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Entomotoxicant Potential of Some Medicinal Plant Against *Ephestia cautella* Infesting Cocoa Bean in Storage

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Abstract: The entomotoxicant action of five different medicinal plant oils extracted with different solvents tested against *Ephestia cautella* infestation was conducted under laboratory condition. The ethanolic and petroleum ether extract of the botanicals were made using soxhlet apparatus. The oils were tested against the insect at 0.5 and 1.0ml dosages and each treatments were replicated three times. The ethanolic oil extract of *M. tennuifolia* was only the extract that acheived 100% moth mortality and its effect was significantly ($p<0.05$) different from all other extracts. However, petroleum ether increased the effect of the other extracts on the survival of the moth as reflected by their LD_{50}. Regardless of the solvent used, all the oils reduced the hatchability of the egg of the insect while adult emergence of the insect was prevented by all the oil extracts except 0.5ml dosage of *C. frutescens* and *A. occidentale*. Since ethanolic extract of *M. tennuifolia* appeared most effective against the adult moth, it could be recommended for immediate control of *E. cautella* infestation while other extracts could be used as protectant.

Keywords: *Ephestia cautella*; cocoa; medicinal plants.

1. Introduction

Insect pests are the major constrains to man's development as their role in food insecurity of many developing nations cannot be over emphasized. In fact, the economic growths of many countries are continuously reducing solely because of insect pests savaging their agricultural produce and products. Ashamo and Ogungbite [1] linked the retrogrades experienced in the economy of many nations to the low growth in agriculture because it is believed that decrease in growth of agriculture sector of any nation is directly proportional to the backwardness of such country [2]. Because of ease of reproduction and multiplication of insects as well as their ability to infest agricultural produce both on the field and in storage, they almost win the vying between them and human in term of food availability. In Nigeria, there is continuous increase in the amount of food importation because of the shortfall in food availability in the country due to high level of post-harvest losses in which insect is a major chief [1-2].

Cocoa (*Theobroma cacao*) is the most popular cash crop in West African countries. In Nigeria, before the discovery of petroleum in the early 1970s, cocoa was the major cash crop exported to foreign countries. In fact, more than half of the total revenue generated from agriculture sector in the country was derived from cocoa exportation alone [3-5]. In spite of the importance of this pertinent crop, the discovery of crude oil had significantly reduced its production and government concern for it had greatly reduced. Because of the less attention given to this worthful cash crop, various challenges among which insect infestation is the most important has been encumbering its

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production and storage [6]. Insect pests ranging from beetle to weevil to moth have been found to be a major factor exacerbating the storage of this crop and they have brought about diminution in the number of individual investing on it production in Nigeria.

Over the years, synthetic chemical insecticides ranging from carbamate to organophosphates to organochlorine have been employed extensively for the control of major insect pests of cocoa including *Lasioderma serricorne*, *Tribolium castaneum*, *Ephestia cautella* and *Corcyra cephalonica* but the dents coupled with them are demoting their popularity and usage in the past few years. So many methods are being suggested to be alternative means of controlling insect pests of cocoa and other stored product insects. Besides, before the discovery of the nowadays popular synthetic chemical insecticides, plant powders and ashes are major missiles used against insect pest by farmers [7-9]. Therefore, researches have been shifted toward the use of plant materials as they were believed to contain myriads of allelochemicals that could be insecticidal in nature while many of them have been proven to be highly medicinal and eco-friendly [1, 9-10]. Ashamo and Ogungbite [1] however opined that the ability of any plant materials to be effective as an insecticide depend on the ability of the solvent used for it extraction to extract its active compounds. Different solvents ranging from polar to nonpolar have their ability of extracting active compounds in plant and also have effect on the effectiveness of the plant materials [11-12]. This present study investigated the effect of two different solvents on the entomotoxicant ability of five different medicinal plants against *Ephestia cautella* infesting cocoa beans.

2. Materials and Methods

2.1. Insect culture

The starter culture used was collected from an existing culture of *E. cautella* in the storage laboratory of the Department of Biology, Federal University of Technology, Akure. The insects were reared on a cocoa powder collected from Oluji cocoa processing company, Ile Oluji, Ondo State, Nigeria. The culture was left for few days to allow the insect to mate and for new adults to emerge.

2.2. Collection of cocoa powder and plant materials

The cocoa powder used was collected from Oluji cocoa processing company and the powders were disinfested inside oven at 70^{o}C for 60 minutes and were kept inside air-tight container until further use. Plant materials used were bought from Oja Oba in Akure and part used is the seed. The seeds were air dried in the laboratory and were pulverized into fine powder with electronic blender. The pulverized plant powders were separately kept in different air tight containers until use.

2.3. Preparation of plant extracts

Twenty grams of the pulverised plant material were put in a muslin cloth and transferred into the thimble and extracted with the soxhlet extractor. The extraction was carried out for about 4 hrs. Thereafter the thimble was removed from the unit and the solvent was separated from the oils using rotary evaporator. The resulting extracts were exposed to the air to remove traces of the solvent. The extracted oils were kept in bottles with lids and stored in a refrigerator until needed. The extraction was done using ethanol and petroleum ether as solvents.

2.4. Bioassay

The effect of the oil extracts on the mortality of the insect will be tested by treating the 2cm by 8cm and 5mm thick white cardboard paper with 0.5 and 1.0ml of the oil extracts of the plants. Two control treatments will be made (positive and negative controls). The negative control will be made by mixing 1ml of the three solvents together in ratio 1:1:1 while Deet will be used as positive control. The treated cardboards will be allowed to air dry before they will be placed separately inside air tight plastic container. Ten male and female of the insect will be introduced into those treated cardboard inside containers and will be covered. The mortality of *E. cautella* will be observed after 24, 48, 72 and 96 hours of application. The experiment will be setup in a complete randomize design with each treatments replicated three times.

2.5. Effect of oils on mortality of fourth instar larval of *E. cautella*

Twenty *E. cautella* fourth instar larvae were introduced into 20 g of cocoa beans treated with 0.5 and 1.0 ml plant materials and each treatment was replicated three times. Cocoa beans that were not treated were set up as control 3 while those treated with 1.0ml of ethanol and petroleum ether were set up as control 1 and 2 respectively. The larval mortality was examined at 24 h interval. The experiment was setup in a complete randomize design.

2.6. Effect of plant oil on hatchability and adult emergence of *E. cautella*

Newly emerged adult *E. cautella* were paired inside a glass vials covered with muslin cloth. Less than a day freshly laid eggs were collected from the glass vials and were placed on filter papers treated with 0.5 and 1.0ml oil extracts inside different Petri dishes. The treatments were replicated three times. Eggs placed on untreated filter papers inside Petri dishes were set as control. After introduction, the eggs were observed for hatchability with aids of stereomicroscope for five days. The numbers of egg hatched were counted.

2.7. Statistical Analysis

The data obtained were subjected to one-way analysis of variance at 0.05 significant levels while means were separated with New Duncan's Multiple Range Tests using SPSS version 17. Also data, obtained from weevil's mortality, were subjected to regression analysis to calculate the LC_{50} of the oil extracts using probit analysis (Finney, 1971).

3. Results

3.1. Mortality of adult *E. cautella* exposed to 0.5 and 1.0ml of ethanolic and petroleum ether oil extract of different plant materials

The effect of ethanol and petroleum ether oil extract of five different medicinal plants at 0.5 and 1.0ml dosage on survival of *E. cautella* was presented on Table 1. The rate of mortality of the insect varied with types of plant materials, solvent used, dosage used and period of exposure. Regardless of the type of solvent used and dosage of the oils, none of the plants achieved upto 50% insect mortality within 48 hours post treatment. Within 72 hours of application, only the ethanolic oil extract of *M. tennuifolia* recorded above 75% *E. cautella* mortality and was also the oil extract that achieved 100% insect mortality within 96 hours post treatment. The effect of ethanolic extract of *M. tennuifolia* at these periods of exposure was significantly (p<0.05) different from other oil extracts. However, petroleum ether of these plants achieved high mortality of the insect than their ethanolic extract except ethanolic oil extract of *M. tennuifolia* which appeared most effective.

Table 1. percentage adult mortality of *E. cautella* treated with 0.5 and 1.0ml of ethanolic and peteroleum ether of some medicinal plants

Solvent	Dosage (ml)	Plant materials	%mortality in hours			
			24	48	72	96
Ethanol	0.5	*C. frutescens*	0.00±0.00[a]	1.63±1.12[a]	11.30±0.27[bc]	35.70±0.16[bc]
		A. occidentale	0.00±0.00[a]	15.30±0.19[b]	26.30±0.36[d]	28.60±1.14[b]
		M. tennuifolia	13.40±1.71[b]	15.60±0.50[b]	32.20±0.70[d]	48.60±0.11[c]
		X. aethiopica	10.00±0.00[b]	13.42±0.42[b]	18.60±0.51[c]	40.40±0.13[c]
		R. communis	3.40±1.71[a]	11.90±2.88[b]	12.30±0.27[bc]	28.62±0.14[b]
	1.0	*C. frutescens*	0.00±0.00[a]	8.50±0.33[b]	18.40±2.04[c]	40.00±0.24[c]
		A. occidentale	0.00±0.00[a]	25.40±2.55[de]	43.90±0.16[g]	66.10±0.20[e]
		M. tennuifolia	14.00±1.50[b]	41.90±0.25[f]	78.90±0.39[i]	100.00±0.00[g]
		X. aethiopica	13.42±0.52[b]	18.60±0.51[cd]	43.90±0.16[f]	60.70±0.22[e]
		R. communis	6.70±1.34[a]	8.40±0.33[b]	15.8±0.29[c]	35.70±0.53[bc]
Pet-ethan	0.5	*C. frutescens*	11.30±0.17[b]	25.40±0.29[de]	50.90±0.20[fg]	67.80±3.11[e]
		A. occidentale	0.00±0.00[a]	32.20±3.33[e]	43.90±0.18[f]	66.60±3.33[e]
		M. tennuifolia	10.00±0.00[b]	32.40±0.29[d]	53.90±0.18[g]	68.30±0.23[e]
		X. aethiopica	6.60±0.13[a]	25.40±0.29[de]	29.90±1.17[d]	39.30±0.21[c]
		R. communis	3.40±0.70[a]	11.90±0.09[b]	14.30±0.14[bc]	28.80±0.24[b]
	1.0	*C. frutescens*	10.00±0.12[b]	25.40±0.29[de]	61.40±2.00[h]	75.00±0.24[f]
		A. occidentale	3.40±0.70[a]	41.90±1.18[f]	54.30±0.51[f]	75.00±0.24[f]
		M. tennuifolia	13.40±2.27[b]	42.20±2.20[e]	67.90±0.62[h]	78.30±0.33[f]
		X. aethiopica	6.70±0.22[a]	28.60±0.53[de]	33.40±1.15[e]	68.10±0.30[ef]
		R. communis	6.70±0.22[a]	18.40±0.33[cd]	22.70±0.13[d]	45.70±0.21[bc]
Control 1	1.0		0.00±0.00[a]	2.50±1.42[a]	6.00±0.24[ab]	6.00±0.24[a]
Control 2	1.0		0.00±0.00[a]	0.25±0.25[a]	4.60±1.33[a]	6.00±0.00[a]
Control 3	0.0		0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]

Each value is a mean ± Standard error of three replicates. Values followed by the same alphabet in the same column are not significantly (p>0.05) different from each other using New Duncan's Multple Range Test.
Note: Control 1 is ethanol solvent control; Control 2 is pet-etha solvent control; Control 3 is the untreated contro.

3.2. Mortality of larvae *E. cautella* exposed to 0.5 and 1.0ml of ethanolic and petroleum ether oil extract of different plant materials

Table 2 presented the effect of the plant oil extracts at 0.5 and 1.0ml dosage on the survival of *E. cautella*. The mortality of the insect varied with type of plant materials and the dosage of the oil extract as well as the solvent used and period of exposure. Regardless of the dosage and the solvent used, none of the plant oil extracts achieve 50% *E. cautella* larvae mortality. Nevertheless, the oil extract of *A. occidentale* achieved the highest insect larvae mortality of 68% within 96 hours of application at 1.0ml dosage and it effect was significanlty (p<0.05) different from other extracts except the petroleum ether extract of *X. aetheiopica* at the same dosage. The effectiveness of the petroleum ether of the oils was higher than their ethanolic extract except the the ethanolic extract of *M. tennuifolia* in which their ethanolic extract was more effective. However, after 96 hours of application all the plant oil extracts were significantly ($p<0.05$) different from the controls except the ethanolic extract of *C. frutescens* at 0.5ml dosage.

Table 2. percentage adult mortality of *E. cautella* treated with 0.5 and 1.0ml of ethanolic and peteroleum ether of some medicinal plants

Solvent	Dosage (ml)	Plant materials	% mortality in hours			
			24	48	72	96
Ethanol	0.5	*C. frutescens*	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]
		A. occidentale	6.70±0.60[a]	42.40±0.33[d]	48.10±0.37[d]	47.20±2.22[e]
		M. tennuifolia	0.00±0.00[a]	6.70±0.22[a]	12.80±0.17[a]	32.20±1.14[b]
		X. aethiopica	6.70±0.60[a]	15.30±0.29[b]	15.80±4.12[b]	32.20±1.06[c]
		R. communis	0.00±0.00[a]	0.00±0.00[a]	5.30±0.28[a]	3.50±0.24[a]
	1.0	*C. frutescens*	0.00±0.00[a]	1.70±0.22[a]	5.20±0.12[a]	7.20±1.40[bc]
		A. occidentale	13.40±0.27[b]	49.10±1.95[d]	52.40±0.12[g]	63.60±1.60[g]
		M. tennuifolia	0.00±0.00[a]	15.90±0.32[b]	26.30±0.33[c]	64.10±1.40[g]
		X. aethiopica	10.00±0.00[b]	16.20±2.86[b]	36.80±0.62[d]	46.50±2.52[e]
		R. communis	0.00±0.00[a]	0.00±0.00[a]	10.80±0.29[b]	15.60±0.24[c]
Pet-ethan	0.5	*C. frutescens*	0.00±0.00[a]	5.10±0.29[a]	1.80±1.27[a]	14.30±1.16[c]
		A. occidentale	6.70±3.42[a]	15.32±0.29[b]	55.80±0.58[e]	57.50±3.00[f]
		M. tennuifolia	5.10±1.30[a]	15.70±0.32[b]	32.30±1.27[d]	44.30±0.58[e]
		X. aethiopica	6.80±0.00[a]	11.90±0.88[b]	40.00±0.00[d]	44.20±0.67[e]
		R. communis	0.00±0.00[a]	0.00±0.00[a]	1.80±0.12[a]	8.80±1.14[bc]
	1.0	*C. frutescens*	26.70±2.12[c]	28.80±1.27[c]	33.40±0.88[d]	36.70±0.19[d]
		A. occidentale	23.40±0.24[c]	45.80±1.30[d]	57.90±0.25[e]	67.80±0.27[g]
		M. tennuifolia	10.22±0.28[b]	11.30±0.29[b]	23.40±1.17[c]	32.20±0.33[d]
		X. aethiopica	10.24±0.00[b]	49.40±1.33[d]	57.40±0.25[e]	65.00±0.63[g]
		R. communis	0.00±0.00[a]	0.00±0.00[a]	18.60±1.88[b]	32.10±0.29[d]
Control 1	1.0		0.00±0.00[a]	0.25±0.25[a]	0.25±0.25[a]	2.50±0.23[a]
Control 2	1.0		0.00±0.00[a]	0.25±0.25[a]	0.25±0.25[a]	1.70±0.65[a]
Control 3	0.0		0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]

Each value is a mean ± Standard error of three replicates. Values followed by the same alphabet in the same column are not significantly ($p>0.05$) different from each other using New Duncan's Multple Range Test.
Note: Control 1 is ethanol solvent control; Control 2 is pet-etha solvent control; Control 3 is the untreated control

3.3. Lethal dosage (LD_{50}) of oil extracts of different botanicals in *E. cautella* after 72 h

The amount of oil extracts needed to achieve 50% mortality of adult and larvae of *E. cautella* were presented in Table 3. *M. tennuifolia* appeared most effective against the adult moth as it recorded the lowest amount of dosage (0.33ml) to achieve 50% adult moth mortality if compared to other oil extracts. However, larger of amount of the dosages of the oils were required to achieve high mortality *E. cautella* larvae. Moreover, the amount of petroleum ether oil extracts of the botanicals appeared more effective than their ethanolic extract as reflected by their fiducial limits except the *M. tennuifolia* in which its ethanolic extract was more effective than its petroleum ether extract. Regardless of the solvent used, the oil extract of *R. communis* appeared least effective against the larvae and adult *E. cautella* among the oil extracts.

Table 3. Lethal concentration of the oil extracts required to achieve 50% mortality of *E. cautella* adult and larvae after 72 hours post treatment

Insect life stages	solvents	LC_{50} of different plant materials				
		C. frutescens	*A. occidentale*	*M. tennuifolia*	*X. aethiopica*	*R. communis*
Adult	Ethanol	2.12 (2.08-2.32)	0.87 (0.83-0.92)	0.33 (0.30-0.50)	1.10 (1.00-1.48)	2.21 (2.10-2.70)
	Pet-ether	0.48 (0.34-0.82)	0.49 (0.34-0.84)	0.76 (0.72-0.82)	0.76 (0.72-0.82)	1.62 (1.59-1.69)
Larvae	Ethanol	4.68 (4.36-4.80)	0.97 (0.94-1.00)	3.58 (2.98-3.63)	2.44 (2.12-2.62)	4.23 (4.21-4.26)
	Pet-ether	2.64 (2.30-2.82)	0.76 (0.72-0.84)	3.64 (3.55-3.68)	0.78 (0.74-0.80)	4.19 (3.96-4.10)

Values in parenthesis represent 95% fiducial limits.

3.4. The effect of ethanolic and petroleum ether oil extract of different botanicals at different dosages on hatchability and adult emergence of E. cautella

Table 4 shows the effect of 0.5 and 1.0ml of ethanolic and petroleum ether oil extract of different botanicals on hatchability and adult emergence of E. cautella. In spite of the solvent used, the oil extracts significantly reduced the hatchability of the insect eggs when compared with the controls. 1.0ml of ethanolic oil extract of *M. tennuifolia* and petroleum ether oil extract of *X. aethiopica* appeared most effective as they recorded lowest % egg hatched of 13.30 and their effect was significanlty ($p<0.05$) different from other extracts. However, none of the extract was able to prevent the hatchability of the insect eggs. Regardless of the solvent and dosage used, oil extract of *M. tennuifolia*, *X. Aethiopica*, and *R. communis* prevented the emergence of adult E. cautella but their effect was not significantly ($p>0.05$) different from *C. frutescen*s and *A. occidentale* oil extracts.

4. Discussion

Insects of stored products have caused significant effect on the food security of the world population especially in the countries where pest control and management is not of major concern. However, synthetic chemical insecticides of various kind have been employed for ages to control the activities of these insects until recently when researches have been shifted toward other methods of insect control because of the perils associated with them. Botanicals and their derivatives are one of the new boulevard of insect control but the type of solvent used for the extract of their active compound has effect on their effectiveness [1].

The result of this research showed that all the oil extracts of the medicinal plants used, have significant effect on the survival of the adult and larvae of E. cautella as well as their eggs. The effectiveness of the oils varied with the type of solvent used for their extraction. The ethanolic extract of M. tennuifolia recorded the highest adult moth mortality while peroleum ether oil extract of A. occidentale recorded the highest larvae mortality. However, it was noted that the effectiveness of the petroleum ether oil extract of the botanicals on both the adult and larvae of *E. cautella* was higher than their ethanolic exract except *M. tennuifolia* in which its ethanolic extract was more effective than its petroleum ether oil extract. Regardless of the dosage used, *M. tennuifolia* was more effective than other oil extracts as reflected by its LD_{50} and the fidicual limit (0.30-0.50). In the same manner, the petroleum ether of *A. occidentale* appeared most potent as shown by its lethal dosage (0.72-0.84). The ability of the oils of these botanicals could be as a result of inability of the insect to feed on the oil coated cocoa beans which may in return leads to starvation. The oil extracts may have also disrupted the normal respiratory activity of the insect and this may lead to asphyxiation and death of the insect. The effect of the oil extracts on the larvae of *E. cautella* could be due to their inability to fully cast off their exoskeleton that attached to their posterior part of their abdomen [1, 6, 13]. The result obtained on the mortality of *E. cautella* exposed to different dosages of botanical oil extracts acquiesced with the work of [14] in which powders of C. patent showed high effecctiveness againt adult *P. Interpunctella*.

Table 4. Effect of 0.5 and 1.0ml of ethanolic and petroleum ether oil extracts of different plants on the *E. cautella* egg hatchability and adult emergence

Solvent	Dosage (ml)	Plant materials	% Hatchability	%adult emergence
Ethanol	0.5	*C. frutescens*	66.10±0.46[ef]	2.00±0.33[a]
		A. occidentale	50.00±1.19[d]	5.00±0.31[a]
		M. tennuifolia	46.70±0.29[cd]	0.00±0.00[a]
		X. aethiopica	68.80±0.42[ef]	0.00±0.00[a]
		R. communis	39.30±0.42[c]	0.00±0.00[a]
	1.0	*C. frutescens*	63.30±1.11[e]	0.00±0.00[a]
		A. occidentale	28.70±0.21[b]	0.00±0.00[a]
		M. tennuifolia	13.30±0.24[a]	0.00±0.00[a]
		X. aethiopica	73.30±0.56[f]	0.00±0.00[a]
		R. communis	26.40±0.33[b]	0.00±0.00[a]
Pet-ethan	0.5	*C. frutescens*	60.00±0.58[e]	5.60±0.11[a]
		A. occidentale	60.00±0.58[e]	4.40±1.13[a]
		M. tennuifolia	76.70±0.42[f]	0.00±0.00[a]
		X. aethiopica	73.30±0.21[f]	0.00±0.00[a]
		R. communis	43.30±0.27[cd]	0.00±0.00[a]
	1.0	*C. frutescens*	43.30±1.23[cd]	0.00±0.00[a]
		A. occidentale	43.30±1.23[cd]	0.00±0.00[a]
		M. tennuifolia	66.70±0.40[e]	0.00±0.00[a]
		X. aethiopica	13.30±0.27[a]	0.00±0.00[a]
		R. communis	36.70±0.29[c]	0.00±0.00[a]
Control 1	1.0		85.00±0.35[g]	80.00±0.55[b]
Control 2	1.0		89.00±1.27[g]	81.00±0.63[b]
Control 3	0.0		90.00±0.57[g]	84.50±0.33[b]

Each value is a mean ± Standard error of three replicates. Values followed by the same alphabet in the same column are not significantly (p>0.05) different from each other using New Duncan's Multple Range Test.
Note: Control 1 is ethanol solvent control; Control 2 is pet-etha solvent control; Control 3 is the untreated control

The result obtained in this reserch also presented the oils of all the botanical used to significantly reduced or prevented the egg of the insect from hatching and their larvae from emerging into adullt. Nevertheless, the petroleum ether of oil extract of *A. occidentale* showed the highest efficacy against the hatching of the egg of the insect. The inability of the eggs to hatch could be as a result of the oils which may have blocked the breathing pore (chorion) of the eggs and thereby cause subsequent death of the larvae which might have emerged into adult. Also, the ability of the oil extracts to prevent the hatching of the eggs and emergence of the adult could be due to the active allelochemicals present in the plants. More so that many of the phytochemicals present in botanicals have been noted to have growth inhibitory effect on insects and as well disrupt the post embryonic development of insect larvae [9, 15-16].

In addition, Bhaduri et al. [17] findings showed that phytochemicals present in plants have homicidal effect which could result in protoplasm coagulation affecting the supply of oxygen and thereby lead to the death of insects. The result obtained on the egg hatchability and adult emergence of *E. cautella* was supported by the findings of [6] in which some botanical oils were found to prevent the hatching of the egg as well as emergence of adult *E. cautella*. The result of this research also agreed with the work of Ashamo and Akinneye [18] in which M. tennuifolia oil extracts reduced the hatching of some insects egg. The report of [1] also showed the efficacy of some plant oil extracts extracted with different solvent against the emergence of adult moth, *Sitotroga cerealella*.

The control of major pest of stored products have gained the attention of many world entomologist but despite the effectiveness of many botanicals that have been suggested to be effective, insect infestation is still at high level. This is probably because different solvent used for the extraction of the oil of these botanicals have different ability of extracting their active compound as opined by [1]. Furthermore, many of the botanicals are effective against the adult insects while others are effective as protectant against other life stages such as egg and larvae which were believed to be more disructive than the adults [1]. Therefore, since botanical still remained the most popular alternative to obviate the hardous synthetic chemical insecticides, the need to understand the best solvent for their extraction, parts that will be most effective and the insect life stage in which their effect will be more pronounced is of great importance.

With the result of this research, it could be suggested that the ethanolic extract of *M. tennuifolia* should be employed for the control of *E. cautella* infesting cocoa beans since it was the only one that acheived complete insect mortality with four days. However, the petroleum ether oil extracts of other plants could be used where there is less infestation since the solvent increase their effectiveness. Moreover, since ability of insect pests to cause damage to stored grains does not depend on the number of eggs they laid but the ability of their eggs to hatch and develop to other destructive stages in their life cycle [1] both ethanolic and pet-ether oil extracts of the botanicals could be used as protectant as they both prevented the emergence of the adult moth except the 0.5ml of *C. frutescens* and *A. occidentale* that did not completely prevent the emergence. The oil extracts of the botanicals used in this research could be introduced into insect pest management program and could go a long way in the government combat against hunger in the country. More so that they are effective as protectant.

References

[1] Ashamo, M. O. and Ogungbite, O. C. 2014. Extracts of medicinal plants as entomocide against *Sitotroga cerealella* (Olivier) infestation on paddy rice. *Medicinal Plant Research*, 4, 9: 1-7.

[2] Oni, M. O. 2014. Cayenne pepper, sweet pepper and long-cayenne pepper oil extracted with different solvents as fumigant entomocide against *Sitophilus zeamais* Infestation. *International Journal of Horticulture*, 4, 9: 44-49.

[3] Central Bank of Nigeria. 1998. "*Annual Report and Statement of Accounts for the Year 1998*", pp. 7-9. Abjua, Nigeria. Central Bank of Nigeria.

[4] Olujide, M. G. and Adeogun, S. O. 2006. Assessment of cocoa growers' farm management practices in Ondo State, Nigeria. *Spanish Journal of Agricultural Research*, 4, 2: 173-179.

[5] Akinnagbe, O. M. and Ajayi, A. R. 2010. Assessent of farmers' benefits derived from Olam Organisation's Sustanable cocoa production extension activites in Ondo State, Nigeria. *Journal of Agricultural Extension*, 14, 1:11-21.

[6] Akinneye, J. O. and Ogungbite, O. C. 2013. Effect of seed extracts of five indigenous plants against the stored product Moth, *Ephestia cautella* (Walker) (Lepidoptera: Pyralidae). *Archives of Phytopathology and Plant Protection*, 46, 12: 1488-1496.

[7] Forim, M. R., Da-silva, M. F. G. F., and Fernandes, J. B. 2012. Secondary metabolism as a measurement of efficacy of botanical extracts: The use of *Azadirachta indica* (Neem) as a model. In: Perveen, F. (Ed.). *Insecticides-Advances in Integrated Pest Management*, pp. 367-390. INTECH Open Access Publisher.

[8] Ogungbite, O. C. and Oyeniyi, E. A. 2014. *Newbouldia laevis* (Seem) as an entomocide against *Sitophilus oryzae* and *Sitophilus zeamais* infesting maize grain. *Jordan Journal of Biological Sciences*, 7, 1: 49-55.

[9] Ogungbite, O. C., Ileke, K. D. and Akinneye, J. O. 2014. Bio-pesticide Treated Jute Bags: Potential Alternative Method of Application of Botanical Insecticides against *Rhyzopertha dominica*(Fabricius) Infesting Stored Wheat. *Molecular Entomology* 5, 4: 30-36.

[10] Akinkurolere, R. O., Adedire, C. O., and Odeyemi, O. O. 2006. Laboratory evaluation of the toxic properties of forest anchomanes, *Anhomanes difformis*, against pulse beetle, *Callosobruchus maculatus* (Coleoptera: Bruchidae). *Insect Science*, 13, 1: 25-29.

[11] Okosun, O. O. and Adedire, C. O. 2010. Potency of cowpea seed bruchid, *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae) of Africa nutmeg seed [*Monodora myristica* (Gaertn) Dunal] extracted with different solvents. *Nigeria Journal of Entomology* 27: 89-95.

[12] Zeeshan, M., Rizvi, S. M. D., Khan, M. S. and Kumar, A. 2012. Isolation, partial purification and evaluation of bioactive compounds from leaves of *Ageratum houstonianum*. *Excli Journal*, 11: 78-88.

[13] Oigiangbe, O. N., Igbinosa, I. B. and Tamo, M. 2010. Insecticidal properties of an alkaloid from *Alstonia boonei* De Wild. *Journal of Biopesticide*, 3, 1: 265–270.

[14] Akinneye, J. O., Adedire, C. O. and Arannilewa, S. T. 2006. Potential of Cleisthopholis patens Elliot as maize protectant against stored product moth, Plodia interpunctella (Hübner) (Lepidoptera; Pyralidae). *African Journal of Biotechnology*, 5, 25: 1015–1025.

[15] Yang, Z., Zhao, B., Zhu, L., Fang, J., and Xia, L. 2006. Inhibitory effects of alkaloids from *Sophora alopecuroids* on feeding, development and reproduction of *Clostera anastomosis*. *Front for China*, 1, 2: 190 – 195.

[16] Ileke, K. D. and Ogungbite, O. C. 2014. Entomocidal activity of powders and extracts of four medicinal plants against *Sitophilus oryzae* (L), *Oryzaephilus mercator* (Faur) and *Ryzopertha dominica* (Fabr.). *Jordan Journal of Biological Sciences*, 7, 1: 57-62.

[17] Bhaduri, N., Gupta D. P., and Ram, S. 1990. Effect of vegetable oils on the ovipositional behavior of *Callosobruchus maculatus* (Fabricius) In: Fuji, K., Gatehouse, A. M. R., Johnson, C. D., Mitchel, R., and Yoshida, R. (Eds.). *Bruchids and Legumes: Economics, Ecology and Coevolution*, pp. 81-84. Dordrecht. Springer Netherland. Netherland.

[18] Ashamo M. O, Akinneye J. O. 2004. Toxicity of powders of some tropical plants against the yam moth, Euzopherodes vapidella Mann (Lepidoptera:Pyralidae). *Nigerian Journal Experimental and Applied Biology*, 5: 63–68.