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ENTOMOTOXIC ACTIVITY OF POWDER OF CLEISTOPHOLIS PATENS BENTH AGAINST THE INDIAN MEAL MOTH, *PLODIA INTERPUNCTELLA* (HÜBNER) (LEPIDOPTERA: PYRALIDAE)

Akinneye J. Onaolapo
Department of Biology, Federal University of Technology, Akure, Nigeria.

A B S T R A C T

This study investigated the insecticidal activity of parts of *Cleistopholis patens* against developmental stages of *Plodia interpunctella* in stored maize grains. The efficacies of the powders as contact and fumigant insecticides were evaluated by admixing different concentrations (0.5, 1.0, 1.5, 2.0 and 2.5g) to maize grains containing developmental stages of the moth. Egg hatchability, adult emergence, larvae mortality and adult mortality of the moth were used as indices of the insecticidal activities at 24hrs, 48hrs, 72hrs, and 96hrs post-treatment periods. The powders from the root bark and stem bark of *C. patens* completely inhibited egg hatching and adult emergence as both contact and fumigant insecticide. Also, they evoked 100% mortality at 2.5% protectant concentration at 96hrs post-treatment period against larvae and adult *P. interpunctella.* The leaf powder was the least effective as both contact and fumigant insecticide.

Keywords: Mortality, development, insecticidal, protectant, powder, oil.

INTRODUCTION

Plodia interpunctella (Hübner), is a cosmopolitan pest that infests wide ranges of stored products including maize grains, nuts, beans, processed foods and dried fruits (Simmons and Nelson 1975). Infestation of commodity by *P. interpunctella* causes 60 - 80% post-harvest losses of staple food crops in Nigeria leading to major economic losses (Oni and Ileke 2008). Infestation of *P. interpunctella* causes direct product loss and indirect economic costs, quality losses and consumer complaints (Philips *et al.* 2000a, b). The feeding activity of the larva results into the entire food surface been matted with web which contaminate the produce, change food colour due to infection by moulds and gives it an unpleasant odour. The webbing also contains larval excreta (frass and exuvia (cast skins)) (Almasi 1984; Fasulo and Knox 2009). Since, insect pest infestation has been reported as the major cause of food grain losses in most developing countries during storage (Adedire *et al.,* 2011), the control of these pests becomes imperative. The control of stored product pest has been centered on the use of synthetic insecticide because of its effectiveness within the shortest post treatment period; but it has serious drawbacks (Sharaby 1988). These include genetic resistance by insect species, toxic residues, increasing cost of application, pollution of the environment and hazard from handling (Leelaja *et al.,* 2007). These have stimulated a search for alternative means of storage-pests control. In view of these, researchers and farmers have diverted their attention toward the use of botanical (plant-based) insecticides in controlling stored product insect pests, because they are eco-friendly, less toxic to humans, easy to use, specific in action and insect pests are not resistance to them (Ileke and Oni 2011). Medicinal plants have demonstrated potential as insect control agents (Adedire and Lajide 2003; Aranilewa *et al*., 2006; Ashamo *et al.,* 2013). Small scale farmers and researchers have often claimed successful use of plant products in insect pest control. Plant materials such as spices, vegetable oils, extracts, powders or inert dust have been reported for their insecticidal efficacy (Keita *et al.,* 2001; Akinkurolere *et al.,* 2006; Akinneye and Ashamo 2009; Adedire *et al.,*

* Corresponding Author:
Email: josephakinneye@yahoo.co.uk
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2011). *Cleistopholis patens* (family: Annonnaceae*)* is a sun-loving tree of about 20 — 35m tall found in many parts of African countries. *C. patens* are commonly known as "salt and oil tree" and its local Nigeria name is Apako or Oke (Yoruba). It is a medicinal plant used in the treatment of headache, malaria, measles and antifertility (Oliver 1960). It can also be used for treatment of infectious diseases caused by *Staphylococcus aureus* (Adonu 2013). This research work is sought to reveal the insecticidal activity of *C. patens* (Benth) against the *Plodia interpunctella* (Hübner) (Lepidoptera; Pyralidae) and its toxicological effect on Albino rats.

MATERIAL AND METHODS

Insect Rearing: The *Plodia interpunctella* larvae used to establish the culture was obtained from naturally infested maize grains from Federal University of Technology, Akure (FUTA) farm, Ondo State, Nigeria. The moths' larvae were reared in 2 litre plastic containers containing 300g of un-infested maize grains. The culture was maintained by continually replacing devoured maize grain and sieving out frass and fragments. The plastic containers were covered with muslin cloth, fastened by rubber band, and placed inside wire mesh cage of dimension 75cm × 50cm × 60cm (L × W × H) with its four stands dipped in water-kerosene mixture contained in a plastic container to prevent entry of predatory ants into the cages. The culture was maintained at a temperature (28 ± 2°C) and relative humidity (75 ± 5%). The whole setup was left inside the postgraduate research laboratory of the Department of Biology, Federal University of Technology, Akure.

Preparation of Plant Materials: The leaf, stem bark and root bark of *C. patens* were harvested from Otasun farm along Ile Oluji road, Ondo, Ondo State, Nigeria. These plant parts were brought to the laboratory, washed thoroughly with water, shade-dried in the laboratory for 30 days. Each plant part was separately pulverized into fine powder using Binatone electric blender (Model 373). The powders were further sieved to pass through 1mm^2 perforations. The fine powders were kept in separate airtight plastic containers and stored at ambient temperature of 28 ± 2°C and 75 ± 5% relative humidity.

EXPERIMENTAL PROCEDURE FOR INSECTICIDAL ACTIVITY

The contact and fumigant toxicity of *Cleistopholis patens* powders and oil extracts were assayed on developmental stages of *Plodia interpunctella* to evaluate their potential entomotoxic effects. All the experiments were conducted at room temperature of 28 ± 2°C and relative humidity of 75 ± 5%.

Contact toxicity of *C. patens* powders on eggs and larval of *P. interpunctella*: Twenty freshly laid eggs (0-24hr old) were placed on 20g of maize grains treated with 0.0 (control), 0.5, 1.0, 1.5, 2.0 and 2.5g root barks, stem barks and leafs powder of *C. patens* inside plastic container of dimension 8cm diameter and 4cm depth. The treated and the control (untreated) were replicated three times. Daily observation were made with dissecting microscope to determine the number of eggs that hatch from the total number of eggs incubated and the setup was left inside insect breeding wire mesh cage measuring (75 × 50 × 60) cm and after 40 days the number of adult emerged insects were determined and percentage calculated. Fine powder of the root barks, stem barks and leaf of *C. patens* was also admixed with maize grains at the rate of 0.0 (control), 0.5, 1.0, 1.5, 2.0 and 2.5g/ 50g of maize in plastic containers (8cm diameter and 4cm depth). The container cover was punched with hot iron rod and lined with muslin cloth on the inside to prevent larvae from escaping and allow aeration. Ten (10) third instars larvae were introduced into the treated and un-infested maize grains and were replicated three times. The numbers of dead larvae were counted after 24h, 48h, 72h and 96h post-treatment and the mean values were calculated.

Contact toxicity of *C. patens* powders on adult *P. interpunctella*: Fine powders of the *C. patens* root bark; stem bark and leaves were admixed with maize grains at the rate of 0.0 (control), 0.5, 1.0, 1.5, 2.0, 2.5g/ 50g of maize in plastic containers (8 diameter and 4cm depth). The container cover was punctured with hot iron rod and lined with muslin on the inside to prevent insect escape and allows for aeration. Ten pairs of newly emerged adult of *P. interpunctella* was introduced into plastic containers containing the treated maize and untreated samples was also infested to serve as control with adult *P. interpunctella* and all treatment were replicated three times. Adult mortality at 24, 48, 72 and 96 hours after treatment were counted and recorded. At the end of the 96 hours post-treatment period, data on percentage adult mortality was corrected using Abbott (1925) formula, stated thus:

$$P_T = \frac{P_0 - P_C}{100 - P_C}$$

Where P_T= Corrected adult mortality

P_0= Percentage mortality of treated insects

P_C= Percentage mortality on untreated insects

Fumigant toxicity of *C. patens* powders on eggs and larvae of *P. interpunctella*: The following concentration 0.0g, 0.5g, 1.0g, 1.5g, 2.0g and 2.5g/50g of maize grain, leaves, stem bark and root powder of *C. patens* were weighed and sealed in muslin cloth of dimension 3cm by 3cm and hanged on the lid of plastic containers of 8cm depth having 4cm diameter. Twenty freshly laid eggs (0-24hr old) were introduced into plastic container containing 50g of maize grains and covered with the lid; the plant powder was hanged at a distance of 4cm from the lid as well from the bottom and was made airtight. The treated and the control (untreated) experiments were replicated three times. Daily observation were made with dissecting microscope to determine the number of eggs that hatch from the total number of eggs incubated and the experiment was left inside the insect breeding wire mesh cage pending adult emergence. At the end of 41 days post-treatment period the total number of emerged adult was determined and percentage calculated. The same of dead larvae were counted after 24h, 48h, 72h and 96h post treatment.

Fumigant effect of *C. patens* powders on adult *P. interpunctella*: The fine powder of the *C. patens* root bark, stem bark and leaves at the rates of 0.0g, 0.5g, 1.5g, 2.0g and 2.5/50g of maize grain were sealed in muslin clothes of dimension 3cm by 3cm and hanged with thread at a distance of 4cm from the lid of the plastic containers of dimension 8cm depth x 4cm width. Ten pairs of newly emerged adult (0-24hrs old) were introduced into plastic containers containing 50g of maize grains and covered with lid hanged with the plant parts powder. Untreated maize grains were on the other hand with adult of *P. interpunctella* and all treatments were replicated three times. Adult mortality at 24h, 48h, 72h and 96 hours after treatment were determined and recorded. At the end of the 96 hours post treatment data on percentage adult mortality were corrected using Abbot (1925) formula:

$$P_T = \frac{P_0 - P_C}{100 - P_C} \times 100$$

Where P_T= Corrected adult mortality

P_0= Percentage mortality of treated insects

P_C= Percentage mortality on untreated insects

RESULTS

Contact toxicity of *C. patens* powders on egg hatchability and adult emergency of *P. interpunctella*: The effect of *C. patens* powder on egg hatchability and adult emergence of *P. interpunctella* is presented in Table 1. Egg hatchability and adult emergence were inhibited at all the concentration relative to the control. There was no significant difference in these responses among the treatment groups.

Contact toxicity of *C. patens* powders on larva of *P. interpunctella*: Toxic effect of *C. patens* on larva mortality of *P. interpunctella* is presented in Table 2. Mortality varied with plant parts, rate of application and exposure period. There was no mortality at 24hrs post treatment at 0.5 – 1.0g rate of the leaf powder and stem bark powder and 1.5g rate of the leaf powder. While all rates of the root bark, 1.5g – 2.5g rate of the stem bark powder and 2.0 – 2.5g rate of the leaf powder caused greater than 16.67% larvae mortality of the moth obtained at 0.5g rate of root bark. At 48hrs post treatment, all rates of the stem bark except 0.5g and 1.5 – 2.5g rate of the leaf powder caused greater than 30.0% mortality. The root bark at 2.0g – 3.0g able to achieve 100% larva mortality of the moth at 96hrs post treatment whereas the stem barks at 2.5g attained 100% mortality at 96hrs post treatment. No rate of the leaf powder attained 100% larva mortality of the moth. The larval mortality obtained at 1.5g and 2.0g of the root bark powder and stem bark powder were not significantly different (P>0.05) at 96hrs post treatment.

Contact toxicity of *C. patens* on the adult mortality of *P. interpunctella*: The contact toxicity of *C. patens* powder on mortality of adult *P. interpunctella* is presented in Table 3. At 24hrs post treatment, 0.5g rate of the root bark 0.5 and 1.0g rates of the stem bark and leaf powder caused no mortality of the moth, while 1.0 – 2.5g rates of the rook bark, stem bark and leaf powder caused greater than 15.0% adult mortality except 1.5g rate of the leaf powder that caused no adult mortality. At 48hrs post treatment, all rates of the root bark, the 1.0 – 2.5g rates of the stem bark and the 1.0g – 2.5g rates of the leaf powders caused 20 – 68% adult mortality of the moth. The root bark at 2.5g was the earliest to cause 100% mortality at 72hrs post treatment whereas the stem bark at 2.5g attained 100% mortality at 96hrs post treatment. No rate of the leaf powder attained 100% mortality of the moth. The mortality obtained at 1.5g and 2.0g of the root bark and stem bark powder were not significantly different (P>0.05) at 96h post treatment.

Table 1. Contact toxicity of *C. patens* powders on egg hatchability and adult emergency of *P. interpunctella*.

Plant powders	Conc.	% Eggs hatch	% Adults Emergence
Root bark	0.0	88.33 ± 4.41^{b}	85.00 ± 2.89^{b}
	0.5	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	1.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	1.5	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	2.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	2.5	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
Stem bark	0.0	86.67 ± 1.67^{b}	85.00 ± 2.89^{b}
	0.5	5.00 ± 2.89^{a}	3.33 ± 1.67^{a}
	1.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	1.5	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	2.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	2.5	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
Leaf	0.0	85.00 ± 2.89^{d}	81.67 ± 1.67^{d}
	0.5	33.33 ± 4.41^{c}	28.33 ± 4.41^{c}
	1.0	25.00 ± 2.89^{b}	25.00 ± 2.89^{b}
	1.5	25.00 ± 2.89^{b}	20.00 ± 2.89^{b}
	2.0	18.33 ± 1.67^{a}	16.67 ± 3.33^{a}
	2.5	15.00 ± 2.89^{a}	10.00 ± 2.89^{a}

Each value is a mean ± standard error of three replicates. Means followed by the same letter along the column are not significantly different (P>0.05) using New Duncan's Multiple Range Test.

Table 2. Contact toxicity of *C. patens* powders on larva of *P. interpunctella*.

Plant Powder	Rate (g/20g) maize grain)	Mean % mortality after			
		24hrs	48hrs	72hrs	96hrs
Root bark	0.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.5	16.67 ± 3.33^{b}	30.00 ± 0.00^{b}	43.33 ± 6.67^{b}	50.00 ± 5.77^{b}
	1.0	26.67 ± 3.33^{c}	40.00 ± 0.00^{c}	53.33 ± 3.33^{c}	70.00 ± 0.00^{c}
	1.5	46.67 ± 6.67^{d}	63.33 ± 3.33^{d}	80.00 ± 11.55^{d}	93.00 ± 6.67^{d}
	2.0	56.67 ± 6.67^{e}	66.67 ± 3.33^{d}	90.00 ± 5.77^{e}	100.00 ± 0.00^{d}
	2.5	60.00 ± 5.77^{e}	76.67 ± 3.33^{e}	93.00 ± 6.67^{e}	100.00 ± 0.00^{d}
Stem bark	0.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.5	0.00 ± 0.00^{a}	26.67 ± 3.33^{b}	36.33 ± 3.33^{b}	40.00 ± 0.00^{b}
	1.0	0.00 ± 0.00^{a}	40.00 ± 0.00^{c}	53.33 ± 5.77^{c}	63.33 ± 6.67^{c}
	1.5	33.33 ± 3.33^{b}	53.33 ± 3.33^{d}	73.33 ± 3.33^{d}	86.67 ± 8.81^{d}
	2.0	53.33 ± 3.33^{c}	63.33 ± 3.33^{e}	83.33 ± 3.33^{e}	90.00 ± 5.77^{d}
	2.5	60.00 ± 5.77^{d}	73.33 ± 3.33^{f}	90.00 ± 5.77^{e}	100.00 ± 0.00^{e}
Leaf	0.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.5	0.00 ± 0.00^{a}	20.00 ± 0.00^{b}	26.67 ± 3.33^{b}	30.00 ± 0.00^{b}
	1.0	0.00 ± 0.00^{a}	30.00 ± 0.00^{c}	36.67 ± 3.33^{c}	40.00 ± 5.77^{c}
	1.5	0.00 ± 0.00^{a}	40.00 ± 0.00^{d}	43.33 ± 3.33^{d}	50.00 ± 0.00^{d}
	2.0	33.33 ± 3.33^{b}	40.33 ± 3.33^{d}	50.00 ± 0.00^{de}	60.00 ± 0.00^{e}
	2.5	36.67 ± 3.33^{b}	43.33 ± 3.33^{d}	53.00 ± 3.33^{e}	60.00 ± 5.77^{e}

Each value is a mean ± standard error of three replicates. Means followed by the same letter along the column are not significantly different (P>0.05) using New Duncan's Multiple Range Test.

Table 3. Contact of *C. patens* powders on adult mortality of *P.interpunctella*.

Plant Powder	Rate (g/20g) maize grain)	Mean % mortality after			
		24hrs	48hrs	72hrs	96hrs
Root bark	0.0	0.00 ± 0.00ᵃ	0.00 ± 0.00ᵃ	0.00 ± 0.00ᵃ	0.00 ± 0.00ᵃ
	0.5	0.00 ± 0.00ᵃ	20.00 ± 2.87ᵇ	33.33 ± 1.67ᵇ	51.67 ± 4.14ᵇ
	1.0	15.00 ± 2.87ᵇ	33.33 ± 7.26ᶜ	53.33 ± 6.00ᶜ	93.33 ± 4.41ᶜ
	1.5	23.33 ± 3.33ᶜ	48.33 ± 6.01ᵈ	66.67 ± 4.41ᵈ	96.67 ± 3.33ᵈ
	2.0	28.33 ± 1.67ᶜ	60.00 ± 5.77ᵉ	83.33 ± 8.82ᵉ	100.00 ± 0.00ᵈ
	2.5	45.00 ± 2.89ᵈ	68.33 ± 4.41ᵉᶠ	100.00 ± 0.00ᶠ	100.00 ± 0.00ᵈ
Stem bark	0.0	0.00 ± 0.00ᵃ	0.00 ± 0.00ᵃ	0.00 ± 0.00ᵃ	0.00 ± 0.00ᵃ
	0.5	0.00 ± 0.00ᵃ	16.67 ± 2.87ᵇ	23.33 ± 1.67ᵇ	33.33 ± 4.14ᵇ
	1.0	0.00 ± 0.00ᵃ	25.00 ± 0.00ᶜ	43.33 ± 1.67ᶜ	53.33 ± 1.67ᶜ
	1.5	20.00 ± 2.89ᵇ	40.00 ± 5.77ᵈ	53.33 ± 3.33ᵈ	63.33 ± 3.33ᵈ
	2.0	28.33 ± 3.33ᵇᶜ	45.00 ± 2.89ᵈ	58.33 ± 1.67ᵈ	76.67 ± 3.33ᵉ
	2.5	38.33 ± 4.41ᵈ	60.00 ± 5.77ᵉ	90.00 ± 5.77ᵉ	100.00 ± 0.00ᶠ
Leaf	0.0	0.00 ± 0.00ᵃ	0.00 ± 0.00ᵃ	0.00 ± 0.00ᵃ	0.00 ± 0.00ᵃ
	0.5	0.00 ± 0.00ᵃ	11.67 ± 1.67ᵃᵇ	16.67 ± 1.67ᵇ	31.67 ± 10.93ᵇ
	1.0	0.00 ± 0.00ᵃ	25.00 ± 0.00ᶜ	33.33 ± 1.67ᶜ	45.00 ± 0.00ᶜ
	1.5	0.00 ± 0.00ᵃ	28.33 ± 4.41ᶜ	43.33 ± 3.33ᶜᵈ	51.67 ± 1.67ᵈ
	2.0	28.33 ± 3.33ᵇ	40.00 ± 5.00ᵈ	55.00 ± 5.00ᵉ	65.00 ± 2.89ᵉ
	2.5	35.00 ± 2.89ᶜ	41.67 ± 1.67ᵈ	60.00 ± 2.89ᵉ	70.00 ± 2.89ᵉᶠ

Each value is a mean ± standard error of three replicates. Means followed by the same letter along the column are not significantly different (P>0.05) using New Duncan's Multiple Range Test.

Fumigant toxicity of *C. patens* powders on egg hatchability and adult emergence of *P. interpunctella*: The effect of various plant parts powder of *C. patens* on the development of *P. interpunctella* from egg to adult are presented in Table 4. There was no egg hatched and adult emergence in all the grains protected with root and stem bark powder whereas 26.7% eggs were hatched and 20% adult emerged in the grain protected with leaf powder. At 1.5g/ 20g of maize, 11.7% eggs were hatched and 8.3% adult emerged and there was no significant difference (P> 0.05) when compared with the 2.0g protectant concentrations of the leaf powder. Also at 2.5g/ 20g of maize, 6.7% eggs were hatched and only 1.7% adult emerged using the leaf powder. There was significant difference (P< 0.05) in the mean number of egg hatched and adult emergence when compared with their control, which had 68.3% hatchability and 61.6% adult emergence.

Fumigant toxicity of *C. patens* powders on larvae of *P. interpunctella*: The fumigant effect of *C. patens* powders on larval mortality of *P. interpunctella* at different concentrations and exposure period is presented in Table 5. The percentage mortality varied with plant parts, the period of exposure and concentrations of the plant powders. After 24hrs of post treatment, all rates of the root bark, the 1.0 – 2.5g rate of the stem bark and the 2.0 – 2.5g rate of the leaf powders caused 33.33 – 80% larvae mortality of the moth. At 48hrs post-treatment, all rates of the root bark, the 1.0 – 2.5g rate of the stem bark and 1.5 – 2.5g rate of the leaf powder caused 50.0% -- 93.3% larvae mortality of the moth. The root bark powder at 1.5g was able to caused 100% mortality of the larvae of *P. interpunctella* at 96hrs post treatment and also the root bark powder at 2.0g was able to evoke 100% mortality of the larvae within 72hrs of post treatment whereas the stem bark powder at 2.5g attained 100% larvae mortality at 96hrs post treatment. However, this was followed by leaf powder which evoked 40.0%, 50.0%, 63.3%, 66.6% and 73.3% mortality of the larvae *P. interpuncella* at rate 0.5, 1.0, 1.5, 2.0 and 2.5g/20g of maize grains after 96hrs post treatment of application respectively. The mortality attained at 1.5g -- 2.5g rate of the root bark and stem bark were not significantly different (P>0.05) at 96hrs post treatment.

Fumigant toxicity of *C. patens* powders on adult mortality of *P. interpunctella*: The fumigant effect of *C. patens* powders on the mortality of adult *P. interpunctella* at different concentrations and exposure period is presented in Table 6. The percentage mortality varied with plant parts, rate of application and exposure period. After 24hrs of post treatment, at all rates of root bark powder, the 1.0 – 2.5g rates of stem bark powder and the 1.0g – 2.5g of leaf powder caused 3.33% – 48.3% adult mortality. At 48hrs post treatment, all rates of root bark powder, the 1.0 – 2.5g of stem bark and the 1.0 – 2.5g of leaf powder were able to achieve 30% – 78% adult mortality. The root bark after 96hrs, 100% mortality was obtained except at 0.5g and 1.0g where 61.67% and 98.33% was achieved. The stem bark at 2.5g/20g maize grains attained 100% mortality at 96hrs post treatment. No rate of the leaf powder achieved 100% mortality of the moth. The mortality attained at 1.0 – 2.5g rate of the root bark were not significantly different (P<0.05) at 96hr post–treatment.

Table 4. Fumigant toxicity of *C. patens* powders on egg hatchability and adult emergence of *P. interpunctella*.

Plant powders	Conc. G	Eggs hatch	% Adults Emergence
Root bark	0.0	73.33 ± 3.33[b]	63.33 ± 3.33[b]
	0.5	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	1.0	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	1.5	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	2.0	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	2.5	0.00 ± 0.00[a]	0.00 ± 0.00[a]
Stem bark	0.0	76.67 ± 3.33[b]	66.33 ± 3.33[b]
	0.5	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	1.0	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	1.5	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	2.0	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	2.5	0.00 ± 0.00[a]	0.00 ± 0.00[a]
Leaf	0.0	68.33 ± 4.41[e]	61.67 ± 4.41[e]
	0.5	26.67 ± 0.33[d]	20.00 ± 2.89[d]
	1.0	16.67 ± 1.67[c]	13.33 ± 1.67[bc]
	1.5	11.67 ± 1.67[b]	8.33 ± 1.67[b]
	2.0	10.00 ± 1.67[b]	6.67 ± 1.67[b]
	2.5	6.67 ± 1.67[a]	1.67 ± 1.67[a]

Each value is a mean ± standard error of three replicates. Means followed by the same letter along the column are not significantly different (P>0.05) using New Duncan's Multiple Range Test.

Table 5. Fumigant toxicity of *C. patens* powders on larvae of *P. interpunctella*.

Plant Powder	Rate (g/20g) maize grain)	Mean % mortality after			
		24hrs	48hrs	72hrs	96hrs
Root bark	0.0	0.00 ± 0.00[a]	0.00 ± 0.00[a]	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	0.5	33.33 ± 3.33[b]	50.00 ± 0.00[b]	60.00 ± 5.77[b]	63.33 ± 5.77[b]
	1.0	46.67 ± 3.33[c]	60.00 ± 0.00[c]	73.33 ± 3.33[c]	83.33 ± 6.67[c]
	1.5	56.67 ± 6.67[d]	73.33 ± 3.33[d]	93.33 ± 6.67[d]	100.00 ± 6.67[d]
	2.0	73.33 ± 3.33[e]	86.67 ± 3.33[e]	100.00 ± 0.00[e]	100.00 ± 6.67[d]
	2.5	80.00 ± 5.77[ef]	93.33 ± 3.33[f]	100.00 ± 0.00[e]	100.00 ± 6.67[d]
Stem bark	0.0	0.00 ± 0.00[a]	0.00 ± 0.00[a]	0.00 ± 0.00[a]	0.00 ± 0.00[a]
	0.5	0.00 ± 0.00[a]	46.67 ± 3.33[b]	56.67 ± 3.33[b]	60.00 ± 0.00[b]
	1.0	20.00 ± 10.00[b]	53.33 ± 3.33[c]	66.67 ± 3.33[c]	83.00 ± 3.33[c]

	1.5	36.67 ± 6.67^{c}	73.33 ± 3.33^{d}	86.67 ± 6.67^{d}	93.33 ± 3.33^{d}
	2.0	53.33 ± 3.33^{d}	83.33 ± 3.33^{e}	96.67 ± 3.33^{e}	96.67 ± 3.33^{d}
	2.5	63.33 ± 3.33^{e}	86.67 ± 3.33^{e}	100.00 ± 0.00^{e}	100.00 ± 0.00^{d}
Leaf	0.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.5	0.00 ± 0.00^{a}	23.33 ± 0.00^{b}	40.00 ± 0.00^{b}	40.00 ± 0.00^{b}
	1.0	3.33 ± 3.33^{b}	30.00 ± 0.00^{bc}	46.67 ± 3.33^{c}	50.00 ± 5.77^{c}
	1.5	23.33 ± 3.33^{c}	53.33 ± 3.33^{c}	60.00 ± 0.00^{d}	63.33 ± 3.33^{d}
	2.0	33.33 ± 3.33^{d}	63.33 ± 3.33^{d}	66.67 ± 3.33^{d}	66.67 ± 3.33^{d}
	2.5	40.00 ± 0.00^{de}	66.67 ± 3.33^{d}	73.33 ± 3.33^{e}	73.33 ± 3.33^{e}

Each value is a mean ± standard error of three replicates. Means followed by the same letter along the column are not significantly different (P>0.05) using New Duncan's Multiple Range Test.

Table 6. Fumigant toxicity of *C. patens* powders on adult mortality of *P. interpunctella*.

Plant Powder	Rate (g/20g maize grain)	Mean % mortality after			
		24hrs	48hrs	72hrs	96hrs
Root bark	0.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.5	3.33 ± 1.67^{a}	30.00 ± 2.87^{b}	43.33 ± 1.67^{b}	61.67 ± 4.41^{b}
	1.0	25.00 ± 2.89^{b}	43.33 ± 7. 26^{c}	70.00 ± 5.00^{c}	98.33 ± 1.67^{c}
	1.5	30.00 ± 2.89^{bc}	55.00 ± 2.89^{d}	86.67 ± 7.26^{d}	100.00 ± 0.00^{c}
	2.0	38.00 ± 1.67^{c}	70.00 ± 5.77^{e}	96.67 ± 3.33^{e}	100.00 ± 0.00^{c}
	2.5	48.33 ± 4.41^{d}	78.33 ± 4.41^{f}	98.33 ± 1.67^{e}	100.00 ± 0.00^{c}
Stem bark	0.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.5	0.00 ± 0.00^{a}	26.67 ± 1.67^{b}	33.33 ± 1.67^{b}	55.00 ± 2.89^{b}
	1.0	10.00 ± 5.00^{b}	36.67 ± 1.67^{c}	53.33 ± 1.67^{c}	63.33 ± 1.67^{c}
	1.5	23.33 ± 5.77^{c}	46.67 ± 3.33^{d}	63.33 ± 3.33^{d}	73.33 ± 3.33^{d}
	2.0	28.33 ± 3.33^{cd}	55.00 ± 2.86^{e}	66.67 ± 3.33^{d}	86.67 ± 3.33^{e}
	2.5	45.00 ± 2.89^{d}	70.00 ± 5.77^{f}	90.00 ± 5.77^{e}	100.00 ± 0.00^{f}
Leaf	0.0	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
	0.5	0.00 ± 0.00^{a}	21.67 ± 1.67^{b}	33.33 ± 1.67^{b}	43.33 ± 4.41^{b}
	1.0	3.33 ± 3.33^{a}	35.00 ± 0.00^{c}	43.33 ± 1.67^{c}	55.00 ± 0.00^{c}
	1.5	21.67 ± 1.67^{b}	40.00 ± 2.89^{d}	53.33 ± 3.33^{d}	61.67 ± 1.67^{d}
	2.0	28.33 ± 3.33^{c}	50.00 ± 8.66^{e}	65.00 ± 5.00^{e}	71.67 ±1.67^{e}
	2.5	35.00 ± 2.89^{d}	55.00± 2.89^{ef}	70.00 ± 2.89^{f}	78.33 ± 3.33^{ef}

Each value is a mean ± standard error of three replicates. Means followed by the same letter along the column are not significantly different (P>0.05) using New Duncan's Multiple Range Test.

DISCUSSION

CONTACT AND FUMIGANT TOXICITY OF *C. PATENS* POWDER ON DEVELOPMENTAL STAGES OF *P. INTERPUNCTELLA*.

Contact and fumigant toxicity of *C. patens* powder on egg hatchability and adult emergence of *P. interpunctella*: The use of plant powders in control of insect pest of stored products is an ancient practice. Many Nigeria medicinal plants and spices have been used as pest control agents (Lale 1992; Ofuya and Dawodu 2002). Several powders of this plant are often used in the control of stored product Coleopteran and Lepidopteran because of their relative high efficacy on all developmental stages of the insects. The result obtained from this research showed that the root bark, stem bark and leaf powder of C. *patens* in both contact and fumigant toxicity were found effective against eggs and emergence of adult of *P. interpunctella* at all levels of concentration. But the leaf powder was slightly effective against the eggs which produced 10 – 28% adult emergence and there was significant difference (P<0.005) when compared with the control. The inability of the egg to hatch to larval may be due to the fact that the powders inhibit gaseous exchange between the egg and external environment. The performance of the root bark, stem bark and leaf powders of *C. patens* in this study agreed with the findings of Echnedu (1991) that the powdered rhizome of *Zingiber officinale* when admixed at 2.5g/500g brown cowpea seed reduced the emergence of adult by 96% compared to the untreated control. The insecticidal activity of *C. patens* plant powder evaluated against eggs and development to adult in this study was also similar to the observation of Akinneye (2003) that *C. patens* inhibited the egg hatch and development to adult stage in *E. cautella.* Olawumi (2014) reported that *U. afzelli* fruit powder inhibited the egg hatch and development of *P. interpunctella* reared on maize grain.

Contact toxicity of *C. patens* powder on larval of *P. interpunctella*: The contact effect of powders and rate of application of *C. patens* root bark, stem bark and leaf on the mortality of larva of *P. interpunctella* depends on concentration and exposure periods. The result obtained from this research showed that the *C. patens* root bark, stem bark and leaf powders have effect on the larvae of *P. interpunctella*, except at 0.5g – 1.5g of stem bark and leaf powders, no mortality were recorded at 24hrs post treatment. At 72hrs post treatment, and an application rate of 1.5g – 2.5g/ 20g of maize grain 73.33% -- 93% mortality was recorded which was significantly higher (P>0.05) than the mortality recorded at 0.5g/20g and 1.0g/20g that caused mortality of 40% -- 63.3% respectively. This was similar to the findings of Ashamo and Akinneye (2004) that *Eugenia aromatica* caused greater than 43.3% mortality of the yam moth *Euzopherodes vapidella.* The mortality of the insect larval may result from inability of the larva to fully cast off their exoskeleton which typically remained linked to the posterior part of their abdomen. This agreed with the result of Adedire (2002) in which nutmeg oil was found to cause asphyxiation and subsequent death of *C. maculatus* on stored cowpea. However, at 96hrs post treatment, at application rate of 2.0 – 2.5g/20g root bark powder and stem bark powder at 2.5g/20g rate caused 100% larval mortality, this showed that the root bark powder and the stem bark powder of *C. patens* were the most effective on mortality of larvae of *P. interpunctella* at the three treatment levels investigated while the leaf powder was slightly effective since the percentage mortality produced at 96hrs post treatment was significantly higher than the control. This agreed with the findings of Pathak and Tiwari (2010) in which powder and oil of *Azadirachta indica* was found to have larvicidal effect on the larvae of *Corcyra cephalonica*.

Fumigant toxicity of *C. patens* powders on larvae of *P. interpunctellai*: The fumigant toxicity of *C. patens* root bark, stem bark and leaf powders on larvae of *P. interpunctella* observed at 24hrs, 48hrs, 76hrs and 96hrs post treatment revealed the insecticidal potency of *C. patens.* At 24hrs of post treatment, the 0.5g rate of stem bark and leaf powder, caused no larva mortality except for root bark powder which caused 33.33% mortality. At 48hrs post treatment, all rates of the root bark, the 1.0 – 2.5g rate of the stem bark and 1.5 – 2.5g rate of the leaf powder caused less than 50% larvae mortality of the moth. This finding was similar to the findings of Ashamo and Akinneye (2004) that *E. aromatica* caused greater than 43.3% mortality of *E. vapidella* at 0.05g/15g of yam.

Contact toxicity of *C. patens* powder on adult mortality of *P. interpunctella*: The contact toxicity of *C. patens* to adult *P. interpunctella* depends on concentration, part used and exposure periods. Mortality varied with plant parts, rate of application and exposure periods. At 24hrs post treatment, the 0.5g rate of the root bark, the 0.5 and 1.0 rate of the stem bark and 0.5 – 1.5g rate of the leaf powder obtained no adult mortality of the moth. This finding was similar to observation of Akinneye (2011) in the control of *E. cautella* with *C. patens* powder. The root bark powder at the rate of 2.0g and 3.0g and stem bark powder at the rate of 3.0g concentration was effective against *P. interpunctella,* producing 100% mortality within 96hrs post treatment. This observation also tallies with the findings of Adedire and Lajide (2001) that the pulverized powder of *Piper umbrellatum* seed and *E. aromatica* were toxic to *C. maculatus* producing 100% mortality at 24hrs post treatment across all concentrations. The toxic effect of the root and stem bark powder of *C. patens* in this study could be attributed to their pungency which evoked suffocating action on the moth. The leaf powder was the least effective of all the *C. patens* part tested but there was significant difference (P<0.05) in the mortality recorded with the leaf powder when compared with the control. Hence, the leaf powder was effective at higher concentration. The powder may also bind to the enzyme, cholinesterase thus preventing the removal and resultant accumulation of acetylcholine, the neurotransmitter, restlessness convulsion and paralysis may occur resulting in death of moth (Ashamo 2000).

Fumigant toxicity of *C. patens* powders on adult mortality of *P. interpunctella*: The fumigant toxicity of *C. patens* root bark, stem bark and leaf powders on adult mortality of *P. interpunctella* observed at 96h post treatment with different level concentration revealed the insecticidal potency of *C. patens* plant parts. The percentage mortality varied with plant parts, rate of application and exposure periods. There was no mortality at 24hrs post treatment, at 0.5g rate of the stem bark and leaf powder, except for root bark powder, which caused 3.33% mortality. At 48hrs post treatment, all rates of the root bark, the 1.0 –2.5g rate of the stem bark and 1.0 – 2.5g of the leaf powder caused greater than 30% adult mortality of the moth.This findings agree with the work of Adedire and Lajide (2003) that *Uvaria afzelli*, *E. aromatica* and *Aframomum melegueta* were toxic to adult *Sitophilus zeamais* at all levels of treatment within 24 hours of application. The root bark at 1.5g/20g maize grains was the earliest to cause 100% mortality whereas the stem bark at 2.5g/20g maize grains attained 100% mortality at 96hrs post treatment. This was in agreement with the observation of Akinneye *et al.,* (2009). The root bark of *C. patens* was the earliest to cause 100% adult mortality of *E. cautella* at 3.0g/20g cocoa beans. No rate of the leaf powder of *C. patens* attained 100% adult mortality. This observation was similar to the findings of Ashamo and Akinneye (2004) in studies with *E. vapidella* in which there was no rate of *Hyptis sauveolens* powder that attained 100% adult mortality of the moth. The powder of *C. patens* acted mainly through fumigant modes of action. This powder may cause death through respiratory inhibition, inhibition of oxidative phosphorylation and amine metabolism (Ashamo 2000).

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EVALUATION OF UNORTHODOX PREPARATIONS AND THEIR COMPARATIVE EFFICACY RELATIVE TO ORTHODOX INSECTICIDES AGAINST HOUSEHOLD INSECTS IN LAGOS

[a]Abiodun A. Denloye*, [a]Kafayat O. Ajelara, [a]Azeezat O. Alafia, [a]Oluwaseun O. Babalola, [b]Albert A. Bajulaiye, [c]Hillary Okoh, [d]Patrick I. Dike

[a] Department of Zoology and Environmental Biology, Lagos State University, Lagos, Nigeria.
[b] Department of Biology, School of Science, Adeniran Ogunsanya College of Education, Oto-Ijanikin, Lagos.
[c] Department of Animal and Environmental Biology, Federal University, Oye–Ekiti, Ekiti State, Nigeria.
[d] Centre for Environment and Science Education, Environmental Resource Management Unit, Lagos State University, Ojo, Lagos.

A B S T R A C T

Various insecticides including industrially compounded orthodox and mixed-up or single concentrate unorthodox (Otapiapia) formulations are used for controlling household insects in Lagos. Empirical information on the use of these formulations by Lagos residents and their efficacy is scanty. This study was consequently conducted to determine the use of unorthodox (Otapiapia) and orthodox formulations in Alimosho Local Government Area (LGA), Lagos and evaluate their efficacy against *Anopheles gambiae, Musca domestica* and *Periplaneta americana* using standard laboratory bioassays. For Otapiapia use, 150 structured questionnaires were administered to Alimosho LGA residents and the Otapiapia available in markets within the LGA were purchased to identify those used as insecticides. Unsexed *Anopheles gambiae* (0 – 2 d), *M. domestica* (0 – 3 d) and *P. americana* (adult) were exposed to various concentrations of selected Otapiapia (GO-90) or each of 13 orthodox formulations in standard air-tight glass cages. The LC_{50} values of each test formulation were computed. The results show that 72 % of respondents use Otapiapia instead of orthodox formulations because it is cheaper and effective, and most respondents use Sniper (35.30 %) and GO-90 (15.30 %). Based on computed 15 min-LC_{50} values, GO-90 was the most effective of all test formulations against *An. gambiae* (10.72 μlL^{-1}) and *M. domestica* (15.51 μlL^{-1}) while Baygon demonstrated higher efficacy against *P. americana* (13.42 μlL^{-1}) relative to other formulations. The GC-MS analyses show that the major constituents in GO-90 by volume are Naphthalene (19.03 %), Cyclododecane (11.48 %) and Tetradecane (10.34 %). Test unorthodox formulations showed comparable efficacy relative to orthodox insecticides.

Keywords: Household insects, unorthodox preparations, orthodox insecticides, bioassay.

INTRODUCTION

The control of nuisance insects using chemicals has become the norm in rural and urban settlements alike. These chemicals may be termed orthodox (OIs) or unorthodox insecticides (UIs) depending on their mode of preparation, packaging and extent of usage. The conventional insecticides compounded using a combination of two or more synthetic compounds especially under well supervised and standardized industrial settings are termed orthodox insecticides. These insecticides are commonly neatly packaged in pressurized aerosol cans and atomizer-fitted covers or in economy large-sized cans and dispensed into spray guns for application. In conformity with the requirements of the National Agency for Food and Drugs Administration and Control (NAFDAC) (NAFDAC, 2005) these orthodox insecticides have well defined modes of application and operation, and they have clearly spelt out content. In contrast, the unorthodox insecticides come in mostly unbranded packages and may take the brand name of a well-used insecticide. They are often not in pressurized cans and are available in plastic containers with or without proper content labels. They

* Corresponding Author:
Email: bio_denloye@yahoo.com
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may also be insecticide concentrates dispensed into small plastic containers, a development that has arisen due to the growing popularity of entrepreneurial activities and government current emphasis on the establishment and development of Small and Medium Enterprises (SMEs). These insecticides are locally referred to as Otapiapia, denoting their quick-action nature. Examples include Sniper, ABi, Go-90, Nopest, Indocide, Lara force, Rambo Rambo, Pestoff, Legacy, Mulvap, New dawn, DDforce, Pestox, Misty-Jom and so on.

In using this Otapiapia, the insects targeted act as carriers of several pathogenic organisms which activity results in human and animal diseases. Mosquito (*Anopheles gambiae*), Housefly (*Musca domestica*) and Cockroach (*Periplaneta Americana*) are among the most encountered and with devastating diseases they cause. Coupled with their nuisance value, each of these insects rank high serving as vectors of diseases. *Anopheles* is the vector for the malaria parasite, *Plasmodium* spp causing malaria responsible for over 5 million infant death and high toll of man-hour losses. *Musca domestica* and *Periplaneta americana* are respectively responsible for spreading many pathogenic micro-organisms such as *Shigella*, *Vibrio cholera*, *Cryptosporidium*, *Entamoeba* etc causing enteric diseases. These alimentary diseases also cause high mortality in epidemic situations (Oyewole *et al*., 2010; Nouctcha and Anumudu, 2011; Omudu and Aluor, 2011). The control of the vectors of these diseases is therefore justifiable. The quest for control of the insect vectors has led many rural and urban folks to use cheap and readily available compounds such as the Otapiapia. The wide and indiscriminate use of Otapiapia in Nigeria is well known as is in Alimosho Local Government (ALG) Area of Lagos State, Nigeria. However, the perception of users of Otapiapia on its uses and its efficacy have neither been determined nor documented. Furthermore, the justification for the use of the Otapiapias instead of the OIs in terms of insecticidal efficacy is not known. The foregoing underscores the need for the present study. The study was conducted to determine the perception of otapiapia users on its efficacy, and generate a checklist of the ones in ALGA, Lagos and characterize the chemical constituents of the prominent Otapiapias.

MATERIAL AND METHODS

Location for administration of questionnaires and conduct of bioassays: Markets in ALG Area of Lagos State served as the location where questionnaires were administered. The LGA is the largest Local Government Area in Lagos State. Alimosho Local Government area is a sub-urban formally part of Ikeja division of Lagos State. It has an estimated population of 1,319,517 inhabitants who are mainly traders, artisans and civil servants. Bioassays were conducted in the Central Research Laboratory, Faculty of Science, Lagos State University, Ojo, Lagos under ambient laboratory temperature and relative humidity.

Test insect species: *Anopheles gambiae*, *Musca domestica* and *Periplaneta americana* were used respectively for bioassays to determine the efficacy of each test insecticide or preparation in the laboratory. Insects were maintained as previously described by Denloye *et al.* (2004, 2009). The *An.gambiae* and *M. domestica* used in the studies were reared in the laboratory of Lagos State University. The test *P. americana* were collected from homesteads and acclimated in the laboratory for ≥ 14 days before exposure to test formulations. Only adult *P. americana* were used for the exposures.

Perception and market sampling for insecticides: The perception of ALG residents on the use of insecticides was evaluated using structured questionnaires randomly administered on 150 respondents living in Ikotun, Igando, Isheri-Olofin, Egbeda and Iyana Ipaja respectively to extract information on their knowledge, attitude towards the use and actual usage of formulations, with particular reference to Otapiapia. Various insecticide samples were procured from vendors in four major markets in ALGA namely – Egbeda, Ikotun, Igando, Iyana-Ipaja for a compilation of names of the unorthodox insecticides on sale and to test them against insect species.

Test insecticides: A total of 14 insecticide samples were tested namely, Raid Flying Insect Killer, Raid multipurpose insect killer, Baygon, GO-90 ("Otapiapia"), Gongoni Tripple Action, Good Knight Flying Insect Killer, Good Knight MultiInsect Killer, Killit Flying and Crawling Insecticide, Mobil Insecticide, Mortein Power Guard Roach Killer, Mortein Power Guard, Rambo Green and Rambo insecticide.

Efficacy of Insecticide samples against *An. gambiae*, *M. domestica* and *P. americana*: Adults of *An gambiae* or *M. domestica* aged 0 – 2 day old were used for formulation exposures as described in previous studies using aluminium sided glass cages that served as fumigation chambers. Each cage measured 0.5 X 0.5 X 0.5 m. Adult *P. americana* of unknown age already acclimated in the laboratory were similarly exposed to insecticides under ambient laboratory conditions. For each formulation/test insect assay various volumes of insecticide vapour were released in the fumigation chamber. The effect of insecticides were determined based on insect mortality after 15 minutes of exposure for *An gambiae* or *M. domestica*, while mortality of *P. americana* was determined after 1 hr of exposure. All tests and controls were replicated four times.

Constituents of selected unorthodox insecticides: Two of the unorthodox insecticides namely – Sniper and Go 90 were selected and analyzed for their respective chemical composition in the laboratory. Samples obtained from each of the two unorthodox insecticides analyzed for their respective constituents by Gas chromatography coupled with mass spectrophotometery (GC-MS) following standard procedure. The GC-MS analysis was carried out on the oils from the two unorthodox insecticide samples with an aglient 5775C chromatography equipped with an aglient mass-spectrometric detector, with a direct capillary interface and fused silica capillary column Hp-5ms (30 x 0.32mm i.d x -0.25pm film thickness). Helium was used as carrier gas at approximately 1.0ml/min, pulsed split less mode. The solvent delay was 4mins and the injector size was 1.0µl. The signal graph, chromatogram generated show peaks represents specific chemical compounds.

Data Analyses: Insect mortality data were subjected to probit analyses using computer programme of the United States Environmental Protection Agency (Version 5.1). Mortality figures obtained were corrected using Abbott (1925) formula before subjecting them to the computer programme.

RESULTS

Perception and availability of insecticides: Respondents to questionnaires indicated that there are 13 different brands of Otapiapia with names and 12 of orthodox used in ALGA Table 1. There are also those that are used but without any label on them. On the basis of use, Sniper was the Otapiapia mostly used in the Local Government Area followed by GO-90 (Table 1). Figure 1 shows the result obtained from questionnaire analyses and the reasons why residents use Otapiapia. A total of 70.00% of the respondents use the Otapiapia because of their efficacy within short time (Figure 1).

Chemical Constituents of selected unorthodox preparations: The results of GC-MS analyses of Sniper and GO-90 samples are presented in Figure 2, Figure 3 and interpreted in Table 2. The analyses showed that the principal chemicals contained in Sniper are Dichlorvos (38.74 %) and Cyclopropanecarboxylic acid (33.66%). The results also showed that the major chemicals in GO-90 are Naphtalene (19.03 %), Cyclododecane (11.48%) and Tetredecane (10.36 %). The constituents of Sniper are shown in Figure 2 while those of GO-90 are depicted in Figure 3.

Efficacy of test orthodox insecticides and unorthodox preparations against An. gambiae, M. domestica and P. Americana: The comparative computed median lethal concentrations (LC50) values based on quantal responses of each test insect species are shown in Table 3, 4 and 5. The 15 min-LC50 values showed that GO-90 (10.72 µlL-1) and a toxicity factor of 1.0 was significantly more toxic to An. gambiae than each test orthodox insecticide with no overlapping 95% confidence limits ($p < 0.05$). The next to GO-90 in toxicity ranking against An. gambiae was Rambo (Table 3). Similarly, GO-90 having the lowest 15 min - LC50 (15.51 µlL-1) was more toxic to M. domestica than any of the orthodox insecticides tested. Rambo was the most toxic to *M. domestica* among all orthodox insecticides tested (Table 4). The computed 24hr-LC50 showed that the most toxic insecticide against P. americana was Baygon (13.42 µlL-1) followed by Gonigoni Tripple Action (14.41 µlL-1). GO-90 was significantly less toxic to the cockroach than either Baygon or Gonigoni Tripple Action (Table 5).

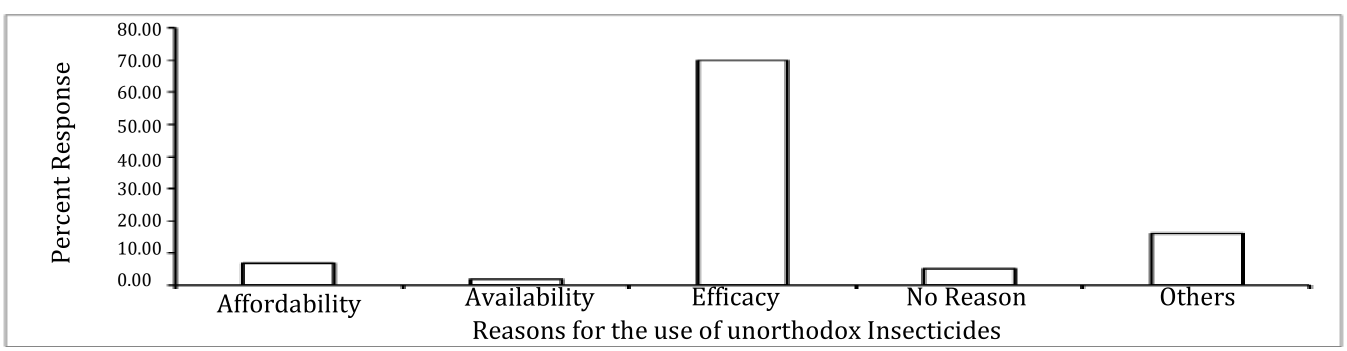

Figure 1. Reasons for choice of Unorthodox Insecticides by Respondents.

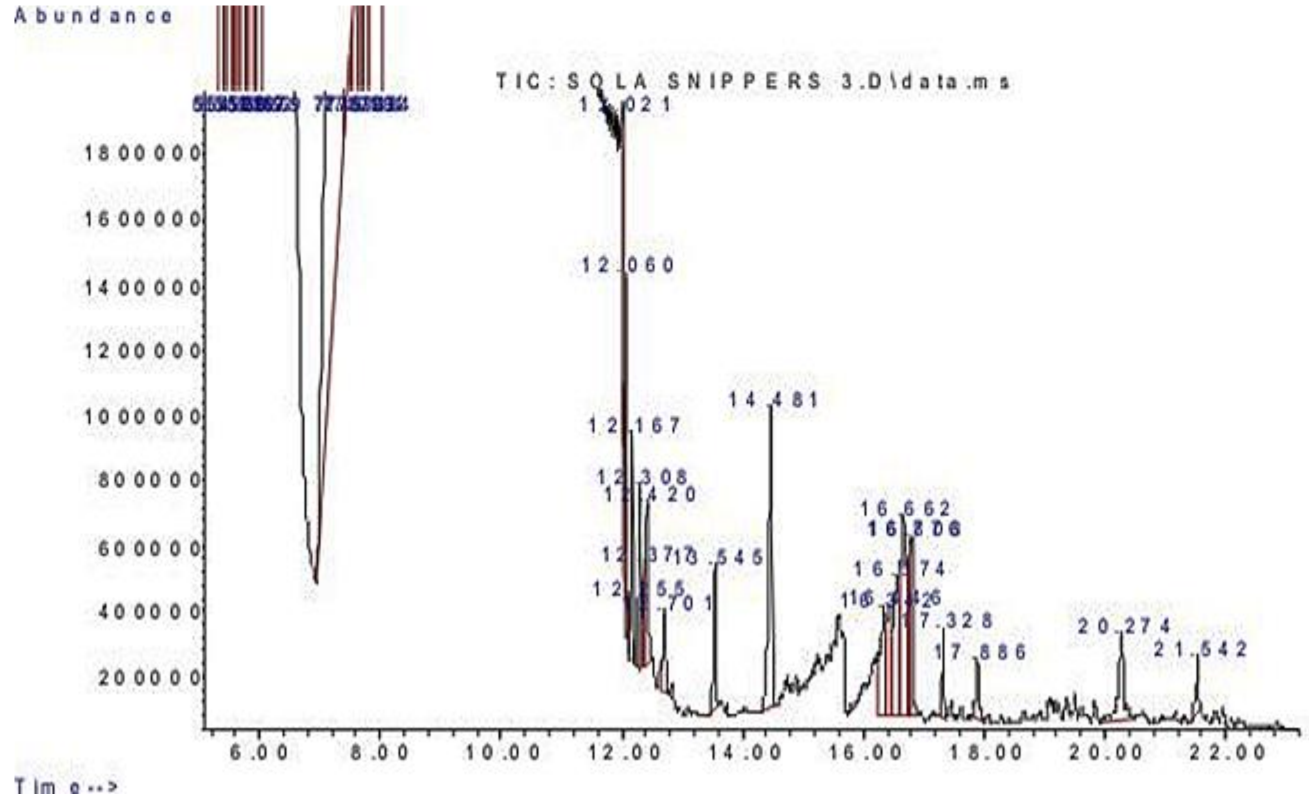

Figure 2. Gas Chromatogram showing chemical composition of Sniper.

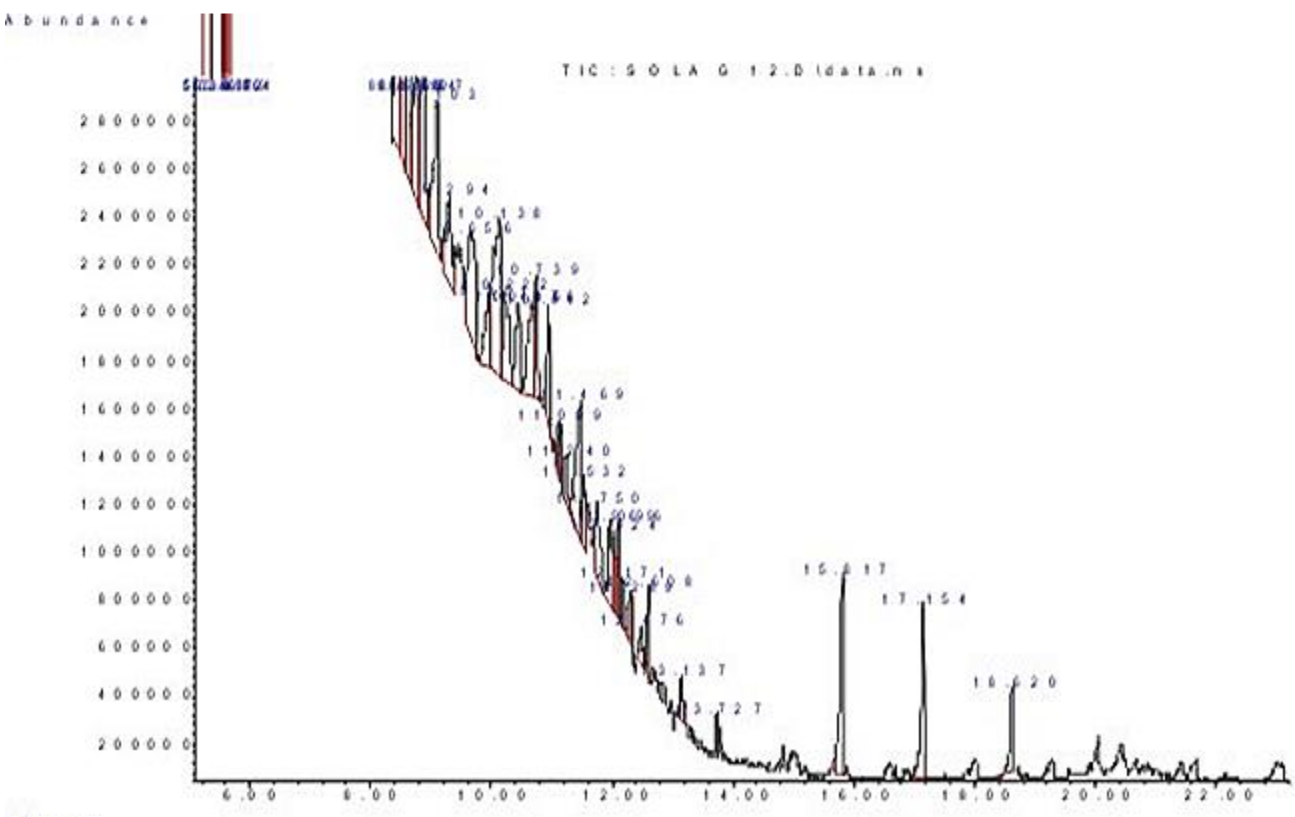

Figure 3. Gas Chromatogram Showing Chemical Composition of GO-90.

Table 1. Brands of Unorthodox Preparations and Orthodox Insecticides In Alimosho Local Government Area.

SN	Unorthodox Preparation		Brands	Orthodox Insecticide Brands	
	Brand Name	% Usage	Producer	Brand Name	Producer
1	Pestox	3.0	Three Points Industries Ltd.	Raid Old Formulation	Sc Johnson Limited
2	Sniper	35.5	Saro Agrosciences Ltd	Raid Multipurpose Insect Killer	Sc Johnson Limited
3	Pestoff	3.0	Pestoff Industries Ltd	Baygon	Sc Johnson Limited
4	Misty-Jom	1.5	Misty-Jom Ventures	Gonigoni Tripple Action	Gonigoni Nig. Ltd.
5	Mulvap	1.5	United Phosphorus Ltd.	Good Knight Flying Insect Killer	Good Knight Industries
6	DD Force	4.5	Jubali Agrotec Ltd.	Good Knight Multipurpose Insect Killer	Good Knight Industries
7	New Dawn	4.5	Not Available	Killit Crawling and Flying Insect Killer	Good Knight Industries
8	GO-90	15.3	Oruhtrade Int'l Ltd	Mobil Insecticide	Mobil Nig
9	Nopest Benckiser Nig Ltd	6.0	Ningbo-Agrostar Industrial Co. Ltd	Mortein Power Guard Roach Killer	Reckitt Benckiser Nig Ltd
10	Govan	3.5	Oruhtrade Int'l Ltd	Mortein Power Guard	Reckitt Benckiser Nig Ltd
11	Legacy	1.5	Not Available	Rambo Green	Gonigoni Nig. Ltd.
12	Lara Force	2.2	Jubali Agrotec Ltd.	Rambo	Gonigoni Nig. Ltd.
13	Rambo Rambo	9.0	Gonigoni Nig. Ltd.		
14	No name	3.0	Unknown		

Table 2. Chemical constituents of Sniper and GO-90.

SN	SNIPER		GO-90	
	Constituents	Proportion	Constituents	Proportion
1	Dichlorvos	38.738	Silane	3.008
2	Cyclopentanecarboxylic acid	1.765	Cyclotetradecane	3.524
3	Humulane	2.991	1-Decanol	5.308
4	Pyridiine	1.872	2-Ethyl-1—dodecanol	6.615
5	3,4,5-Trimethylpyrazole	1.578	Naphthalene	19.03
6	Imidazole	3.442	7-Tetradecane	6.54
7	m-Trifluoromethylbenzonitrile	1.463	Cyclododecane	11.484
8	Pyrazole-3-carbohydrazide	2.491	Cyclotetradecane	2.690
9	Butyl dimethyl phosphate	7.725	Tetradecane	10.632
10	Cyclopropanecarboxylic acid	33.655	1-Pentadecene	4.166
11	Butylphosphonic acid	1.422	Benzyl alcohol	2.973
12	Oleic acid	2.858	1-Heptanol	5.223
13	-	-	Azulene	1.394
14	-	-	Hexadecane	1.796
15	-	-	Methoxyacetic acid	0.708
16	-	-	2-(4-Iodo-phenyl)-6-pentyl-5,6,7,8-etrahydro-quinoline	5.417
17	-	-	Benzamide	6.201
18	-	-	Unknown	3.561

Table 3. Toxicity (LC50 values) of test insecticides against Mosquitoe (*Anopheles gambiae*).

Test formulations	15 Min LC_{50} ($\mu L L^{-1}$)	95 % Confidence Limits	Regression Equation	Degree of Freedom	Slope (± S.E)	Toxicity Factor
Raid Flying Insect Killer	23.45	19.25 - 29.52	Y = 2.27 + 1.99x	2	1.99 ± 0.31	2.19
Raid M. Insect Killer	17.86	14.32 – 21.79	Y = 2.54 + 1.97x	2	1.97± 0.30	1.67
Baygon	15.63	13.29 – 18.11	Y = 1.32 + 2.08x	2	2.08 ± 0.85	1.46
GO – 90	10.72	9.43 – 12.17	Y = 2.04 + 2.86x	2	2.86 ± 0.03	1.00
Gongoni Tripple Action	16.88	14.14 – 19.78	Y = 1.86 + 2.56x	2	2.56 ± 0.32	1.57
Good Knight F I Killer	15.83	13.32 – 18.41	Y = 1.71 + 2.75x	2	2.75± 0.32	1.48
Good Knight M I Killer	20.76	17.53 – 24.53	Y = 1.75 + 2.46x	2	2.46± 0.32	1.94
Killit Flying and Crawling In	16.25	13.82 – 18.78	Y = 1.49 + 2.90x	2	2.90± 0.33	1.52
Mobil Insecticide	21.75	18.00 – 26.43	Y = 2.15 + 2.13x	2	2.13± 0.31	2.03
Mortein P G Roach Killer	21.98	18.40 – 26.39	Y = 1.94 + 2.28x	2	2.28± 0.32	2.05
Mortein Power Guard	22.23	18.75 – 26.47	Y = 1.77 + 2.40x	2	2.40± 0.32	2.07
Rambo Green	14.40	12.09 – 17.16	Y = 2.01 + 2.58x	2	2.58± 0.88	1.34
Rambo	13.09	11.43 – 18.05	Y = 2.67 + 2.09x	2	2.09± 0.85	1.22

S. E = Standard Error; LC_{50} values with no overlap in their 95 % confidence limits are significantly different ($p < 0.05$).

Table 4. Toxicity (LC50 values) of test insecticides against Common Housefly (*Musca domestica*).

Test formulations	15 Min LC_{50} ($\mu L L^{-1}$)	95 % Confidence Limits	Regression Equation	Degree of Freedom	Slope (± S.E)	Toxicity Factor
Raid Flying Insect Killer	41.40	34.71 – 54.55	Y = 0.51 + 2.78x	2	2.78 ± 0.47	2.67
Raid M. Insect Killer	41.69	33.92 – 54.96	Y = 1.77 + 1.99x	2	1.99± 0.80	2.69
Baygon	17.39	14.49 – 20.41	Y = 2.37 + 2.12x	2	2.12 ± 0.61	1.12
GO – 90	15.51	12.62 – 20.36	Y = 3.05 + 1.64x	2	1.64 ± 0.26	1.00
Gongoni Tripple Action	16.22	13.14 – 19.45	Y = 2.36 + 2.18x	2	2.18 ± 0.31	1.05
Good Knight F I Killer	19.89	14.11 – 23.03	Y = 2.34 + 2.05x	2	2.05± 1.01	1.28
Good Knight M I Killer	17.38	14.51 – 20.45	Y = 1.93 + 2.48x	2	2.48± 0.32	1.12
Killit Flying and Crawling In	17.31	14.05 – 20.15	Y = 2.45 + 2.06x	2	2.06± 1.01	1.12
Mobil Insecticide	27.43	23.09 – 33.67	Y = 1.66 + 2.32x	2	2.32± 0.34	1.77
Mortein P G Roach Killer	25.06	21.07 – 30.50	Y = 1.81 + 2.28x	2	2.28± 0.33	1.62
Mortein Power Guard	27.77	23.75 – 33.29	Y = 1.23 + 2.61x	2	2.61± 0.36	1.79
Rambo Green	18.25	14.45 – 22.58	Y = 2.68 + 1.84x	2	1.84± 0.30	1.18
Rambo	17.53	13.93 – 21.51	Y = 2.63 + 1.91x	2	1.91± 0.30	1.13

S. E = Standard Error; LC_{50} values with no overlap in their 95 % confidence limits are significantly different ($p < 0.05$).

Table 5. Toxicity (LC50 values) of test insecticides against American Cockroach (*Periplaneta americana*).

Test formulations	15 Min LC_{50} ($\mu L L^{-1}$)	95 % Confidence Limits	Regression Equation	Degree of Freedom	Slope (± S.E)	Toxicity Factor
Raid Flying Insect Killer	68.64	62.15 – 93.02	Y = 1.53 + 1.89x	3	1.89 ± 1.27	5.11
Raid M. Insect Killer	37.94	33.65 – 67.17	Y = 1.84 + 2.00x	3	2.00± 0.54	2.83
Baygon	13.42	9.22 – 17.44	Y = 3.36 + 1.45x	3	1.45 ± 0.23	1.00
GO – 90	25.31	20.78 – 32.25	Y = 2.37 + 1.88x	3	1.88 ± 0.22	1.89
Gongoni Tripple Action	14.41	12.28 – 23.19	Y = 3.68 + 1.14x	3	1.14 ± 0.54	1.07
Good Knight F I Killer	28.40	3.47 – 185.13	Y = 1.67 + 2.29x	3	2.29± 0.51	2.12
Good Knight M I Killer	25.94	15.77 – 30.16	Y = 2.03 + 2.10x	3	2.10± 0.72	1.93
Killit Flying and Crawling In	22.05	18.83 – 25.38	Y = 1.60 + 2.53x	3	2.53± 0.27	1.64
Mobil Insecticide	67.93	44.38 – 87.16	Y = 1.95 + 1.67x	3	1.67± 1.06	5.06
Mortein P G Roach Killer	43.52	39.18 – 73.20	Y = 2.09 + 1.77x	3	1.77± 0.60	3.24
Mortein Power Guard	52.65	48.20 – 79.11	Y = 0.22 + 2.77x	3	2.77± 1.21	3.92
Rambo Green	33.99	26.84 – 45.49	Y = 2.87 + 1.39x	3	1.39± 0.24	2.53
Rambo	18.76	16.29 – 31.36	Y = 3.06 + 1.53x	3	1.53± 0.69	1.40

S. E = Standard Error; LC_{50} values with no overlap in their 95 % confidence limits are significantly different ($p < 0.05$).

DISCUSSION

This report documents the attitude of Alimosho Local Government Area residents to the use of insecticides to control insect-vectored parasitic diseases. In particular, the questionnaires provide insight to the knowledge, attitude and practices of using unorthodox insecticides known locally as Otapiapia by residents of ALGA, Lagos State. It establishes the fact that some of the residents of ALGA rely on unorthodox insecticides for various reasons especially economic since they perceive it as cheap. It is well known that residents of this Local Government Area are mostly artisans, middle-low cadre civil servants, market men and women, petty traders and skilled professionals who survive on meager income and yet have to protect themselves and the families from insect bites. The approved minimum wage by the Federal Government is ₦18, 000.00 (Nwude, 2013). This implies that there is a little fund, part of which will go for procurement of such groceries as insecticides. Consequently, these residents rely on the purchase and use of Otapiapia which cost far less than the orthodox insecticides.

The study also revealed that the residents use unorthodox insecticides because it is readily available. Availability is an important factor to consider in the use of insecticides. As low income earners ALGA residents would prefer to procure insecticides that are available as soon as they get the required funds and when the need for its use arises. The artisans are often daily paid workers who earn little and would therefore spend a fraction of it on their immediate needs like insecticides. Consequently not-far-fetched insecticides are the ones they go for. It is notable that most of the respondents to questionnaires administered on them use unorthodox insecticides because its perceived effectiveness and that majority use Sniper. GC-MS analyses of the two selected insecticides (Table 2), Sniper and GO-90 shows their respective chemical constituents. The analyses also reveal why Sniper gives the best result of insecticidal efficacy since its major constituent is Dichlorvos, an organophosphate insecticide which efficacy is well documented. Similarly, the major constituents of GO-90 are Naphtalene (19.03 %), Cyclododecane (11.48 %) and Tetredecane (10.34 %). Dichlorvos is an organophosphate residual insecticide which has been employed over several decades in Nigeria for the control of malaria vector (Foll *et al*., 1965; Foll and Pant, 1966). Although it has proven to be an effective fumigant control against mosquitoes, chronic exposure by humans and domestic animals result in neurotoxicity, carcinogenicity, DNA damage and even death (ASTDR, 1997; Alavanja *et al*., 2004; Jamal *et al*., 2002; Kathyrene *et al*., 2006; Okeniyi and Lawal, 2007; Remmington *et al*., 2008). Also, it is fairly well established that Naphtalene is a naturally occurring bicyclic aromatic compound which is a component of crude oil and widely used in insecticide formulations. The other major constituents of GO-90 such as Tridecane and Dodecane are also hydrocarbons but are found as components of insecticides although they are part of kerosene (paraffin) which is a solvent for the active ingredient in the Otapiapia. These hydrocarbons have hazardous effects documented by Chilcott (2006) including dermatitis, cataract, vomiting etc. The major constituents of GO-90 namely Naphthalene, Cyclododecane and Tridecane as well as the minor constituent, Azulene are natural constituents of some plant essential oils such as *Morus rotunbiloba, Psidium cattleianum* var. *lucidum* and *Zanthoxylum gilletii* (Japhet *et al*., 2014; Chalanavar *et al*., 2012; Patharakom *et al*., 2010). The natural occurrence of these chemical constituents of GO-90 suggests its biological safety to animals and the environment, but there is need to verify this by empirical means.

This report shows a high efficacy of GO-90 against the test insects especially *An. gambiae* and *M. domestica*. It therefore gives credence to the perception of ALGA residents who justified their use of Otapiapia relative to orthodox insecticides because of the perceived efficacy of the former more than the latter. This indicates that the continued use of GO-90 by the population sampled in this study is not a mere adherence to tradition but a response to the real activity of the Otapiapia. Also the study gives an empirical documentation of the efficacy of Otapiapia as exemplified by GO-90. By the foregoing, it would be advisable for governments to encourage SMEs producing Otapiapia and create enabling environment for them to thrive. Insecticide users should also be advised to procure locally produced preparations that are safe, environmentally benign and registered with NAFDAC.

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