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THE LARVICIDAL ACTIVITY OF SOME PLANT OILS ON *Dermestes maculatus* (DEGEER) LARVAE IN SMOKE-DRIED *Protopterus annectens* (OWEN)

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Abstract

The larvicidal activity of *Dermestes maculatus* larvae by the oils of *Allium sativum* (Garlic), *Cocos nucifera* (Coconut), *Zingiber officinale* (Ginger), *Jatropha curcas* (Jatropha) and *Azadirachta indica* (Neem) was evaluated. Late instar larvae of *D. maculatus* were introduced into Kilner jars containing fish treated with these oils, whose physicochemical properties and the fatty acid compositions had been previously determined. Untreated fish were also placed in jars to serve as control. Results showed that the oils caused significant mortality ($P<0.05$) on the larvae of *D. maculatus* in treated fish compared to the untreated fish at 96h after infestation. 100% mortality was recorded for all the oils at the highest concentration by the 96th hour of exposure. The fatty acids detected in the oils were: oleic acid (in *J. curcas* and *A. indica*); octadecanoic acid (in *Z. officinale* and *C. nucifera*); stearic and palmitic acids (in *A. indica* and *C. nucifera*); lauric, linoleic and myristic acids (in *C. nucifera*); octadecanoic acid (in *J. curcas*) and cyclopropanepentanoic acid (in *Z. officinale*). The larvicidal potential of the oils in offering effective protection against infestation and damage by *D. maculatus* have been clearly demonstrated in this study; the oils are therefore recommended for utilization in post-harvest preservation of smoke-dried fish.

Keyword: Fatty acids, mortality, preservation

Introduction

Consumption of fish provides important nutrient to a large number of people worldwide and thus makes a very significant contribution to nutrition (Fasakin and Aberejo, 2002; Azam *et al.,* 2004). Fish is easily perishable in tropical climates and needs to be preserved quickly after capture (Omojowo *et al.,* 2009). Drying is one of the most popular means of preservation and dried fish is highly favoured in many traditional Nigerian dishes. Most of the dried fish available to fish consumers in the tropics is smoke-dried, salted, fermented and sun dried. Insects invade dried fish during storage and feed on it extensively causing up to 50% loss in weight (FAO, 1981). Dried fish can suffer considerable loss of weight due to damage caused by insects and mites (Eke *et al.,* 2008). These losses in quantity and quality often lead to lowering or reduction of commercial value. *Dermestes maculatus* is widely recognized as a cosmopolitan pest of stored commodities especially those containing animal protein. The hide beetle feeds on hides, skins, feathers and horns, and it is a known pest of dried fish. Losses in quality and quantity of dried fish

during storage have been attributed to *D. maculatus* infestation (Fasakin and Aberejo, 2002). Pests commonly found on dried fish are beetles, flies and mites (FAO, 1989). In Nigeria, fly genera such as *Calliphora*, *Chrysomia*, *Lucillia* and *Musca* and the beetles, *Dermestes maculatus* Degeer and *Necrobia rufipes* Degeer have been reported as pests of dried fish (Osuji, 1985). *Dermestes maculatus* is widely recognized as a cosmopolitan pest of stored commodities especially those containing animal protein. The hide beetle feeds on hides, skins, feathers and horns, and it is a known pest of dried fish. Losses in quality and quantity of dried fish during storage have been attributed to *D. maculatus* infestation (Fasakin and Aberejo, 2002).

Dermestes maculatus accounts for about 71.5% of dried fish infestation in most of the producing areas with a substantial loss in dry weight of about 43-62.7% from both larvae and adults (Osuji, 1974). Khan and Khan (2001) reported that fish curers apply different types of insecticides such as dichlorvos, malathion, gamaxine, endrine and Dichloro-diphenyl-trichloroethane (DDT) on dried fish to protect them from infestation, thus contravening the recommendations of Codex Alimentaris or FAO/ WHO Joint Meeting Pesticide Residue Committee (JMPRC). One promising area to control pest infestation is the use of plant-derived pest control agents. According to Akinwumi (2011), there are some active ingredients in plant materials which protect fish from beetles and reported 100% toxicity of different plant powders on the adult and larvae of *D. maculatus*. Several natural plant products, including oils derived from plant materials, have been tested as protectants of dried fish from insect infestation. The fruit oil of *Piper guineese* Schum `and Thonn (Uziza) was found to be effective as protectant of dried fish against larval and adult stages of *D. maculatus* (Amusan and Okorie, 2002).

The aim of this study was to evaluate the adverse effects of the oils of *Allium sativum* (Garlic), *Azadirachta indica* (Neem), *Cocos nucifera* (Coconut), *Jatropha curcas* (Jatropha) and *Zingiber officinale* (Ginger) and on the larvae of *D. maculatus.*

Materials and Methods

Source and Processing of plant materials

Azadirachta indica and *Jatropha curcas* seeds were obtained from National Research Institute of Chemical Technology, Zaria, Kaduna State while rhizomes of *Zingiber officinale*, bulbs of *Allium sativum* and fruits of *Cocos nucifera* were purchased from Sabon-gari market, Zaria, Kaduna State. The plant materials were sun-dried for two weeks, pulverized using mortar and pestle and then stored in pre-labelled new plastic bags. Oils were extracted from the resulting powders using Soxhlet procedure with n-Hexane as solvent. The fatty acid compositions of the oils were determined according to standard procedure. (Oils and Fats, 2012).

Culture of *Dermestes maculatus* larvae

Adults of *D. maculatus* were obtained from infested fish concentrates purchased from Sabon-gari market, Zaria. A pure culture of the beetle was maintained on dried fish and wet cotton wool in wire gauze secured Kilner jars at room temperature and 70-80% relative humidity.

Collection of fish

Smoke-dried *Protopterus annectens* were purchased from Sabon-gari market, Zaria and were identified using taxonomic keys.

Bioassay

The smoke-dried fish was heat-sterilized in the oven at 60°C for one hour and allowed to cool down to room temperature after which they were weighed and tagged. The oils were applied to the fish at concentrations of

0.001ml/g of fish, 0.004ml/g, 0.016ml/g, 0.064ml/g and 0.256ml/g. The oil-treated fish were then introduced into separate Kilner jars. 20 larvae of *D. maculatus* were introduced into each jar containing treated fish including the control and labelled for oil type, oil volume and time of larval inoculation. The experiment was replicated thrice for each oil volume. The setup was maintained for 96 hours and mortality of larvae in treatments and control was recorded after 24, 48, 72- and 96-hours exposure period at room temperature. Larvae that failed to respond to the gentle touch of a small pair of forceps were considered dead.

Data Analysis

Mortality data were subjected to Analysis of Variance at $P<0.05$ to determine any significant difference among treatments. Duncan Multiple Range Test (DMRT) was employed to separate the means. Mortality data from all the oils were subjected to Probit Analysis (Finney, 1964) to determine their median lethal concentration (LC_{50}).

Results

Table 1 shows the result for fatty acid composition of the oils. Oleic acid was found only in the oils of *J. curcas* and *A. indica*; octadecanoic acid in *Z. officinale* and *C. nucifera.* Stearic and palmitic acids in *A. indica* and *C. nucifera;* lauric, linoleic and myristic acids *C. nucifera* only; octadecanoic acid in *J. curcas* and cyclopropanepentanoic acid in *Z. officinale*.

The mortality at 0.001ml/g of fish for all the oils is presented in Figure 1. After 96 hours of exposure, *A. sativum* oil was the most effective with a mortality of 15% while *A. indica* oil had the lowest mortality (5%). *C. nucifera* and *J. curcas* had the same mortality of 11.67% at 96 hours of exposure. *Allium sativum* oil had the highest mortality at this concentration with 10% and 21.67% at 24 hours and 96 hours exposure respectively. Although, no significant difference (>>0.05) at 24 hours exposure in comparison with the oil of *C. nucifera* as shown in Figure 2, the lowest mortality of 1.67% was observed in *Z. officinale* at 24 hours while *A. indica* had the lowest mortality from 48 hours (5%) to 96 hours (6.67%) exposure.

The highest mortality was observed in *A. sativum* from 24 hours (35.00%) to 96 hours (53.33%) exposure, which was significantly different ($P \leq 0.05$) from the other plant oils. *A. indica* had the lowest mortality from 24 hours (8.33 %) to 96 hours (10.00%) exposure; while *J. curcas* had the same mortality as *A. indica* at 24 hours and *Z. officinale* at 96 hours (23.33%) exposure for fish administered 0.016mg/l test plant oils. The mortality at 0.064ml/g of all the oils is shown in Figure 4. *Allium sativum* gave the highest mortality from 24 hours (70.00%) to 96 hours (88.33%) of exposure. *C. nucifera* gave the same mortality as *A. sativum* at 48 hours (76.67%) exposure. The lowest mortality was observed in *A. indica* oil from 24 hours (18.33%) to 96 hours (20.00%) exposure. The mortality of all the oils at 0.256ml/g is shown in Figure 4.5. 100% mortality was recorded in *A. sativum, J. curcas* and *C. nucifera.* There was no significant difference ($P>0.05$) among the plant oils from 48 hours to 96 hours, although *A. indica* had the lowest mortality at 24 hours (83.33%) exposure which is significantly different from the other plant oils.

Median Lethal Concentration (LC_{50}) of the Plant Oils

As exposure time proceeds, there was increase in the toxicity of the oil to the larvae of *Dermestes maculatus*. The LC_{50} values of the oils were obtained from the graphs Figure 6 – Figure 10. The values obtained include; 5.495 for *A. indica*, 0.011 for *A. sativum*, 0.021 for *C. nucifera* 0.066 for *J. curcas* and 0.200 for *Z. officinale*. A lower LC_{50} is indicative of

increased toxicity, which shows that *A. maculatus* larvae. *sativum* was of higher toxicity to *D.*

Table 1: Fatty acid composition (%) of the plant oils of *Allium sativum, Cocos nucifera, Jatropha curcas, Zingiber officinale* and *Azadirachta indica*

	Oil type (%) ±S.E.				
Fatty Acids	***A. sativum***	***Z. officinale***	***J. curcas***	***A. indica***	***C.nucifera***
Pentadecanoic acid (U)	5.6±0.25	_	6.20±0.01	_	_
Palmitic acid (S)	7.57±0.18	_	_	20.09±00	12.84±0.69
Elaidic acid (M)	12.68±0.54	_	_	9.87±0.98	-
Stearic acid (S)	5.91±1.97	32.38±5.60	_	2.96±0.17	3.24±0.17
Hexadecanoic acid (S)	47.60±6.56	_	_	_	_
Pentanoic acid (S)	5.36±0.43	8.87±0.01	_	_	_
Oleic acid (M)	_	_	25.30±0.09	60.13±2.8	_
Lauric acid (S)	_	_	_	_	1.76±0.00
Myristic acid (S)	_	_	_	_	0.88±0.19
Linoleic acid (U)	_	_	_	_	47.54±4.75
Total	**84.72±9.93**	**74.80±6.82**	**31.50±0.10**	**93.05±3.95**	**73.39±5.80**

U= Unsaturated, M= Monounsaturated, S=Saturated

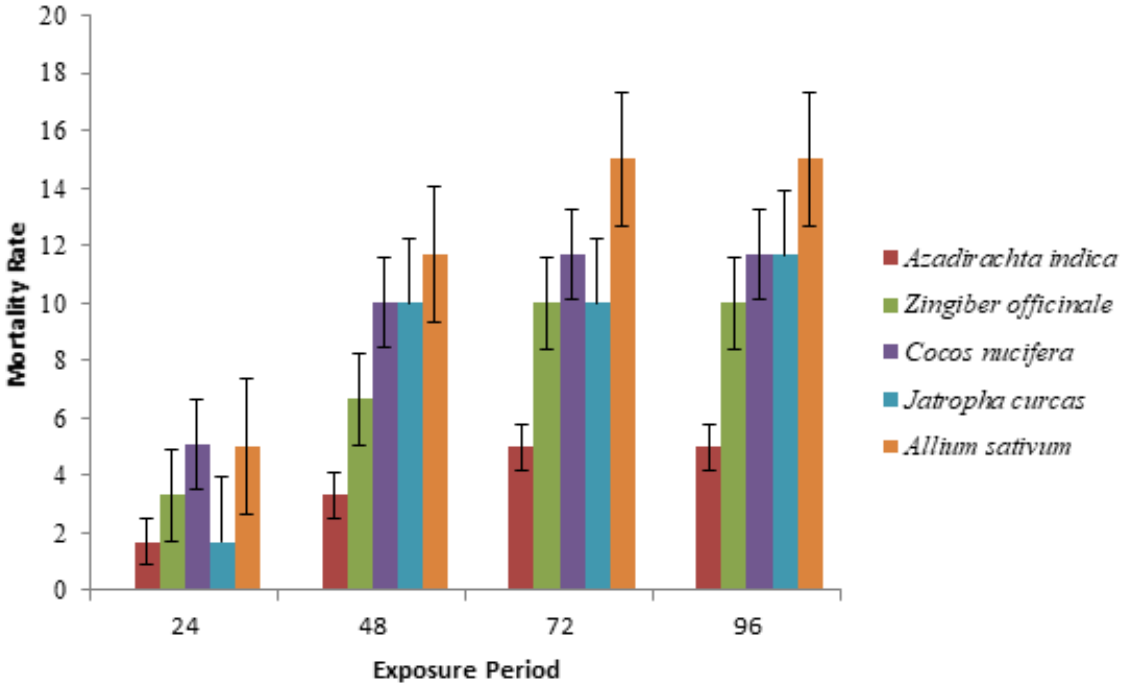

Figure 1: Mortality of *Dermestes maculatus* larvae exposed to 0.001ml/g test plant oils

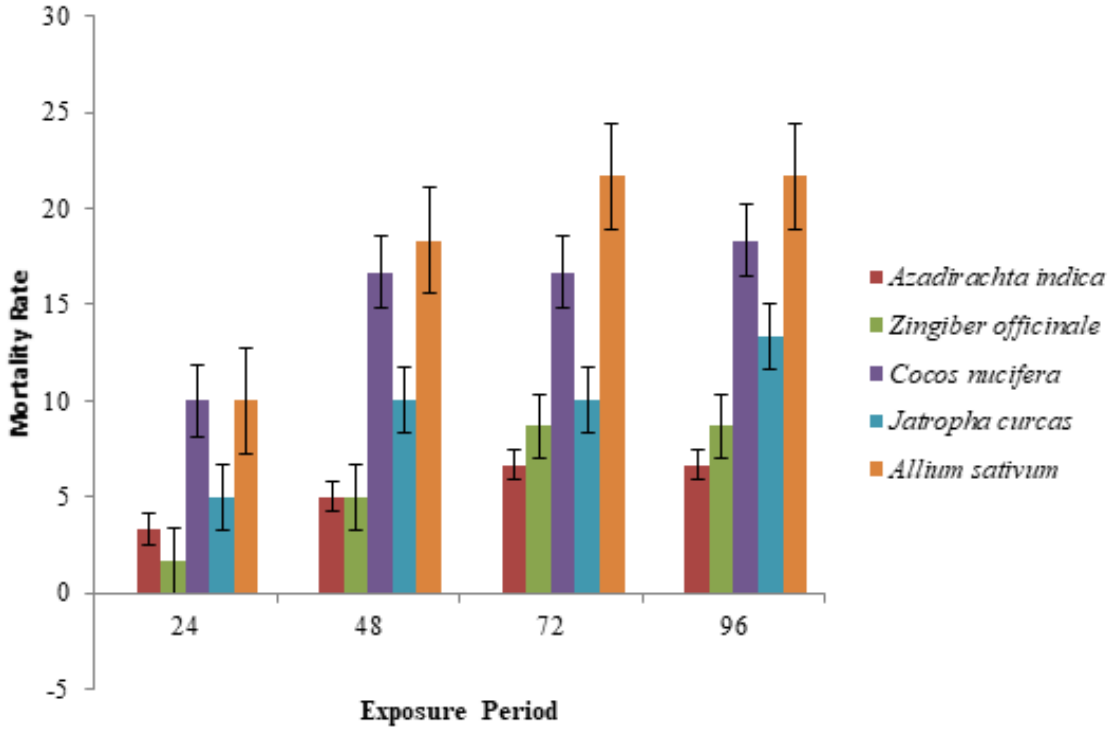

Figure 2: Mortality of *Dermestes maculatus* larvae exposed to 0.004ml/g test plant oils

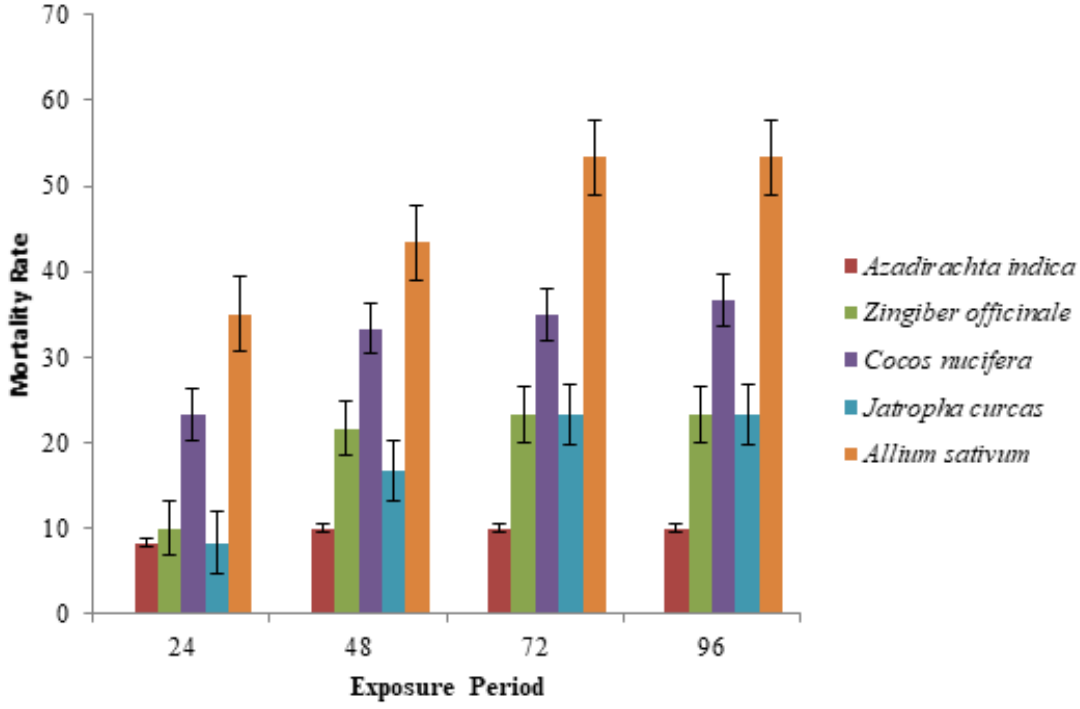

Figure 3: Mortality of *Dermestes maculatus* larvae exposed to 0.016ml/g test plant oils

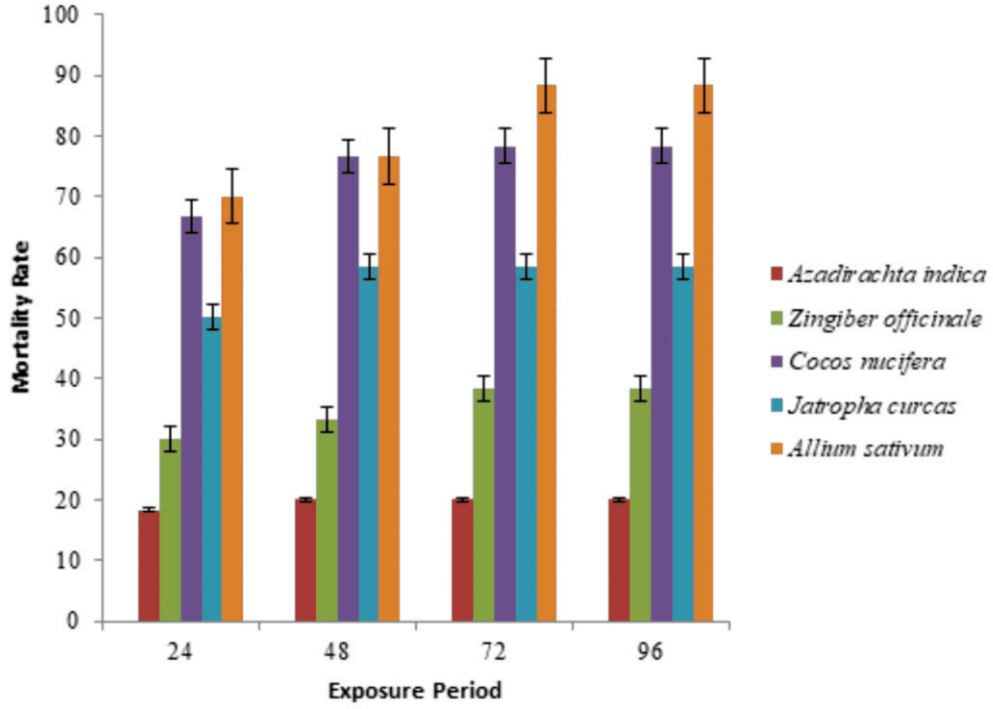

Figure 4: Mortality of *Dermestes maculatus* larvae exposed to 0.064ml/g test plant oils

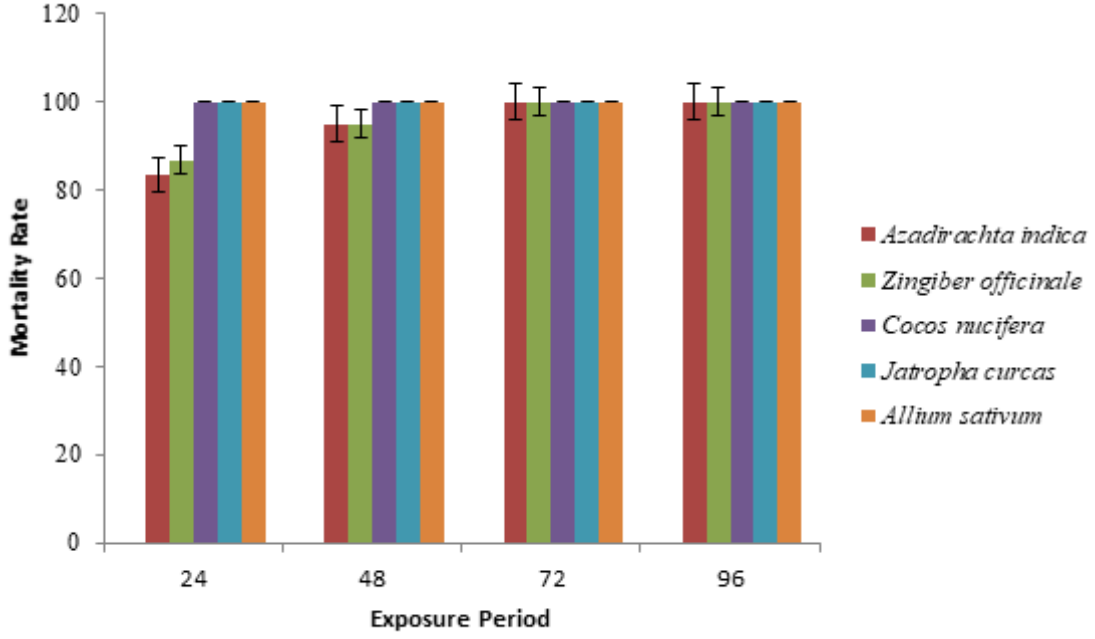

Figure 5: Mortality of *Dermestes maculatus* larvae exposed to 0.256ml/g test plant oils

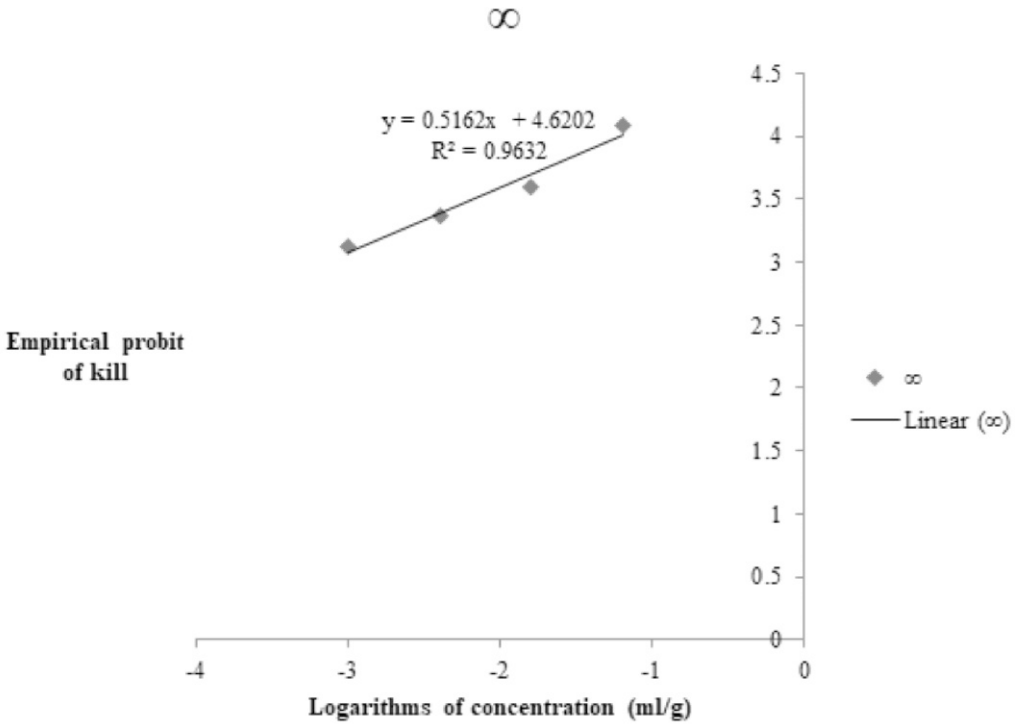

Figure 6: Probit determining the LC_{50} of *Azadirachta indica* oil against the larvae of *Dermestes maculatus*

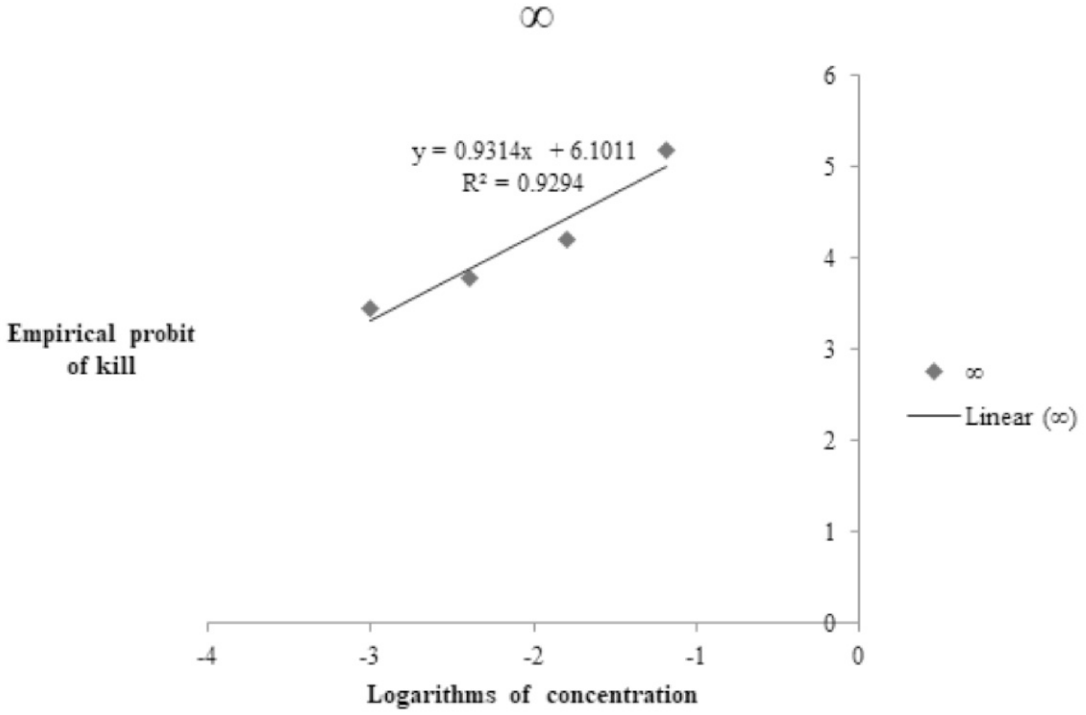

Figure 7: Probit determining the LC_{50} of *Jatropha curcas* oil against the larvae of *Dermestes maculatus*

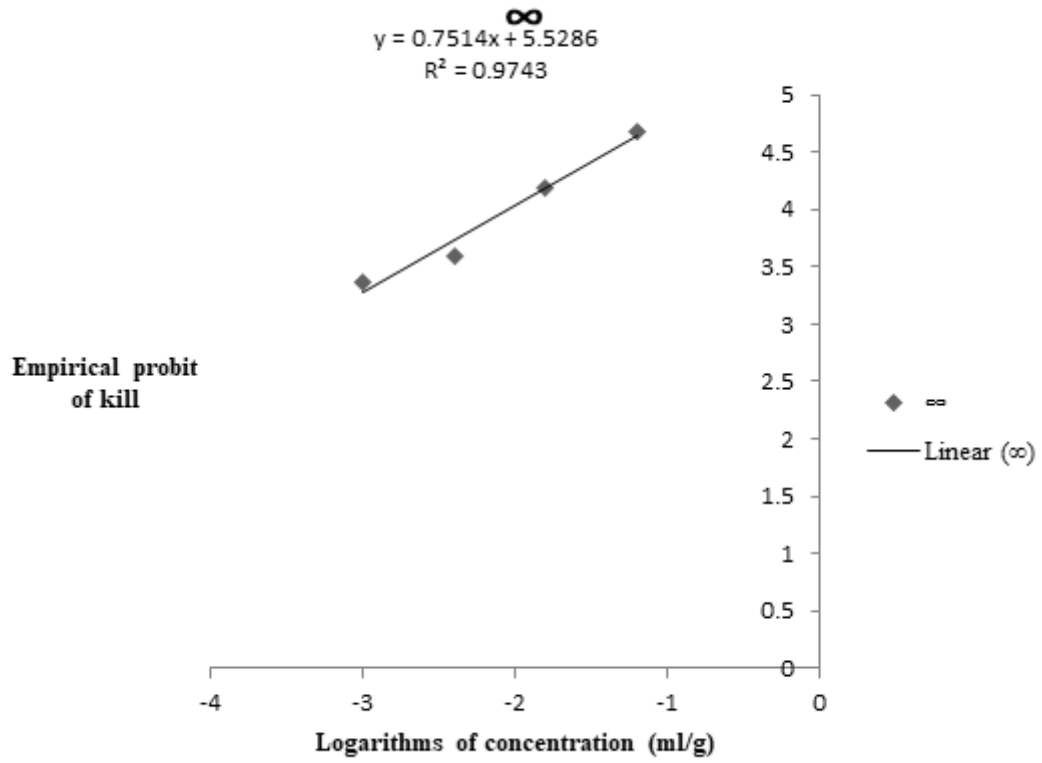

Figure 8: Probit determining the LC_{50} of *Zingiber officinale* oil against the larvae of *Dermestes maculatus*

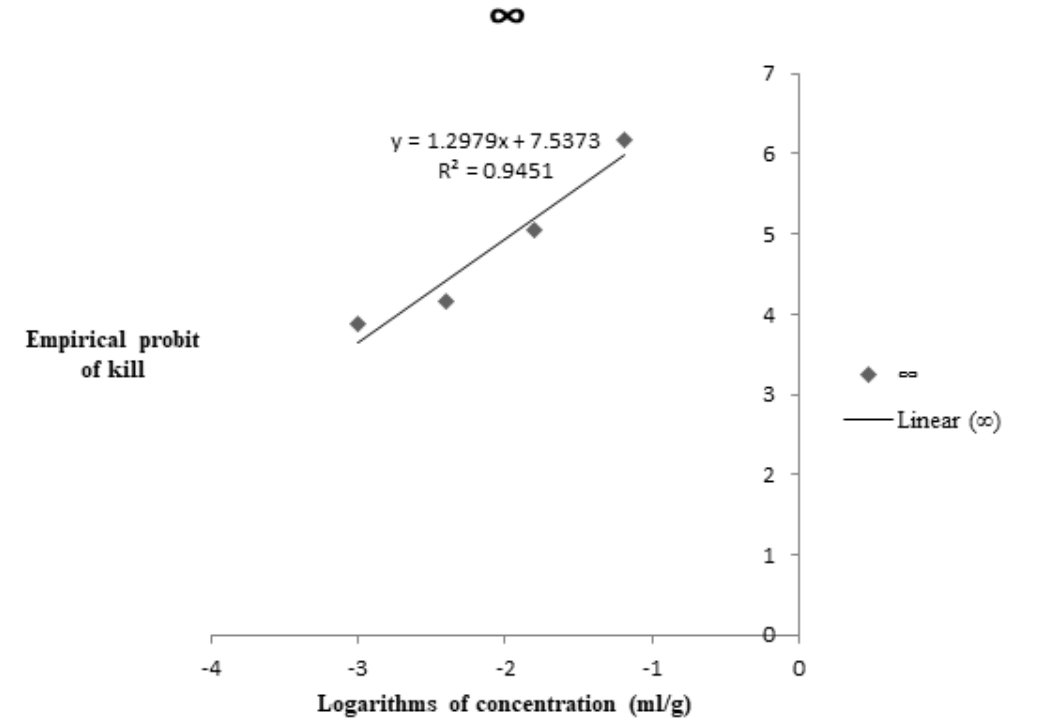

Figure 9: Probit determining the LC_{50} of *Allium sativum* oil against the larvae of *Dermestes maculatus*

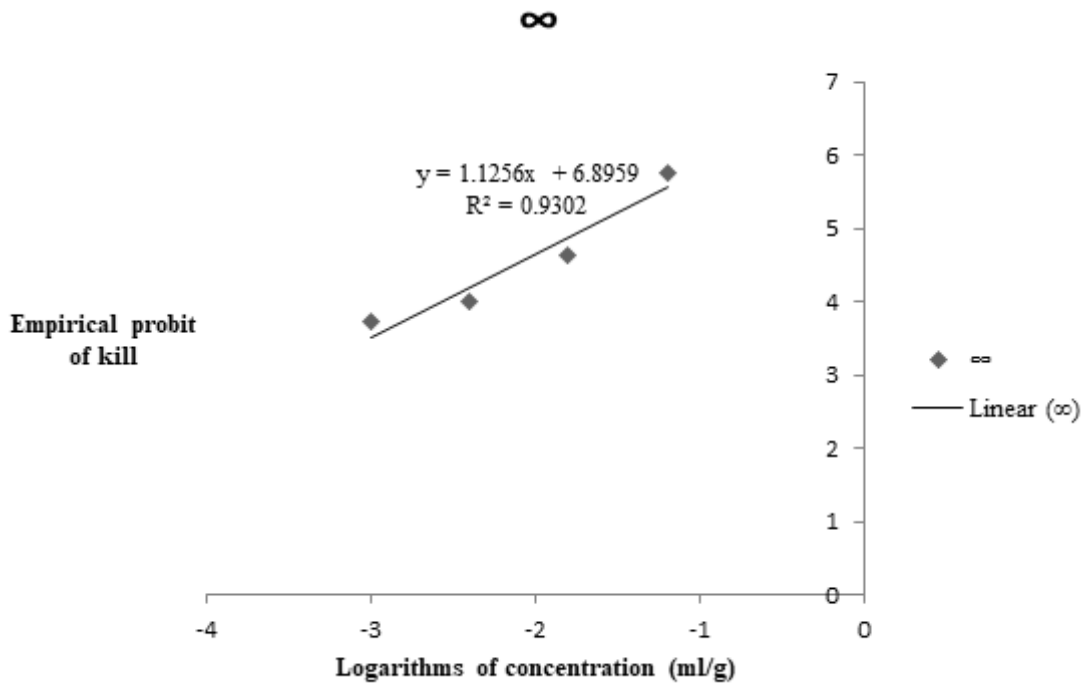

Figure 10: Probit graph for determining the LC_{50} of *Cocos nucifera* oil against the larvae of *Dermestes maculatus*

Discussion

The result of this study indicate that the highest larval mortality was caused by the oils of *A. sativum* and this was closely followed by *C. nucifera*. This phenomenon could be ascribed to the presence of fatty acids in the oils especially hexadecanoic acid (47.6%) in *A. sativum* and linoleic acid (47.54%) in *C. nucifera* which had the highest composition in theseoils. The fatty acids found in *A. sativum* oil have been reported to show larvicidal activities when isolated. According to Rahuman *et al.* (2000), n-hexadecanoic acid in *Feronia limonia* dried leaves was toxic against fourth instar larvae of *Culex quinquefasciatus*, *Anopheles stephensi* and *A. aegypti* while Salud *et al.* (2011) reported that oleic, palmitic and stearic acids extracted from *Carica papaya* showed insecticidal activity against *Spodoptera frugiperda* (armyworm). Ramsewak *et al.* (2001) found that both linoleic and oleic acids isolated from hexane of *Dirca palustris* (leatherwood) seeds were toxic when tested against fourth instar larvae of *A. aegypti* at 24hours exposure.

Various amounts of oleic and linoleic acid were detected in the some of the oils, the presence of the fatty acids could have contributed to the efficacy of the oils against *D. maculatus*. According to Rollo *et al.* (1995), oleic and linoleic acids have been indicated in death recognition and death aversion (repellency) in cockroaches. It has been established in this study that oils obtained from *A. sativum*, *A. indica*, *C. nucifera*, *J. curcas* and *Z. officinale* induce high mortality in the larvae of *Dermestes maculatus* infesting smoke-dried *P. annectens*, particularly at the highest tested concentration (0.256ml/g). The toxicity of the oils must be due to some of their components having insecticidal

properties; these components may also act in synergy to enhance the toxic substances present in the oils either by increasing or prolonging their effects. The effectiveness of these plant oils may stem from their impact on the respiratory system of the insect larvae by blocking the spiracles and preventing oxygen inhalation, leading to death. Death of stored product pests due to asphyxia when oils are applied to grains has been reported by Cooping and Menn (2000).

Conclusion

The oils of *Cocos nucifera, Zingiber officinale*, *Jatropha curcas*, *Azadirachta indica* and *Allium sativum* have larvicidal effects on the larvae of *D. maculatus*. The oil of *Allium sativum* caused the highest mortality whereas that of *Azadirachta indica* caused the least. The oils caused high mortality of the larvae of *Dermestes maculatus* at different concentrations.

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