from ripe plantain peel, all the other peel powders exercised significant kill of *C. maculatus* adult in comparison with the control at 0.8g or more per 20g of grain and as from 12hours post treatment. All peel powders at all rates of application generally produced significant kill of *S. zeamais* adults as from 24hours post treatment. All peel powders at all rates of application significantly reduced oviposition by *C. maculatus* in comparison with the control treatment. The insecticidal effect of unripe peel powders was generally higher than ripe peel powders. The plantain and banana peel powders and hexane extracts were generally more toxic to adult of *C. maculatus* than *S. zeamais* adults.

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INTRODUCTION

Food legumes (pulses or legumes) occupy a prominent place in the nutrition of the Nigeria people because their edible seeds form a cheap alternative source of protein in their diets. Cowpeas are important source of vegetable protein in Africa, particularly in Nigeria which produced nearly 80% of the total world output of 10.5 million tonnes in 1974. Depredation to stored food commodities by insects is a major factor militating against food availability and security in Nigeria (Lale 2001). Insect pests are a major constraint to cowpea production and utilization in Africa. According to Fashina (1985) the bruchid

beetle, *C. maculatus* has been a major pest of cowpea both in field and in storage. Stored product insects cause damage by eating portion of products and this is usually manifested by reduction in weight and volume and also by contaminating food commodities with frass, exuviae and corpses of dead insect altering their biochemical constitution or by outright reduction in the amount of important nutrients (Lale and Mustapha, 2000). It has been estimated that about 4% of the total annual production of cowpea (beans) in Nigeria or about 30,000 tonnes valued at over 30 million US dollars is lost annually to the cowpea storage beetle, *C. maculatus* (F.), (Singh, 1986).

Sitophilus zeamais is also a destructive agricultural pest of stored grains. It is species among the weevils that belong to the family Curculionidae. They cause very heavy damage on maize grains through feeding with a reported weight loss of up to 10% (Haines, 1991). Damage done to stored maize by maize weevil, *S. zeamais* (Mots.) in the tropics can be enormous (Campton and Sherington, 1999). Unequivocally, adequate protection of stored food commodities from insect infestation and damage is of paramount importance in achieving and maintaining food sufficiency in Nigeria. Bananas are one of the most consumed fruits in tropical and subtropical regions. New economic strategy to increase utilization of banana includes the production of banana flour when the fruit is unripe and to incorporate the flour into various innovative products such as slowly digestible cookies (Aparico-Saguilan *et al.*, 2007), high fibre bread (Juarez-Garcia *et al.*, 2006) and edible films (Rungsine and Natcharee, 2007). Potential applications of banana peel flour however depend on its chemical composition, (Emaga *et al.*, 2007) as well as physiochemical and functional properties. In its original form, it is relatively easy to differentiate between the peel of ripe and green banana and with experience it is also possible to differentiate between skin (skin colour, appearance, size and other dimension). Plantain (*Musa paradisiaca*) is a native of India. Various parts of the plant such as the leaves, root and fruits have been used for medical purposes, for example, the fruit is consumed as food, and again the leaf juice is used in the treatment of fresh wounds, cut and insect's bites. The sap of the plant is used as a remedy for diarrhea, dysentery and epilepsy. In addition, fruit has been reportedly used as diuresis (Gill, 1992). Omole *et al* (2008) reported that the peels have potentials of replacing maize (corn starch) in the diet of snail. Synthetic insecticides which are very effective in the control of *C. maculatus* in cowpea and *S. zeamais* in maize are available, but their wide spread has several drawbacks such as high cost, inconsistent supplies and hazards to man and the environment (Adedire, 2001; Lale, 2002; Ofuya, 2003). Therefore, many scientists have conducted research over the last few decades aimed at identifying botanicals that may replace the synthetic insecticides (see reviews of Lale, 1995; Dales, 1996; Golob *et al*, 1999; Boeke *et al*, 2001). In Nigeria, the insecticidal efficacies of powders from a few plants such as seeds of neem tree, *Azadirachta indica* A Juss' dry flower buds of clove; *Eugenia aromatic* (L) Bail; dry fruits of West Africa brown pepper, *Piper guineense* Schum and Thonn; dry seeds of 'peeper fruit' *Dennetia tripetala* Baker and dry bark of the 'tooth ache' plant *Zanthoxylum zanthoxyloides* (Lam) have been investigated and confirmed by many workers (Ivbijaro and Agbaje, 1986; Olaifa and Erhun, 1988; Lale, 1994; Ogunwolu and Odunlami, 1996; Adedire and Lajide, 2001; Boeke *et al*, 2001; Ofuya and Salami, 2002; Ofuya *et al.*, 2005; Ashamo,

2007; Oni, 2009). Recently, most of these insecticidal active plants appear to have been tested mainly as contact poisons against stored products insect pests, while relatively fewer studies have been conducted on the possibility of using plant products (such as oils and their extracts) as fumigants and contact poisons in stored products insects pest control (Shaaya *et al*, 1997; Papachristos and Stampoulos, 2002). This study was conducted in addition to efforts to crop researchers to minimize the indiscriminate use of synthetic chemicals and their effects; N-hexane oil extracts of plantain and banana commonly grown in African continent was investigated for their contact insecticidal activity against cowpea bruchid *Callosobruchus maculatus* (Fabricius) and maize weevil *Sitophilus zeamais* (Motschulsky).

Therefore, the overall objective of this study is to access the toxicity of extracts of plantain and banana peels on *Callosobruchus maculatus* infesting cowpea and *Sitophilus zeamais* infesting maize in storage.

LITERATURE REVIEW

Life History of *C. maculatus*

The seed beetle *C. maculatus* is a cosmopolitan pest of legume seeds, both in human stores, and in the field. Populations vary substantially in their host associations and vary in a suite of life history and behavioural traits associated with these host plant differences (Messina, 1991; Messina and Slade, 1997; Kawecki and Mery; 2003). The growth, development and reproduction of *C. maculatus* in the laboratory have been studied by different workers (Casewell, 1956; Howe and Curie, 1964; Osuji, 1982, Giga and Smith, 1987). The optimum conditions for these processes in the beetle are 30-35°C and 50% relative humidity which closely approximates to what is obtained during a major part of the cowpea storage period in West Africa (Pest of Stored Cereals and Pulses in Nigeria Biology Ecology and Control by T.I. Ofuya and N.E.S. Lale 2001). Under optimal conditions, *C. maculatus* eggs hatch in 3-5 days and larval development takes 8-16 days. Oviposition starts soon after mating and majority of the eggs are laid within 3 days (Wasserman 1985, Credland and Wright 1989). Adult females lay eggs individually on pods or seeds, on hatching, the first instar larva burrows through the egg chorion either, into a pod and then into a seed within it or directly into a seed. Once inside a seed, the larva feed and molts three times to produce a fourth instar larva which esculates a cell immediately beneath the seed surface. Thereafter, the larva molts into a pupa and then turns to an adult. The adult emerges from the seed through a circular exit holes as from three (3) weeks after the egg was laid, the period depending mainly on incubator. Emerged adult mates as soon as they have opportunity.

Life History of *Sitophilus zeamais*

Under optimum conditions, female *S. zeamais* may lay 100-150 egg separately deposited inside the grain, in the first three (3) weeks after emergence of adults. The eggs are laid in minute holes chewed in the grain by the female and the holes are sealed up by a secretion. Eggs are laid at temperatures 15-35⁰C and moisture content of 10%. The incubation period is The larvae are plump, measure about 4mm length (Hill, 1983), creamy while in the appearance and apodous (legless), immobile, and each develops within a single grain. Pupation takes place inside the grain and adult emerges through a circular hole made on the outer coat of the grain. Adult *S. zeamais* measures 3.5-4.0mm in length and the thorax is large and conspicuous (Hill, 1983). Emerged adults *S. zeamais* are small in size, brown in colour, and has greater ability and tendency to fly than other species. The life cycle of *S. zeamais* takes about five (5) weeks at 30⁰C and 70% relative humidity and there are many generations in a year i.e. multivoltine (Hill, 1983). Adults can live up to 5 months in one year under favourable conditions.

Banana

Musa sapientum which is commonly called banana is an herbaceous plant of the family *Musaceae*. It is known to have originated from the tropical region of Southern Asia. According to Leslie, (1976), it is now cultivated throughout the tropics. Akinyosoye, (1991), reported that the plant is cultivated primarily for its fruits and to a lesser extent for the production of fibre. It is also believed to be an ornamental plant. The *Musa sapientum* grows up to height of about 2-8m with leaves of about three (3). Kudan (1962) reported that the peels in conjunction with other substances create a liniment for reducing the acuteness of the arthritis aches and pains. The stem which is also called pseudostem produces a single bunch of banana before dying and replaced by new source of considering the upsurge in the prizes of livestock feeds and pseudostem. The fruit grows in hanging cluster, with twenty fruits to tier and 3-20 tiers to a bunch. The fruit is protected by its peel which is discarded as waste after the inner fleshy portion is eaten. *Musa sapientum* fruits have been reported to prevent anaemia by stimulating the production of haemoglobin in the blood. Its role to regulate blood pressure has been associated with the content of potassium (Akinyosoye, 1991). Banana helps in solving the problem of constipation without necessary resorting to laxatives. Wath and Brayer (1962) reported that banana can cure heart burns stress, strokes, ulcers and many other ailments. *Musa sapientum* peel which is often ignore and considered as waste could be domesticated for proper utilization as livestock feeds.

The main components of banana peel used for preparation of dietary fibre are listed above. The banana peel had higher fat, ash and total dietary fibre

about 6 days at 25⁰C (Howe, 1952). The eggs hatch into larvae commonly called grubs that feed exclusively on the grain, excavating a tunnel as it develops. There are four larval instars and at 25⁰C and 70% R.H. The larval stage is the most destructive stage of the weevil and accounts for most of the damage done to the grain.

content, but lower protein and starch content than those of the banana peels at stage 1 of ripeness reported by (Emaga *et al.*, 2007).

Plantain

Plantain is the common name for herbaceous plants of the genus *Musa*. The fruit they produce is generally used for cooking, in contrast to the soft, sweet banana (which is sometimes referred to as the dessert banana). There is a formal botanical distinction between bananas and plantains based on its structure and genus/species. The population of North America was first introduced to the fruit as banana plantain, and in the United States and Europe "banana" generally refers to that variety. The word "banana" is sometimes used to describe other plantain varieties, and names may reflect local uses or characteristics of varieties: cooking plantain, banana plantain, beer banana, bocadillo plantain, etc.

Plantains are classified formally as *Musa acuminata*, *Musa balbisiana* or hybrids *Musa acuminata* × *balbisiana*, depending on their genomic constitution. The old scientific name *Musa paradisiaca* is no longer used. Most plantains come from the hybrid AAB and ABB Cultivar Groups (Randy *et al.*, 2007). All members of the genus *Musa* are indigenous to the tropical regions of Southeast Asia and Oceania, including the Malay Archipelago (modern Indonesia, Malaysia, Brunei and the Philippines) and Northern Australia. Plantains tend to be firmer and lower in sugar content than dessert bananas. Bananas are almost always eaten raw, while plantains tend to be cooked or otherwise processed, and are used either when green or unripe (and therefore starchy) or overripe (and therefore sweet). An average plantain has about 220 calories and is a good source of potassium and dietary fiber. Plantains are a staple food in the tropical regions of the world, treated in much the same way as potatoes and with a similar neutral flavour and texture when the unripe fruit is cooked by steaming, boiling or frying (Oke *et al.*, 1998). Farmers grow plantains as far north as Northern California and as far south as KwaZulu-Natal. Despite old systems of classification that incorrectly separated plantains as a different species solely because of their culinary use, they are now known to belong to the same species as dessert bananas. They are mostly sterile triploid hybrids between the species *Musa acuminata* (A genome) and *Musa balbisiana* (B genome). Most modern plantains belong to the AAB Group, commonly known as the

'Plantain Group', and the ABB Group. Other economically important plantain groups include the East African Highland bananas (Mutika/Lujugira subgroup) of the AAA Group and the Pacific plantains (including the Popoulo, Maoli, and Iholena subgroups) of the AAB Group (Randy *et al.*, 2007).

MATERIALS AND METHODS

Plant Materials

The experiment was carried out in the research laboratory of the Crop, Soil and Pest Management Department, The Federal University of Technology Akure, Nigeria under ambient condition of $28 \pm 4^\circ\text{C}$ temperature and $65 \pm 10\%$ relative humidity. The cowpea seeds (Ife Brown) and maize seed (Downey Mildew Resistant Variety) used for the experiment were obtained from International Institute of Tropical Agriculture (IITA) Ibadan. The plant materials used (ripe and unripe plantain peel and ripe and unripe banana peel) were obtained from a local market in Akure, Nigeria.

Culturing of *C. maculatus*

A culture of cowpea seed beetle *C. maculatus* was established at ambient temperature and relative humidity in the laboratory. This was done by putting clean, sterilized cowpea seeds in the Kilner jar and introducing some adults of *C. maculatus* into the jar. The jar was then left in the laboratory for fourteen days for the insects introduced to lay eggs and after twenty one days of oviposition, the adult emerged. The culture was subsequently recycled as necessary.

Culturing of *S. zeamais*

Adult maize weevils, *S. zeamais* were obtained from infested maize in The Federal University of Technology Teaching Research farm Akure. Cultures for the project were established on a clean susceptible maize variety. The weevils were introduced into the jar containing this maize variety and they were allowed to lay eggs for a period of fourteen days after twenty one days of oviposition the adult emerged. The culture was subsequently recycled as necessary.

Plant Extraction

The oils used were extracted separately from powders of ripe and unripe banana and plantain peels using Soxhlet extraction. N-hexane was used as solvent in this experiment. In carrying out the Soxhlet extraction process, 40g of the powder of each plant materials was weighed and put inside a thumble surrounded by thumble holder. The thumble holder was then placed fittingly on a round bottom plastic that was three quarter filled with N-hexane solvent. The apparatus was set up using a clamp on a heating mantle and heated for a period of four (4) hours. The oil extracted from each plant material was then separated from the solvent. This procedure was repeated until required quantity of oil was obtained from each plant material.

Preparation of Insecticidal Plant Powders

Ripe and unripe plantain and banana peels were used for preparation of insecticidal plant powders. Peels were removed separately from each of the ripe and unripe plantain and banana and sundried for ten (10) days to remove moisture content. Thereafter, the peels were pulverized in an electric blender into a fine powder. Each powder type was immediately put in a separate plastic container with tight fitted lids and stored in an open laboratory.

Effect of Plant Extract from Plantain Peel on *C. maculatus* and *S. zeamais*

Oil extracted from ripe and unripe plantain and was tested separately on *C. maculatus* and *S. zeamais* at different application rates of 1.0, 5.0, 10.0ml/kg of cowpea and maize seeds. Twenty adults (10 males and 10 females) of adult *C. maculatus* (age unknown) and *S. zeamais* were used to infest the treated cowpea and maize in petri dishes (8.5cm diameter) with lids respectively. There were three replicates per treatment. Insect's mortality was monitored separately of cowpea and maize seed at 12, 24 and 48 hours for plantain and banana plant extract, thereafter, the number of eggs laid by *C. maculatus* was counted and recorded. Cowpea seeds were examined for adult emergence as from 21 days after oviposition and the adult that emerged were counted and recorded while adult emergence from maize seeds were observed as from thirty one days after oviposition, and the adult were counted and recorded.

Effect of Plant Extract from Banana Peel on *C. maculatus* and *S. zeamais*

The bioassay used for determination of the effect of plant extract from banana on *C. maculatus* and *S. zeamais* described in 3.6 was similarly adopted in this experiment.

Effects of Plant Powder from Plantain Peel on *C. maculatus* and *S. zeamais*

Plant powder of plantain (ripe and unripe) was tested separately on *C. maculatus* and *S. zeamais* at different levels of 0.4, 0.8, 2.0g per 20g of cowpea and maize seeds. Twenty adults (10 males and 10 females) of adult *C. maculatus* (age unknown) and *S. zeamais* were used to infest cowpea and maize seeds in separated petri dishes (8.5cm diameter) with lids respectively. There was also a control treatment in which the insects were not exposed to the plant powders. There were three replicates per treatment. Insect's mortality was monitored separately on cowpea and maize seeds at 12, 24 and 48 hours for plantain and banana plant powder, thereafter, the number of eggs laid by *C. maculatus* was counted and recorded. Cowpea seeds were examined for adult emergence as from 21 days after oviposition and the adults that emerged were counted and recorded, while adult emergence from maize seed were observed as from thirty one days after oviposition.

Effects of Plant Powder from Banana Peel on *C. maculatus* and *S. zeamais*

The procedure for determining the effect of plant powder of banana on *C. maculatus* and *S. zeamais* described in 3.8 was similarly adopted in this experiment.

Data Analysis

Data collected from the experiments were subjected to analysis of variance (ANOVA), using SPSS 15.0. Where necessary data were transformed before analysis (percentages were arcsine transformed). Where the ANOVA test indicated significant difference between treatments, Tukey's test was used to separate means at 5% level of probability.

EXPERIMENTAL DESIGN

Table 1 shows the mean percentage adult mortality, egg laid and adult emergence of *C. maculatus* treated

with different concentrations of ripe banana peel hexane extract. At 12hr post treatment, adult mortality was significantly higher ($P < 0.05$) at the application rate of 10.0ml/20g of seed than the control treatment but was not significantly different from adult mortality caused by 5.0ml application rate. At 24hr and 48hr of post treatment, adult mortality of *C. maculatus* was significantly higher ($P < 0.05$) at the application rate of 10.0ml/20g of seed than the control and other treatments. Number of eggs laid by *C. maculatus* was higher in the control treatment than on the cowpea seeds treated with ripe banana peel hexane extract. Number of eggs laid was lowest in cowpea seeds treated with ripe banana peel hexane extract at the application rate of 10.0ml/20kg of cowpea seed followed by the application rate of 5.0ml/20g of cowpea seed. A similar trend was observed in adult emergence of *C. maculatus* treated with different application rates of banana peel hexane extract.

Table 1

Mean percentage adult mortality, number of eggs laid and adult emergence of *C. Maculatus* on cowpea treated with ripe banana peel hexane extract

Conc. (ml)	Mean % adult mortality in 12hr	Mean % adult mortality in 24hr	Mean % adult mortality in 48hr	No of eggs laid	adults emerged
Ctrl	0.0±0.00a	3.3±3.33a	10.0±5.77a	75.0±7.23b	43.3±4.33b
1	6.6±2.89a	8.3±5.77ab	18.3±14.43a	16.3±2.87ab	5.6±4.04ab
5	23.3±7.64ab	31.6±12.58b	60.0±10.0b	3.3±3.21a	0.6±0.58a
10	28.3±10.41b	41.6±12.58c	80.0±8.66c	1.0±1.73a	0.2±1.15a

Means in each column bearing the same letter are not significantly different at the 5% level of probability by Tukey test.

Table 2 shows the mean percentage of adult mortality, eggs laid and adult emergence of *C. maculatus* treated with unripe banana peel hexane extract. At 12hr, 24hr and 48hr post treatment, adult mortality was significantly higher ($P < 0.05$) on cowpea seeds treated with 10.0ml/20g of cowpea of unripe banana peel hexane extract than the control treatment and other treatment. Egg laid by *C. maculatus* was higher in the control and was significantly different ($P > 0.05$) from the number of eggs laid by *C. maculatus* when seed was treated with different application rates of banana

peel hexane extract. There were a similarly lower number of eggs laid on cowpea seed treated with banana peel hexane extract at the application rate of 5.0ml/20g of seed. A similar trend was also observed in the number of adult emergence of *C. maculatus* when treated with concentration of unripe banana peel hexane extract.

The mean percentage of adult mortality at 12hr, 24hr and 48hr was higher in the treated seeds than the control.

Table 2

Mean percentage adult mortality, number of eggs laid and adult emergence of *C. Maculatus* on cowpea treated with unripe banana peel hexane extract

Conc. (ml)	Mean % adult mortality in 12hr	Mean % adult mortality in 24hr	Mean % adult mortality in 48hr	No of eggs laid	adults emerged
Ctrl	0.0±0.00a	3.3±3.33a	10.0±5.77a	75.0±7.23b	43.3±4.33b
1	33.3±7.64ab	45.0±13.23ab	56.7±5.77ab	8.7±1.15ab	5.6±0.58ab
5	51.1±2.89b	65.0±13.23b	68.7±2.89b	1.3±1.54a	0.6±0.58a
10	70.0±10.0c	86.7±10.41c	96.7±5.77c	0.6±1.55a	0.6±0.01a

Means in each column bearing the same letter are not significantly different at the 5% level of probability by Tukey test

(Table 3). However, this did not differ significantly from the number of eggs laid on cowpea seeds treated with 1.0g and 5.0g/20g of cowpea seed and control. Adult mortality was higher on cowpea seed treated with ripe plantain peel hexane extract at application rate of 10.0g/20g of cowpea seed. Number of eggs laid by *C. maculatus* was significantly higher ($P < 0.05$) in the control than the treated cowpea seeds. The lowest number of eggs was laid on cowpea seeds treated with ripe plantain peel hexane extract at application rate of 10.0g/20g of seed. Adult emergence was higher in the control but was not significantly different from the number of adult that emerged from cowpea seeds treated with 1.0g/20g of seed. Similar lower number of

adult emergence was observed in cowpea seeds treated with ripe plantain peel hexane extract at the application rate of 5.0g and 10.0g/20g of seed, but was not significantly different ($P > 0.05$) from cowpea seeds treated with 1.0g/20g of seed.

At 12hr, 24hr and 48hr mean percentage adult mortality of *C. maculatus* was significantly higher ($P < 0.05$) in the treated seed of 10.0g/20g of cowpea seed, followed by the application rate of 5.0g of cowpea seed treated unripe plantain peel hexane extract. There was also significant difference between 1.0g of cowpea seed and other treatment. Adult mortality was lower at the control treatment.

Table 3
Mean percentage adult mortality, number of eggs laid and adult emergence of *C. Maculatus* on cowpea treated with ripe plantain peel hexane extract

Conc. (ml)	Mean % adult mortality in 12hr	Mean % adult mortality in 24hr	Mean % adult mortality in 48hr	Mean % eggs laid	No of adults emerged
Ctrl	0.0±0.00a	3.3±3.33a	16.7±2.88a	75.0±5.77c	43.3±4.33b
1	11.6±2.81ab	11.6±2.81ab	16.7±2.28a	36.3±19.85b	10.0±9.17ab
5	15.0±5.00ab	20.0±10.00ab	35.0±8.66ab	24.0±2.52ab	3.3±2.08a
10	23.3±2.89b	36.7±5.78b	60.0±8.66c	4.6±8.88a	1.6±2.52a

Means in each column bearing the same letter are not significantly different at the 5% level of probability by Tukey test

RESULTS AND DISCUSSIONS

Ofuya (2010) opined that agricultural plant residues such as banana and plantain peels may be converted to ash, pulverized or extracted by appropriate solvents for insecticidal purposes. In this study empirical evidence has been provided to support the assertion of Ofuya (2010). Powders made from ripe and unripe banana and plantain peels and hexane extracts from these powders were found to have insecticidal effect on *C. maculatus* in stored cowpea and *S. zeamais* in stored maize. At the highest concentration of application (10ml/kg) each hexane peel extract always caused significant mortality of both *C. maculatus* and *S. zeamais* adults in comparison with the control. Significantly reduced oviposition by *C. maculatus* and F_1 adult emergence in *C. maculatus* and *S. zeamais* was also observed in treatments involving the highest concentration of each hexane peel extract. The insecticidal effect of hexane extract from unripe peels was generally greater than extracts from ripe peels. Except for powder obtained from ripe plantain peel, all the other peel powders demonstrated significant kill of *C. maculatus* adult in comparison with the control at 0.8g or more per 20g of grain and from 12hours post treatment. All peel powders at all rates of application generally produced significant kill of *S. zeamais* adults as from 24hours post treatment. All peel powders at all rates of application significantly reduced oviposition by *C. maculatus* in comparison

with the control treatment. The insecticidal effect of unripe peel powders was generally higher than ripe peel powders. The plantain and banana peel powders and hexane extracts were generally more toxic to adult of *C. maculatus* than *S. zeamais* adults. For instance whilst the highest concentration 10ml/kg of hexane extracts of ripe banana peel produced 80% kill of *C. maculatus* adults in 48hours, it could only produce 10% mortality of *S. zeamais* within the same period. Also, whilst the highest rate of application (2.0g/20g of grain) of unripe banana powder caused 86.7% mortality of *C. maculatus* adults in 48hours, it could only kill 10% of adults of *S. zeamais* within the same period.

M. sapientum and *M. paradisiaca* fruits are known to be of insecticidal and pharmaceutical significance in Nigeria (Odugbemi, 2008). Many of these medicinal plants have been observed to exhibit insect control activity (Makanjuola, 2008). This study has perhaps for the first time reported insect pest control capability of products from the peels of *M. sapientum* and *M. paradisiaca* against *C. maculatus* and *S. zeamais*. The insecticidal effects include outright kill of adult beetles, reduction of oviposition in *C. maculatus* and reduction in progeny production in the two beetles. Similar mechanisms have been reported for many other botanical insecticidal materials (Boeke *et al.*, 2001; Lale, 2010). The insecticidal effect of botanicals is often attributed to a vast array of chemical substances which they contain (Dales,

1996; Makanjuola, 2008; Lale, 2010). Banana and presumably plantain peels contain polyunsaturated fatty acids particularly linolenic acid and α -linolenic acid and also pectin, amongst other chemical substances (Emaga *et al.*, 2007, 2008). Fatty acids are known to be biologically active chemicals against stored product coleoptera (Lale, 1995) and may therefore be contributory to the insecticidal activity observed for plantain and banana peels against *C. maculatus* and *S. zeamais* in the study. The observations that the insecticidal effect of production from unripe peels was greater than the ripe peels may be due to the fact that metabolism during the process of ripening have converted the insecticidal chemicals to less harmful ones. Maturation and ripening in banana and plantain fruits is certainly accompanied by degradation by endogenous enzymes (Emaga *et al.*, 2007). It is clear from the results obtained in this study that complete protection of treated grains from damage by *C. maculatus* and *S. zeamais* may not have been achieved. This is because at the highest level of application of both peel powders and oils, F₁ adult emergences still occurred, but significantly lower than what was recorded in the controls. When and where some levels of insect damage to grain can be tolerated, particularly in many poor tropical countries. (Van Huis, 1991), products from unripe plantain and banana peels can be recommended for reducing damage by storage beetles in cowpea and maize.

CONCLUSION

- 1) Powders obtained from unripe and ripe plantain and banana peels and hexane extracts of these powders show insecticidal activity against *C. maculatus* and *S. zeamais*
- 2) Insecticidal activity was greatest when the powders were applied at 2.0g/20g of grain and the hexane extracts at 1.0ml/kg of grain. However total protection of the grains was not obtained.
- 3) The insecticidal effects of powders of ripe and unripe banana and plantain peels and the hexane extracts include outright kill of adult of *C. maculatus* and *S. zeamais*, reduction in progeny production in the two beetles.
- 4) The insecticidal effects of unripe peel powders and their hexane extracts against *C. maculatus* and *S. zeamais* was generally greater than that elicited by ripe peel powders and their hexane extracts.

RECOMMENDATIONS

- 1) The basis for the insecticidal activity of powders of unripe and ripe plantain and banana peels and their extracts needs to be determined.

- 2) Studies should be carried out to determine the possible compatibility of production of banana and plantain peels for storage production by households, farmer, traders etc.
- 3) Ways of enhancing the insecticidal effects of products of banana and plantain peels against storage insects should be investigated.

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