World Journal of Pharmaceutical and Life Sciences
WJPLS
www.wjpls.org
SJIF Impact Factor: 7.409

INSECTICIDAL AND TOXICOLOGICAL EVALUATION OF PLANT BASED POWDERS AGAINST MAIZE WEEVIL (*SITOPHILUS ZEAMAIS*)

Ogundari A. A., Otitoju L. K.* and Ajatta M. A.

Department of Food Science and Technology, Bamidele Olumilua University of Education Science and Technology. Ikere Ekiti.

***Corresponding Author: Otitoju L. K.**
Department of Food Science and Technology, Bamidele Olumilua University of Education Science and Technology. Ikere Ekiti.

Article Received on 30//04/2025 **Article Revised on 21/05/2025** **Article Accepted on 11/06/2025**

ABSTRACT
This study investigated the insecticidal activities of different concentrations of the powder and oil extract of *Piptadeniastrum africanum* against *Sitophilus zeamais* in stored grains. Adult *S. zeamais* was introduced into the container with the treated maize seeds. Weevils were exposed to contact and fumigant toxicity test at 0.5g, 1.0g, 1.5g, 2.0g and 2.5g/ 100g of maize grains and mortality was assessed at exposure period of 24, 48, 72 and 96 hours post- treatment. Results obtained show that weevils exposed to oil extract of *P. africanum* showed higher mortality value of (52-100%) at 2.5g concentration and exposure period of 72 hours while that of root powder of *P. africanum* showed mortality value of (48-100%) at 2.5g concentration and exposure period of 96 hours. Both the powder of *P. africanum* and its oil extracts significantly reduced adult emergence in treated grains. Furthermore, the powder and oil extract of *P. africanum* root bark tested on the liver and kidney of albino rat were found to be non-toxic, since there was not significant difference between the control and the animal treated with the powder and the oil extracts. This study showed that the powder and oil extract of *P. africanum* would provide alternative to synthetic insecticides in the management of *S. zeamais* infesting maize grains in Nigeria.

KEYWORDS: "Piptadeniastrum africanum", "Sitophilus zeamais", "Insecticidal", "Adult emergence".

INTRODUCTION

Among all crops, cereals contribute the most to human food consumption (Sarwar, 2008).

Maize (*Zea mays*) is one of the most important cereal grains in tropical Africa, providing over 55 percent of the energy intake and ensuring the survival and food security of a large segment of the population. (Nout, 2009). Maize and other nutritional supplements are widely incorporated into various pharmaceutical and food products globally. Their flours are utilized either in their pure form or blended with other grain flours, such as cowpea (*Vigna unguiculata*) and groundnut (Akapapunam and Darbe, 1994; Akubor and Onimawo, 2003). Additionally, maize plays a significant role in industrial production, serving as a raw material for glucose, adhesives, oils, and alcohols.

Despite this, small holder farmers produce large quantities of maize annually, often exceeding market demand. However, due to inadequate storage facilities and infestations by insect pests like *Sitophilus species*, substantial post-harvest losses occur. The maize weevil (*S. zeamais*) alone is responsible for 60–80% of post-harvest losses of staple crops in Nigeria, leading to significant economic setbacks and posing a serious threat to food security in Africa (Abebe *et al*., 2002; Oni and Ileke, 2018). These weevils are recognized as major pests that affect maize grains from the field to storage worldwide (Adedire, 2001).

These have stimulated a search for alternative means of storagepests control. In view of these, researchers and farmers have diverted their attention toward the use of botanical insecticides to control 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), (Isman, 1997; Odeyemi, 1998; Adedire and Lajide, 2003; Arannilewa et al, 2006). 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; and Adedire et al., 2011). This study is therefore sought to evaluate the insecticidal activity of *P. africanum* powder, against adult *Sitophilus zeamais* and also determine the toxic effect of the plant powder on albino rats.

MATERIAL AND METHODS

Collection of Maize Seeds

The maize seeds used for this research work were obtained from the newly harvested stock of maize grains free of insecticides at the Ministry of Agriculture, Agricultural Development Programme, Ado Ekiti, Ekiti State, Nigeria. To ensure that any existing insect eggs and larvae are eliminated, the clean grains were sterilized by placing them in a deep freezer and keeping them at -5°C for 72 hours. This process was followed since all phases of insect life, including eggs and larvae, are vulnerable to low temperatures (Koehler, 2003). To prevent the grains from becoming moldy, the disinfested maize grains were air dried naturally in the laboratory for 72 hours (Adedire *et al*., 2011).

Insect Rearing

Adults of *S. zeamais* used for this study were obtained from Postgraduate Entomology Research Laboratory of the Department of Biology, Federal University of Technology, Akure, Ondo State, Nigeria. Fifty pairs of *S. zeamais* were introduced into 1 litre glass kilner jar containing 500 g of *Zea mays* (yellow maize) variety Ife brown respectively obtained from the Ministry of Agriculture, Agricultural Development Programme, Ado Ekiti, Ekiti State, Nigeria. They were reared in 1litre Kilner jars, with three replicates. The insect culture was placed and maintained in an insect rearing cage under a constant insectarium condition of an ambient temperature of 28±3°C and 75±5 % relative humidity.

Identification and Sexing of Adult of *S. zeamais*

The identification and sexing of *S. zeamais* were carried out in the Entomology Research laboratory, Department of Biology, FUTA. The weevils were identified to species according to features of genital morphology (Odeyemi and Daramola, 2000), antennae Odeyemi and Daramola, 2000), reddish-brown or orange-brown ovals markings on the elytra, and circular punctures also present on the prothorax (Odeyemi and Daramola, 2000). Then, adults were sexed according to the length of the rostrum (the female has a comparatively longer rostrum than the male).

Collection and Preparation of Plant Materials

P. africanum plants were collected in Ago Aduloju Camp in Ado Ekiti Local Government Area of Ekiti State. Nigeria. The root and stem bark of *P. africanum* were taken to the Crop, Soil and Part Management, Federal University of Technology Akure. For authentication. The root and stem bark were washed thoroughly with water and air-dried in the Laboratory for 30 days. The root and stem bark were then pulverized into fine powder using Binatone Electric Blender (Model 373). The powdery samples were further sieved to pass through 1mm sieve and were kept in an airtight container labeled separately and stored at 4°C in a refrigerator to maintain their quality.

Extraction of Plant Materials

About 200 g of the pulverized plant parts (Root and stem bark) were measured separately into a beaker, parked into a thimble using muslin cloth, and were extracted with 500 ml of methanol in a Soxhlet extractor. In each case, the extraction was carried out between 40 to 60°C. Excess solvent was subsequently recovered using rotary evaporator. The resulting extract was concentrated by air-drying to remove traces of solvent The oil extracts were kept separately in labeled plastic bottles.

Phytochemical Screening of the Experimental Plants

Phytochemical analyses were carried out on the powders and oil extracts of the roots and stem bark of *P. africanum* for the qualitative determination of phytochemical constituents using standard procedures as described by Trease and Evans (1985) and Sofowora (1993).

Experimental Procedure for Insecticidal Activity

In this experiment, fumigant, contact toxicity and persistent toxicity for 30, 60 and 90 days *P. africanum* root and stem bark powder and oil extracts obtained were tested against *S. zeamais* to assess them as a potential bioinsecticides candidates. All the experiments were conducted at ambient temperature at 28±2°C and 75±5% relative humidity. Viability of the seeds treated with the plant materials were also assessed after 30, 60 and 90 days post storage.

Contact Toxicity Assay of Plants Root and Stem Bark Powders on Adult *S. zeamais*

Twenty grams (20 g) of maize seeds was weighed separately using Metler beam PB 3002 weighing balance and thoroughly mixed with 0.0 g (control), 0.1, 0.2, 0.5, 1.0, and 2.0 g of the plant materials root and stem bark powders separately in 250ml plastic containers. Also, the maize seeds were admixed thoroughly with 5, 10, 15, 20 and 25% oil extracts. The powder, the oil extracts and the maize seeds were thoroughly mixed together (Akinneye *et al*., 2016). Using glass rod to ensure uniform coating of maize seeds with the powders. Twenty (20) pairs of adult *Sitophilus zeamais* was introduced into each plastic container separately and covered. Each treatment was carried out in three replicates and adult mortality were assessed after 24, 48, 72 and 96 hours post treatment period. Adults were considered dead when probed with sharp objects and there were no responses. At the end of Day 4, all insects, both dead and alive, were removed from each of the containers and number of eggs laid was counted and recorded before returning the seeds into their respective containers. The containers of the experiments were left for 30 days to allow for adult emergence and the number of emerged adults were counted.

Data on percentage adult mortality were corrected using Abbott (1925) formula thus,

$$P_r = \frac{P_o - P_c}{100 - P_c} \; X \; \frac{100}{1}$$

Where P = Corrected adult mortality (%)

P_o = Percentage mortality of insects on treated seeds (%)

P_c = were kept inside the insect rearing cage for further 30 days for adult emergence. Percentage adult emergence were calculated using the method of Odeyemi and Daramola (2000).

$$\% \text{ Adult emergence} = \frac{\text{Total number of adult emergence}}{\text{Total number of egg laid}} \text{ X } \frac{100}{1}$$

Percentage weight loss of the cowpea seeds was determined by re-weighing after 30 days and the % loss in weight were determined as follows.

$$\% \text{ Weight loss} = \frac{\text{Change in weight}}{\text{Initial weight}} \text{ X } \frac{100}{1}$$

Contact Toxicity Assay of Plant Oils on Mortality of Adult *S. zeamais*

The oil extract was measured at 0.1, 0.2, 0.5, 1.0, and 2.0 ml concentration and admixed thoroughly with the grains in replication. Twenty pairs of adult insects were introduced, and mortality were monitored at 24, 48, 73 and 96 hours post application period. Untreated maize seeds were set as control. The set up was replicated three times.

Fumigant Assay of the Plant Parts Oil Extracts on *S. zeamais*

Ten newly emerged adults (0- 24 hours old) were placed on 20 g of grains inside plastic containers (8cm diameter and 4cm depth) containing different concentrations of oil extracts which was obtained using graduated syringe, filter paper measuring 4 X 3.5 (cm) and 0.5mm thick. The filter was impregnated into the oil at required concentration and allowed to air dried for 4 hours and was then be placed inside a plastic container containing 20 g of maize grains. The container was then covered to create an airtight environment. Untreated paper strips were used as the control experiment. The set up was replicated three times, adult mortality was counted at 24, 48, 72 and 96 hours after application.

Experimental Procedure for Persistent Ability of Powder and Oil Extracts of the Used Plant on *S. zeamais* after 30, 60 and 90 days Post Treatment

In this experiment, both cowpea and maize seeds weighing 20 g each that have been previously treated with the various plant materials powders and oils for 30, 60 and 90 days. Parameters described in 3.3.5 were assessed for the persistent toxicity of the plant materials to 30, 60 and 90 days post treatments.

Gas Chromatography Mass Spectrometry (GC- MS) Analysis of the Plant Extracts

The Gas chromatography coupled with mass spectrometry (GC- MS) analysis were used to reveal the profiles of compounds contained in each of the extracts. One millilitre of each extract was analyzed using Agilent Technologies, with machine model; Mass spectrum (5975C VLMSD). Injector (7683B Series) and GC (7890A). The Capillary volume will be HP- 5MS. The column dimension is 30 cm in length, 0.32mm internal diameter and a film thickness of 0.2micro meter. Helium will be used as a carrier gas. The GC oven temperature will be set at 80^{o}C for 2 minutes. The temperature will be increased steadily at 6^{o}C per minutes to 240^{o}C and will be held for 6 minutes. The running time for each sample was 36 minutes. The peak of each chemical compound was expressed based on retention time and balance.

Experimental Animals

Albino rats (18 adult) weighing between 150-170 g were used for the experiment and were purchased from the breeding colony of the Department of Biochemistry, Federal University of Technology Akure, Nigeria. The rats were maintained at 25°C on 24 hours light/ dark cycle with free access to food and water. The animals were acclimatized for a period of two weeks before the commencement of the experiment. All animals were handled according to the standard ethical provisions for using experimental animals.

Feed Formulation and Treatment Group

After acclimatization, animals were arranged in a completely randomized design, comprising three rats per experimental and control groups with free access to food and water. The diets were freshly formulated according to the modified method of Oboh (2005) and were kept in an airtight containers at 4 °C until needed for use.

Group I: Control rats, that were fed with basal diet (18% corned starch, 18% rice grain, 50% skinned milk, 4% minerals & vitamin primates and 10% vegetable oil)

Group II: Rats' diet supplemented with grains treated with 0.5 g *P. africanum.*

Group III: rats' diet supplemented with grains treated with 1.0 g *P. africanum*..

Group IV: rats' diet supplemented with grains treated with 1.5 g *P. africanum.*

Group V: rats' diet supplemented with grains treated with 2.0 g *P. africanum.*

Group VI: rats' diet supplemented with grains treated with 2.5 *P. africanum.*

Animals Grouping

After two weeks acclimatization, the eighteen albino rats was randomly grouped in three (Group I-III) of six animal each. Group I was fed with basal diet containing grains treated with 1.0 g of *P. africanum* Group II was fed with basal diet containing grains treated with 5..0 g *P. africanum and* Group III was fed with basal diet containing grains treated with 10 g *P. africanum*, The experiment lasted for 7 days and cage side examinations was performed daily for overt signs of toxicity (salvation, lacrimation, convulsion, loss of hair, stress, behavioural abnormalities and dead rats) (Ratnasoriya *et al*., 2000). After 24 hours the animals were sacrificed by cervical dislocation.

Preparation of Serum

The procedure described by Yakubu *et al*. (2007) was adopted for the preparation of serum. The animals were sacrificed by cervical dislocation and the blood collected by direct heart punctured into EDTA sample bottles and will be spinned at 3000 rpm for 20 minutes. The serum were carefully aspirated with pasture pipette into sample bottles for the various biochemical assays.

Biochemical Assays

The serum was analyzed using the available biochemical assays Akaline phosphate (ALP), Asparate aminotransferase (AST), alanine amino transferace (ALT), Urea, Total bilirubin, Direct bilirubin, and Creatinine.

Data Analysis

The data were subjected to one- way Analysis of variance (ANOVA) ($p<0.05$) and significant means were separated using Duncan's new multiple Range test. All analysis were done using SPSS 20.0 software package.

RESULTS

Contact Toxicity Effect of Selected Plant Powder against *C. maculatus* Adult

The contact toxicity of *P. africanum* powder is represented in Table 1 in respect to the period of exposure. After days of plant powder application, the toxicity of all the plant powder was significantly different ($p<0.05$) from the control. The effectiveness of the plant as dosage-dependent and time-dependent. The contact toxicity effectiveness of 0.5 g root and stem powder of *P. africanum was* not significantly different ($p>0.05$), 46.67% mortality rate was observed;. The toxic effect of 0.5 g of root and stem powder of *P. africanum* is was not significantly different ($p>0.05$) from 1.0 g of stem powder of *P. africanum* The highest mortality rate was recorded from the application of 2.0 g of *P. africanum* root (86.67%) After Day 4 of plant powder application, the toxicity of 0.1 g of all the plant powder were not different significantly ($p>0.05$). The effectiveness of 0.1 g of the plant was not different significantly ($p>0.05$). *P. africanum* stem powder of 0.5 g dosage evoked 80% mortality of *S. zeamais.*

Estimated Dosage of Plant Powder Required for 50% (LD_{50}) and 90% (LD_{90}) Mortality of *C. maculatus*

The estimated dosage of *P. africanum* (root and stem) powder needed to evoke 50% and 90% population mortality of *S. zeamais* are given in Table 2. The estimated dosage of *P. africanum* root powder required to achieve 50% mortality within day 1, 2, 3, and 4 exposure periods was 0.37 g, 0.27 g. 0.24 g, and 0.12 g respectively, while the dosage needed for 90% mortality for those exposure periods were 5.47 g, 3.03 g, 2.53 g, and 1.42 g respectively. The same trend was observed in the estimated dosage of *P. africanum* stem powder with 0.54 g, 0.31 g, 0.29 g, and 0.14 g is needed to evoke 50% mortality for the exposure period of 1, 2, 3, and 4 days respectively. Likewise, 11.58 g, 5.26 g, 5.46 g, and 1.68 g of *P. africanum* stem powder is required to evoke 90% for the 1, 2, 3, and 4 days period of exposure respectively.

Table 1: Contact Toxicity of some Plant Powder on Mortality of Adult *S. zeamais.*

Plant Powder	Dosage (g)	%Mortality (Mean±S.E.)			
		Day 1	Day 2	Day 3	Day 4
P. africanum Root	0.1	16.67±3.33b	26.67±3.33b	26.67±3.33b	40.00±0.00b
P. africanum Stem		20.00±0.00bc	33.33±3.33bc	33.33±3.33bc	40.00±0.00b
P. africanum Root	0.2	20.00±0.00bc	26.673.33b	26.67±3.33b	46.67±3.33bc
P. africanum Stem		20.00±0.00bc	33.33±3.33bc	33.33±3.33bc	46.67±3.33bc
P. zeylanica Root		26.67±3.33bcde	30.00±5.77bc	30.00±5.77bc	46.67±3.33bc
P. africanum Root	0.5	36.67±3.33ef	46.67±3.33def	46.67±3.33def	60.00±0.00d
P. africanum Stem		33.33±3.33def	40.00±0.00cde	40.00±0.00cde	56.67±3.33cd
P. africanum Root	1.0	50.00±0.00g	60.00±5.77gh	60.00±5.77gh	80.00±5.77e
P. africanum Stem		46.67±3.33g	53.33±3.33fg	53.33±3.33fg	76.67±6.67e
P. africanum Root	2.0	70.00±5.77h	80.00±5.77i	80.00±5.77i	96.67±3.33f
P. africanum Stem		63.33±3.33h	70.00±0.00hi	70.00±0.00hi	96.67±3.33f
Control	0.0	0.00±0.00a	0.00±0.00a	0.00±0.00a	0.00±0.00a

Mean follow by the same letters in column are not significantly different from one another ($p>0.05$) using Duncan New Multiple Range Test (DNMRT).

Table 2: Lethal Dosage (LD) of Plant Powder Contact Toxicity on *S. zeamais.*

Plant Powder	Exposure Period	Intercept± S.E.	Slope± S.D.	R^2	LD_{50} (LCL - UCL)	LD_{90} (LCL -UCL)	*p* value
P. africanum Root	Day 1	5.07±0.16	1.16±0.86	0.97	0.87 (0.42 – 1.83)	11.39 (5.44 – 23.88)	0.79
	Day 2	5.34±0.16	1.15±0.87	0.94	0.50 (0.24 – 1.04)	6.74 (3.24 – 14.01)	0.55
	Day 3	5.34±0.16	1.15±0.87	0.94	0.50	6.74	0.55

					(0.24 – 1.04)	(3.24 – 14.01)	
	Day 4	6.04±0.13	1.53±0.66	0.89	0.21 (0.12 – 0.38)	1.57 (0.87 – 2.84)	0.50
P. africanum Stem	Day 1	4.95±0.19	0.94±1.06	0.94	1.13 (0.46 – 2.78)	38.13 (12.37 -117.57)	0.64
	Day 2	4.95±0.19	0.94±1.06	0.94	1.13 (0.46 – 2.78)	38.13 (12.37 -117.57)	0.64
	Day 3	5.15±0.25	0.73±1.38	0.87	0.63 (0.21 – 1.95)	26.68 (10.88 – 65.45)	0.64
	Day 4	5.99±0.13	1.49±0.67	0.85	0.22 (0.12 – 0.40)	1.78 (0.98 – 3.26)	0.41

Note: R^2 = Statistical measure of mortality proportion in regression model. S. E. = Standard error. S. D. = Standard deviation. LD_{50} = Lethal dosage at which 50% population response. LD_{90} = Lethal dosage at which 90% population response. LCL = Lower confidence limit. UCL = Upper confidence limit. *p* value = Chi -square (X^2) Significant.

Effect of some Selected Plant Powder on Rate of *S. zeamais* Adult Emergence

The result of maize treated with *P. africanum* root and stem powder to protect and reduce adult *S. zeamais* is presented in Table 3. The overall effect of the selected plant on *S. zeamais* adult emergence show that the lowest dosage (0.1 g) of the plant powder has the highest adult emergence.

Table 3: Percentage Adult Emergence of *S. zeamais.*

Plant Powder	Dosage (g)	Adult Emergence
P. africanum Root	0.1	15.13±0.13d
	0.2	11.57±0.46abcd
	0.5	7.35±0.34ab
	1.0	7.16±0.29ab
	2.0	5.73±0.74a
P. africanum Stem	0.1	12.30±1.69bcd
	0.2	11.85±0.94bcd
	0.5	9.90±2.82abcd
	1.0	9.54±3.69abcd
	2.0	7.02±2.74ab
Control	0.0	59.44±1.95e

Mean follow by the same letters in column are not significantly different from one another (p>0.05) using Duncan New Multiple Range Test (DNMRT).

Effect of some Selected Plant Powder on Maize Grains Damage, Weight Loss, and Beetle Perforation Index

Protectant effects of *P. africanum* root powders is presented in Table 4. With the application of *P. africanum* root powder, there was no maize grain damage, weight loss, and perforation index observed. Statistically, there were no difference in rate of seed damage of maize grains treated with all levels of dosage from *P. africanum* root powder. The rate of maize seed damage, weight loss and perforation index observed in maize grains treated with the plant powders were significantly low (p<0.05) compared with what was observed in the control.

Table 4: Protectant Effect of some Plant Powders on Maize Grains Damage, Weight Loss, and Beetle Perforation Index against *S. zeamais.*

Plant Powder	Dosage (g)	Number of Seed	% Seed Damage	% Weight Loss	Weevil Perforation Index
P. africanum Root	0.1	72.33	0.00±0.00a	0.00±0.00a	0.00±0.00a
	0.2	71.33	0.00±0.00a	0.00±0.00a	0.00±0.00a
	0.5	69.67	0.00±0.00a	0.00±0.00a	0.00±0.00a
	1.0	68.33	0.00±0.00a	0.00±0.00a	0.00±0.00a
	2.0	71.00	0.00±0.00a	0.00±0.00a	0.00±0.00a
P. africanum Stem	0.1	70.00	5.73±0.89fgh	6.00±0.87ef	8.07±1.46ef
	0.2	70.00	0.95±0.95abc	1.67±1.67ab	1.27±1.27ab
	0.5	70.67	0.47±0.47ab	0.50±0.50ab	0.66±0.66a
	1.0	70.67	0.48±0.48ab	0.50±0.50ab	0.65±0.65a
	2.0	71.33	0.00±0.00a	0.00±0.00a	0.00±0.00a
Control	0.0	71.67	73.93±1.8i	79.50±2.29g	>50g

Mean follow by the same letters in column are not significantly different from one another (p>0.05) using Duncan New Multiple Range Test (DNMRT).

Table 5: Gas Chromatography – Mass Spectrometry Analysis of *P. africanum* Plant Extract.

PK	Compound	Retention Time	Area %	Molecular Formular	Molar Mass (g/mol)
1	Octamethlycyclotetrasiloxane	3.187	1.19	$C_8H_{24}O4Si_4$	296.61
2	Benzene	3.387	1.62	C_9H_{12}	120.19
3	3,6-dimethyldecane	3.865	1.62	$C_{12}H_{26}$	170.33
4	Undecane	4.442	1.29	$C_{11}H_{24}$	156.31
5	2H-Benzotriazole	4.598	7.44	$C_8H_9N_3$	147.18
6	5-hydroxy-2-(hydroxymethyl)-4H-pyran-4-one	5.042	1.26	$C_6H_6O_4$	142.11
7	(1R,3R,4R,5S)-1-Isopropyl-4-methyl bicyclo[3.1.0]hexan-3-yl acetate-rel-	5.675	2.24	$C_{12}H_{20}O_2$	196.29
8	Dodecane	5.820	1.33	$C_{12}H_{26}$	170.33
9	Benzene acetic acid	6.675	1.48	$C_8H_8O_2$	136.15
10	Dichloroxylenol	8.331	0.98	$C_8H_8C_{l2}O$	191.05
11	Tetradecane	8.475	2.13	$C_{14}H_{30}$	198.39
12	Benzeneethanol, 4-hyroxy-	8.931	1.48	$C_8H_{10}O_2$	138.16
13	2,4-Di-tert-butylphenol	9.897	1.63	$C_{14}H_{22}O$	206.32
14	Hexadecane	10.908	1.69	$C_{16}H_{34}$	226.44
15	Dibutyl phthalate	14.741	2.03	$C_{16}H_{22}O_4$	278.34
16	n-Hexadecanoic acid	14.885	19.94	$C_{16}H_{32}O_2$	256.42
17	Cyclopentadecane	16.385	1.46	$C_{15}H_{30}$	210.40
18	Octadecanoic acid	16.707	17.85	$C_{18}H_{36}O_2$	284.5
19	2-Piperidinone, N-[4-bromo-n-butyl]-	18.340	0.88	$C_9H_{16}BrNO$	234.13

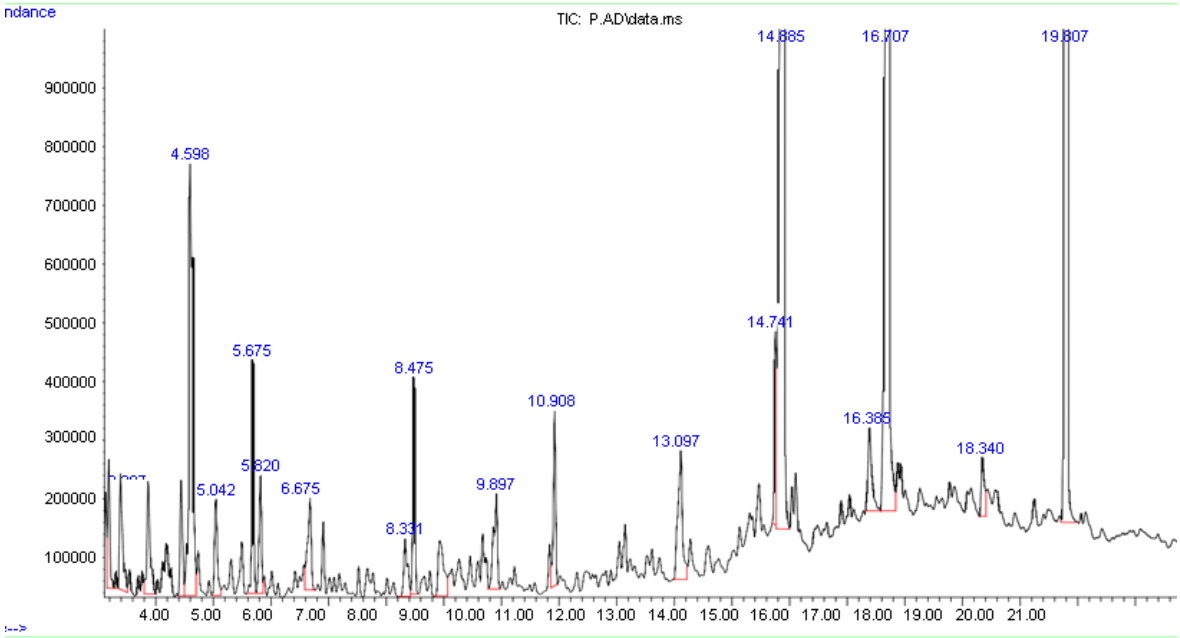

Figure 1: Chromatograph of *P. africanum* Plant Extract.

Insecticidal Potency of Different Fractions of *Piptadeniastrum africanum* Extract against Maize Weevil *Sitophilus zeamais*

Table 6 presented the insecticidal screening test of *P. africanum* fractions (PAF) against *S. zeamais*. The most effective fraction against *S. zeamais* were PAF5 achieving 100% mortality at day 1 of application, it shows rapid insecticidal activity. Fraction PAF10 achieved 100% mortality at day 2 of application, while PAF11 recorded 100% mortality at day 4 of application, indicating slower but complete effectiveness compared to PAF10. Moderate effectiveness was observed from PAF4, PAF6, PAF8, PAF12, and PAF19 with gradual increase in mortality of 70–80% at day 4 of application. Fractions PAF15 and PAF18 achieved 60% mortality at day 4 of application, reflecting moderate effectiveness. Low effectiveness was observed from PAF1, PAF3, PAF7, PAF9, and PAF14 exhibiting low activity, with mortality rates ranging from 10% to 40% at day 4 of application. Fraction PAF17 showed a maximum of 30% mortality at day 4. Fraction PAF2, PAF13, and PAF16 were ineffective; showing minimal or no insecticidal activity, with mortality rates of 10% or less at day 4 of application.

Table 6: Insecticidal Screening Test on *P. africanum* Fractions against *S. zeamais.*

Fraction Sample	Number of Adult	% Mortality			
		Day 1	Day 2	Day 3	Day 4
PAF1	20	0.00	10.00	20.00	40.00
PAF2	20	0.00	0.00	0.00	10.00
PAF3	20	0.00	0.00	0.00	20.00
PAF4	20	20.00	40.00	70.00	80.00
PAF5	20	100.00	100.00	100.00	100.00
PAF6	20	10.00	30.00	50.00	70.00
PAF7	20	0.00	0.00	0.00	10.00
PAF8	20	10.00	20.00	40.00	70.00
PAF9	20	0.00	0.00	0.00	30.00
PAF10	20	90.00	100.00	100.00	100.00
PAF11	20	30.00	50.00	70.00	100.00
PAF12	20	20.00	50.00	60.00	80.00
PAF13	20	0.00	0.00	0.00	0.00
PAF14	20	0.00	0.00	10.00	30.00
PAF15	20	0.00	20.00	40.00	60.00
PAF16	20	0.00	0.00	0.00	0.00
PAF17	20	0.00	0.00	10.00	30.00
PAF18	20	10.00	20.00	40.00	60.00
PAF19	20	10.00	30.00	50.00	80.00

Biochemical Indices of Liver of Rats Fed with *P. africanum* Root Bark Powder

Table 7 presents liver function marker and enzymes in rats fed with diet containing different doses of *P. africanum* root bark powder. The control group had high Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT); 191.84 and 152.76 observed, respectively, which is an indication of normal liver function. The AST and ALT decreased significantly ($p<0.05$) as the dosage of *P. africanum* in the diet increases; AST and ALT observed from the animal liver fed with 10 g of the treatment in group C were 115.87 and 93.04, respectively. This is an indication of a potential suppression of liver enzyme activity at high dosage which could result to liver damage or dysfunction, as healthy liver cells actively produce these enzymes. The liver health marker Alkaline Phosphatase (ALP) was high in animal liver in the control group (50.89) compared to those in the group C animal fed with diet containing 10 g *P. zeylanica* root bark powder, lowest ALP was observed (19.08) which indicated impaired liver function, toxicity, poor bile flow, and metabolic suppression. The liver's synthetic function of the animals was determined with Total Protein (TP). The control group had the lowest protein level of 1.90 g/dL. Protein levels increased significantly as the treatment dosage increases with the animal fed with higher the *P.africanum* root bark powder (10 g) diet in group C having TP of 4.99 g/dL, which indicate a stress response, liver inflammation, and altered metabolism.

Table 7: Biochemical Indices of Liver of Rat Fed with *P. africanum* Powder.

Animal Group	Dosage (g)	Aspartate Aminotransferase	Alanine Aminotransferase	Alkaline Phosphatase	Total Protein
A	1	187.85 ± 0.31^{c}	149.78 ± 0.15^{c}	46.84 ± 0.21^{c}	2.09 ± 0.03^{b}
B	5	182.74 ± 0.14^{b}	141.19 ± 0.30^{b}	42.02 ± 0.17^{b}	2.52 ± 0.06^{c}
C	10	115.87 ± 0.22^{a}	93.04 ± 0.11^{a}	19.08 ± 0.10^{a}	4.99 ± 0.04^{d}
D	Control	191.84 ± 0.17^{b}	152.76 ± 0.23^{d}	50.89 ± 0.17^{d}	1.90 ± 0.02^{a}

Means followed by the same letter in superscript along the column are not different significantly ($p>0.05$) using Duncan New Multiple Range Test (DNMR)

KEY

Group A – rats fed with basal diet plus 1% *P. africanum* root bark powder

Group B – rats fed with basal diet plus 5% *P. africanum* root bark powder

Group C - rats fed with basal diet plus 10% *P. africanum* root bark powder

Group D – Normal control rats fed with basal diet

DISCUSSION

The ongoing and widespread issues with stored product pests have had a major impact on the food security for people around the globe, particularly in sub-Saharan Africa and nations where pest control and management are not prioritized (Olotua, 2014). Insect pests are seen as a primary hurdle to human advancement, and their contribution to food insecurity along with their persistent detrimental effects on the economic stability of numerous countries is well recognized (Akinneye and

Ogungbite, 2016). Grain storage practices globally have depended significantly on various synthetic insecticides, which have been crucial for grain preservation and protection, greatly benefiting humanity over the years. However, even though these chemicals have been helpful, their ongoing use has led to several ecological, environmental, and health issues, as noted by Verma and Dubey (1999). These issues include the emergence of pest species that are resistant, the resurgence and appearance of new pests, harm to non-target species, and negative impacts on the environment, thereby threatening the sustainability of ecosystems (Jeyasanka and Jesudusan, 2005).

As a consequence, the pursuit of environmentally safe and biodegradable pesticides for safeguarding and managing crops has significantly increased in recent years (Sengottaiyan, 2013). The ideal insecticide is anticipated to effectively manage the intended pest, break down quickly, and pose no harm to humans or animals. Over the years, utilizing insecticides derived from plants to address the limitations found in synthetic pesticides has shown great potential (Tan and Luo, 2011). Research findings has shown that plant-based insecticides can fully replace commonly utilized synthetic chemical insecticides, as many have proven effective in controlling various prevalent stored product insect pests, such as Coleoptera and Lepidoptera. It is thought that these natural insecticides break down easily and pose no harm to humans. The studies were conducted with concentrations ranging from 0.1 g to 2.0 g and exposure times ranging from 24 to 96 hours. The findings demonstrate that *P. africanum* root bark powder, when applied as fumigant and contact insecticides, was effective against *S. zeamais* at dosages ranging from 1.0 g to 2.0 g of the powders when compared to the control samples. This is consistent with Echendu, (1991) findings that, when added to 500 g of brown cowpea seeds, the powdered rhizome of *Zingiber officinales* decreased adult emergence by 96% as compared to the untreated samples.

All of the results from the various concentrations also support Akinneye (2003) who reported that *C. patens* have the capacity to cause maximum larval and adult mortality in *Ephestia cautella* raised on cocoa beans. The study's conclusions also show that exposure and dose had an impact on the contact effects of the plant powders and the rate at which *P. africanum* root bark was applied. *P. africanum root powder* was able to induce 100% adult mortality when exposed to 2g of the plant powder within 96 hours after treatment, as demonstrated by the study's findings. This is consistent with Ashamo and Akinneye (2004) observations that yam moth *Eugenia aromatic*. Cause mortality above 43.3% on *Euzopherodes vapidella*. The result is also in agreement with the findings of Adedire (2002) in which nutmeg oils was found to cause asphyxiation and subsequent death of *C. maculatus* on cowpea seeds. It is also in agreement with the findings of Pathak and Tiwari (2010). In which powders and oils of *Azadirachta indica* as found to be effective in the management of the larval stage of *Corcyra cephalonica*.

P. africanum showed 20 bioactive compounds in phytochemical composition and the column fractions of the extracts used in this study were observed to be very effective against *S. zeamais* as maximum adult mortality was achieved within 24 hours post treatment exposure periods in fraction samples of *P. africanum* (PAF5 and PAF10). The fraction was more effective against *S. zeamais*.

The measurement of the activities of various enzymes in tissues and body fluids play a significant role in disease investigations and diagnosis (Bamisaye *et al.*, 2013). In animal exposed to 1 g concentration, there are slight increases in liver enzyme levels, indicating minimal liver stress. In those exposed to 5 g concentration, moderate elevation in ALT and AST levels was observed showing some hepatocellular damage while significant elevations in liver enzymes, indicating marked hepatotoxicity, coupled with histological findings such as hepatocellular drainage and severe haemorrhage in animal fed with 10 g *P. africanum*. Similar observation has been made by Bamisaye *et al.* (2013) in normal rats fed with the extract of *Morinda lucida*, castor seed oil and powder of *Nigella sativa* for 7 days, 30 days and 5 weeks respectively.

CONCLUSION

The goal of this study is to evaluate the insecticidal potential of three indigenous plants *Piptadeniastrum africanum* against *Sitophilus zeamais*. The study also made a significant effort in screening the insecticidal potency of the chosen plant. The study also isolates and characterize the active ingredients of the chosen plants which was responsible for control of the pests as discovered. The effectiveness of the column fraction of the plant were determined and lastly, the toxicological study of the plant powder in the course of this findings. The following conclusion and recommendations were drawn from the study. Findings from this study indicate that these plant materials provide promising alternatives to synthetic insecticides, offering eco-friendly and effective grain protection. However, higher concentrations posed observable toxicological effects, emphasizing the need for balanced application strategies. This study highlights the potential for biopesticides derived from local plants in achieving sustainable agricultural practices and ensuring food security. In animal model, the higher the dosage the more toxic and damage it causes to the vital organs of the animal. Thus, dose-dependent toxicity profile was observed with higher concentrations of *P. africanum* powder causing pronounced effects on liver, kidney, serum, and haematological parameters. This highlights the importance of controlled usage in bio-pesticidal applications of the studied plants.

REFERENCES

1. Abbott, W.S. A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*, 1925; 18: 265–267.
2. Adedire, C.O., Biology, ecology and control of insect pests of stored cereal grains. In: Ofuya, T.I., Lale, N.E.S. (Eds.), Pests of Stored Cereal and Pulses in Nigeria: Biology, Ecology and Control. Dave Collins Publications, Akure, Nigeria, 2001; 59–94.
3. Adedire, C.O. Use of Nutmeg, *Myristca fragrans* (Houtt). Powder and oil for the control of Cowpea storage Bruchid, *Callosobruchus maculatus*. *Journal of Disease and Protection*, 2002; 109: 193-199.
4. Adedire, C.O. and Ajayi, T.S. Assessment of the insecticidal properties of Some plant extracts as grains protectants against the maize weevil, *Sitophilus zeamais*, Motschulsky. *Nigerian Journal of Entomology*, 1996; 13: 95-141.
5. Adedire, C.O. and Lajide, L. Ability of extracts of ten tropical plants species to protect Maize grains against infestation by the maize weevils *Sitophilus zeamais*, during storage. *Nigeria Journal of Experimental Biology*, 2003; 4: 174-179.
6. Adedire C.O., Obembe, O.O., Akinkurolere, R.O. and Oduleye, O.M. Response of Callosobruchus maculatus (Coleoptera, Chysomelidae: Bruchidae) to extract of cashew kernels. *Journal of plant Diseases and protection*, 2011; 118(2): 75-79.
7. Adesuyi, S.A. Relative resistance of some varieties of maize to attac by *Sitophilus zeamais* (Motsch). Rep. Nigeria Stored Product Res. Inst. 1976/77. Tech. Rep., 1977; 7: 79-82.
8. Adeyera, O.J and Akinneye J.O. (2020). Entomotoxic potential of *Morinda lucida* (Benth.) leaf powder as contact and fumigant biopesticides in the management of Plodia *interpunctella* (Hubner) [Lepidoptera: Pyralidae]. DOI:10.35841/2591-7897.4.2.2-5, 52.
9. Ajayi, O.E. and Adedire, C.O. Insecticidal activity of an underutilized plant seed oil, *Hura creptitans*. L. on cowpea seeds bruchid. *C. maculatus*. *Nigerian Journal of Entomology*, 2003; 20: 74-81.
10. Akubor, P.I. and I.A. Onimawo. Functional properties and performance of soybean and maize flour blends in cookies. *Plant Foods Human Nutrition*, 2003; 58: 1-12.
11. Akinkurolere, R.O., Adedire, C.O. and Odeyemi, O.O. Laboratory evaluation of the toxic properties of forest anchomanes, Anchomanes difformis against pulse beetle Callosobruchus maculatus (Coleoptera: Bruchidae). *Insect Science*, 2007; 13: 25-29.
12. Akinneye J.O. Biology and control of the yam Moth *Euzopherodes vapidella* (Mann) (Lepidoptera Pyralidae) Federal Univeersity of Technology Akure. M.Tech Thesis, 2003; 65.
13. Akinneye, J.O. Aspects of biology and control of tropical warehouse moth. *Ephestia cautella* (Walker) (Lepidoptera: Pyralidae) in Cocoa beans. Ph.D Thesis, Federal University of Technology, Akure. Nigeria, 2011; 59.
14. Akinneye, J.O., Adedire, C.O. and Arannilewa, S.A. Potential of *Cleisthopholis patens* (Benth). as maize protectant against the stored product moth *Plodia interpunctella* (Hubher). (Lepidoptera: Pyralidae). *African Journal of Biotechnology*, 2006; 5(25): 2510-255.
15. Akinneye J.O and Ogungbite O.C. Insecticidal activities of some plants against *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) on stored maize. *Archives of Phytopathology and Plant Protection*, 2013; 46(10): 2006-2013.
16. Akinneye J.O and Ogungbite O.C. Entomotoxicant potential of some medicinal plants against *Ephestia cautella* (Walker) (Lepidoptera; Pyralidae). Infesting cocoa beans in storage. *International Journal of Applied Science and Engineering*, 2016; 14(1): 59-68.
17. Ashamo M.O. and Odeyemi O.O. Effects of rearing temperatre on fecundity and development of yam moth. *Euzopherodes vapidella* Mann. (Lepidoptera: Pyralidae). A pest of stored yam. *Journal of Stored Product Research*, 2001; 37: 253-261.
18. Ashamo M.O and Akinneye J.O. Toxicity of powder of some tropical plants against the yam moth *Euzopherodes vapidella* Mann. (Lepidoptera: Pyralidae). *Nigerian Journal of Experimental and Applied Biology*, 2004; 5(1): 65-68.
19. Ashamo M.O, Morawo T.O. and Oke B.T. Effects of oil and Eight different plants against the Angoumois Grain Moth *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae). *Nigerian Journal of Entomology*, 2011; 28: 35-41.
20. Ashamo, M.O. and Akinnawonu, O. Isecticidal Efficacy of some plants powders and Extract against the Angoumois Grain Moth *Sitotroga cerealella* (Oliver) (Lepidoptera: Gelechiidae). *Archives of pathology and plant protection*, 2012; 45(9): 1-8.
21. Atanda S. A., Agoda, S., Ihionu, G.C., and Usanga, O.E. Protection of grains and Cereals- A Review. *Applied Science Reports*, 2016; 13(2): 96-106.
22. Bamisaye, F.A., Odutua, A.A., Minari, J.B., Dairo, J.O., Oluba, O.M. and Babalola, I.J. Evaluation of hypoglycemic and toxicological effects of leaf extracts of *Morinda lucida* on albino rats. *International Research Journal of Biochemistry and Bioinformatics*, 2013; 3(2): 37-43.
23. Dobie. P. Laboratory assessment of the inherent susceptibility of 25 varieties of Malawi maize to post-harvest infestation by *Sitophilus zeamais* (Motsch). *Tropical Product Infestation*, 1973; 1(33): 1-6.
24. Derbalah, A.S. and Ahmed, S.I. Oil and powder of spearmint as an alternative to Sitophilus oryzae chemical control of wheat grains. *Journal of Plant Product Research.* 2011; 51(2): 145-150.
25. Echend, Y.N.T. Ginger, Cashew and Neen as surface Protectant against Cowpea Infestation and Damage by *Callosobruchus maculatus* (F). *Tropical*

Science, 1991; 31: 209-211.
26. Falomo, A.A. Post- harvest susceptibility of maize varieties to infestation by Sitophilus zeamais (Motsch). Rep. Nigerian Stored Product Res. Inst. 1981: *Technical Report*, 1979; 6: 57-63.
27. Fernado, A.C., Silva, K.F.S.D., Juunior, K.A.I.R. and Ana, A.E.S. "Activities of some Brazillian plant against larvae of the mosquito *Aedes aegypti*. *Fitoterapiai*, 2005; 76: 234-239.
28. Ileke, K.D. and Oni, M.O. Toxicity of some plant powders to maize weevil, *Sitophilus zeamais* b(Motschulsky) Coleoptera curculionidae) on stored grains. African Journal of Agricultural Research, 2011; 6: 3043-3048.
29. Ileke, K. D., Odeyemi, O. O., & Ashamo, M. O. Response of cowpea bruchid, *Callosobruchus maculatus* (Fabr.) [Coleoptera: Chrysomelidae] to cheese wood, Alstoniabooneide wild stem bark oil extracted with different solvents. *Archives of Phytopathology and Plant Protection*, 2013; 46(11): 1357–1370.
30. Ileke, K.D. Cheese wood, Alstonia boonei De Wild a botanical entomocides for the management of maize weevil, *Sitophilus zeamais* (Motschulsky) [Coleoptera: Curculionidae]. *Journal of Bioscience*, 2014; 2(2): 64–68.
31. Lale, N.E.S. An overview of the use of plant prodcts in the management of stored product coleopteran in the tropics. Post-harvest news and information, 1995; 6: 69N-75N.
32. Mbata, G.N. and Philips, T.W. Effects of temperature and exposure time on mortality of stored product insects exposed to low temperature. *Journal of Economic Entomology*, 2001; 94: 1302-1307.
33. Morah, S.C. and Mbata G.N. Assessment of the relative susceptibility of some maize varieties to post-harvest infestation by the maize weevil *Sitophilus zeamais* (Motsch). Rep. Nigerian Stored Product Research Inst. Tech. Rep., 1982; 5: 63-68.
34. Ofuya., T.I. Growth and Development of *Callosobruchus maculatus* (Fabricius) (Coleoptera: Bruchidae) on some wild and cultivated cowpeas. *International pest control*, 1987; 29: 112-113.
35. Ofuya, T.I. Oviposition deterrence and Ovicidal properties of some plant powders against *Callosobruchus maculatus* in Stored cowpea (Vigna nguiculata) seed. *Journal of Agricultural Science*, Cambridge, 1990; 115: 345-345.
36. Ofya, T.I., Okoye, B.C. and Olola, A.O. Efficacy of Crude Extract from the seed of Monorado myristica (Gaertn) Dunal as surface protectant against Callosobruchus maculatus (F.) Attacking Legumes seed in storage. *Journal of Plant Disease and Protection*, 1992; 99: 528-532.
37. Ofuya, T.I. Pest of Stored Cereals and Pulses in Nigeria in: Ofuya T.I. and Lale, N.E. S. Biology, Ecology and control of insect pests of stored Food legumes. *Bave Collins publications Nigeria*, 2001; 25-58.
38. Ofuya, T.I. and Lale N.E.S. Pest of stored cereals and pulses in Nigeria, 2001; 174.
39. Ogunwolu EO and Odunlami AT. Suppression of seed bruchid Callosobruchus maculatus development and damage on cowpea (*Vigna unguiculata* (L.) Walp.) with *Zanthoxylum zanthoxyloides* (Lam). Waterm. (Rutaceae) root back powder when compared to neem seed powder and Pirimiphos-methyl. *Crop Protection*, 1996; 15: 603-607.
40. Olotuah O.F. (2014). Bio-efficacy of oil extract of *Eugenia aromatica* in the control of storage Insect pests. International Journal of Geology, Agriculture and Agriculture Science, 2: 4-10. www.woarjournal or/GAES.
41. Oni, M.O and Ileke K.D. (2008). Insecticidal efficacy of oil extracts of Balanites a egyptiaca seeds and cashew nuts against Callosobruchus maculatus fabr. Coleoptera Bruchidae. *African Journal of Agricultural Research.*
42. Oni, M.O. (2009). Insecticidal activities of oil extracts from fruits of three local cultivars.
43. Ratnasoriya, D. and Dharmasiri, M.G. Effects of *Terminalia catappa* seeds on sexual behaviours and fertility of male rate. *Asian Journal of Andrology*, 2000; 2: 213-226.
44. Verma, N.K. and Dubey, A.K. Prospectus of botanical and microbial products as pesticides of tomorrow. *Current in Science*, 1999 ; 76: 172-178.
45. Yakubu, M.T., Akanji, M.A. and Oladiji, A.T. Haematological evaluation in male albino rats following chronic administration of aqueous extracts of *Fadogia agrestis* stem. *Journal of Pharmacognosy Magazine*, 2007; 3: 34-38.