International Journal of Innovative Agriculture & Biology Research 12(1):72-86, Jan.-Mar., 2025

© SEAHI PUBLICATIONS, 2025 www.seahipublications.org ISSN: 2354- 2934

doi:10.5281/zenodo.15103473

Toxicity Evaluation of Selected Indigenous Plants Leaves Extracts against Bambara nut Weevils' Infestation in Stored Bambara nut Grain in Mubi Adamawa State

Allen Abu Dusa[1] & Nachana'a Allen Dusa[2]

[1]Department of Agricultural and Bioenvironmental Engineering
Federal Polytechnic Mubi, Nigeria
Corresponding Author Email address: allen.dusa@gmail.com

[2]Department of Pure and Applied chemistry
Adamawa State University Mubi , Nigeria

ABSTRACT

The toxicity effect of n-hexane, ethanol and aqueous extracts from the selected locally available aromatic plants (Lantana Camara L., Ambrosia Artemisiifolia L., Hyptis Spicigera Lam. and Mentha Aquatic L) collected from Mubi North Local Government area of Adamawa State, Nigeria on the storability of Bambara nut grain against Bambara nut weevils (C. Maculatus) was evaluated. The plants extracts were extracted by chemical methods using a Soxhlet apparatus. Bambara nut samples collected from the local farmers were treated with the various plants leaves extracts concentration of 83.33 mg/mL/200g Bambara nut grain of individual plants leaves extracts. The treated Bambara nut grains were stored for four months. At two-weeks intervals, data were gathered and statistically analyzed regarding the weevil population, uninfested and infested grains, and the quantity of eggs laid by C. Maculatus. The Mean value were also compared and considered significantly different at $P<.05$. The FDI values for all the plants leaves extracts and at all times showed strong (+++) anti feedant effect (FDI > 70%). The percentage of uninfested cowpea grain (%) varied considerably ($p < 0.05$) between all treatments (plants leaves extract) and the untreated control group. Additionally, a significant difference ($p < 0.05$) was observed between the treatments (plants leaves extract). Throughout the trial, the Bambara nut grain was considerably protected by the leaves extracts of all plant types from attacks by the Bambara nut weevils (C. Maculatus) as opposed to the control. In comparison to the control, the percentage of weevil mortality was significantly ($p < 0.05$) higher in all treatments (plants leaves extracts). All the plants leaves extracts protected the Bambara nut grain significantly ($p < 0.05$) better than the direct (dried leaves powder) against Bambara nut weevils (C. Maculatus). According to the study, the leaves of Lantana Camara L., Ambrosia Artemisiifolia L., Hyptis Spicigera Lam., and Mentha Aquatic L. provided sufficient protection against the attack of Bambara nut weevils (C. maculatus) on the Bambara nut grains.

Keywords: Bambara nut, Storage, Pest, Control, Method, Plant, extracts, Toxicity and Evaluation

The authors wish to acknowledge tertiary education trust fund (TETFund) for financing the research .

INTRODUCTION

Bambara nut (BN) (Vigna subterranean L. Verdc.) is a nutrient rich, drought tolerant food legume that can contribute to food security and community resilience (Mubaiwa, 2018; Oballim *et al.*, 2022). Bambaranut (Vigna subterranean L. Verdc.) is considered the third most important food legume in Africa after groundnut and cowpea (Dansi *et al*., 2016), with relatively high carbohydrate (63%) and protein (19%) contents and a sizeable amount of fat (6.5%) (Afolabi, 2018). It is extremely tolerant to drought and poor soils (Oballimm *et al*., 2022) and can replace soil nutrients through nitrogen fixation (Musa *et al.*, 2016), making it suitable for the low input agricultural production systems of the dry lands of Sub - Saharan Africa (Christiansen, 2017; Karunaratne *et al*., 2015).

In developing countries such as Nigeria and Mubi area in particular insect pests are a major constraint to Bambara nut production. The primary insect causing losses to stored Bambara nut is the Bambara nut weevil (*Callosobruchus maculatus)*. It suffers heavily from the insects, when grains are stored after harvest. Yield reductions caused by insects can reach as high as 97%, depending on the location, cultivar and the year (Thompson and Abba, 2021*)*. Infestation starts on the field at low level and after the crop is placed in storage, the insect population continues to multiply until the Bambara nut is completely damaged (Thompson and Abba, 2021).

Weevil infestation on stored Bambara nut normally causes quality deterioration, weight loss resulting in overall impaired germ inability of grains and unacceptability in the markets (Aviara *et al.,* 2013; Mbah-Omeje, 2019). Infested grains are rendered unfit for sale and consumption.

However, insecticides are widely available; they require training and expensive equipment for their use. They are expensive, potentially dangerous to users and are polluting. Therefore, in Mubi many Bambara nut growers do not use insecticides because they cannot afford them; they cannot obtain them; they do not have the necessary equipment and they are not taught how to use them properly as a result many Bambara nut growers have quite the production. Therefore it is necessary to make use of sustainable and environmentally friendly alternative strategies, such as natural products from wild / indigenous plants (Nuruzzaman *et al*., 2019; Liambila *et al*., 2021).

The present study seek to evaluate the toxicity of leaves extracts from common indigenous plants on Bambara nut weevils *(Callosobruchus maculatus).*The results will serve as a guide in using natural plants product to control Bambara nut weevils *(Callosobruchus maculatus)* in stored Bambara nut grains.

MATERIALS AND METHODS

Study Area

The research was carried out in Mubi North Local Government Area of Adamawa State, Nigeria.

Equipment / Apparatus

The equipment and apparatus used were of Laboratory standard, which include: stainless steel spoons, soap, cellophane bags, mortar, pestle, sieve (of 0.2 mm), Oven, 1000 mL volumetric flasks, beaker, hot plate, filter paper (of what man No.540), graduated flask, analytical weighing balance and soxhlet apparatus

Chemicals / Reagents

The chemicals / reagents used were of analytical grade: such as nitric acid (HNO_3), Dimethylsulphoxide (DMSO), distilled water, n-Hexane, Ethanol $FeCl_3$, H_2SO_4, NH_4OH, filter paper and HCl.

Sample Collection

The leaves of the four plant species: *Lantana Camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam, Mentha Aquatica L.,* were collected from the farm lands in Mubi Adamawa State, which was identified by using plant net and botanical taxonomist in the department of Botany in Adamawa State University. The Bambara nut grains were also obtained from the local farmers in Mubi North Local Government area of Adamawa State

The plants leaves samples were divided into pieces and shade-dried for seven days (Edwin and Jacob, 2017). After that, they were dried for three hours at 30 degrees Celsius to a consistent weight in an oven. Following drying, an electric blender (Model BLG-400) was used to grind each plant leaves sample. The resulting powder was then repeatedly sieved through 1 mm^2 perforation meshes to produce the finest powder, which was then stored separately in a screw-capped container at room temperature for later use.

Extraction

Each of the four plant species (*Lantana Camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam, Mentha Aquatica L*) 200 grams (200 g) of powdered leaf soaked in 1000 milliliters of n-hexane, which was then macerated for 72 hours while being regularly shaken and stirred with a glass rod three times a day. What man No. 1 filter paper and cheesecloth were used to filter the solvent. To obtain n-hexane extract, which was labeled as F1, the filtrate was extracted using a Soxhlet apparatus for five to seven hours. It was then concentrated under pressure to dryness in a rotary evaporator at 27 to 32^0C. While the residue from the n-hexane extract was macerated in 1000 ml Ethanol, same cycle was followed to get Ethanol fraction (F2). The residue from the Ethanol extract were macerated again in Aqueous and same procedure were repeated to get F3 following the procedure adopted by Yusuf *et al*. (2019). From each stock 2.5 g (2500 mg) was weighed and dissolved in 30 ml solvents (n-hexane, Ethanol and aqueous) to give 83.33 mg/mL concentration of each solvent. The extract concentration (83.33 mg/mL) of each plant species was used for the Bambara nut storage.

Insects Culture

The Bambara nut weevil, *C. maculatus*, was the insect pest employed in this investigation. In order to acclimate the *C. maculatus* to the laboratory environment, they were raised on Bambara nut grain in the laboratory using the technique outlined by Edwin and Jacob, (2017). Already-infested Bambara nut grain with *C. maculatus* was gathered from local food vendors in Mubi, Adamawa State. The mature weevils were separated from the grain that was infected. In order to guarantee that there were no insects, mites, or pathogenic microbes present in the Bambara nut grain used as the culture medium for the weevils, it was carefully cleaned and placed in an oven. Five hundred grams (500 g) batches of treated grain were first cleaned, sterilized, and dried before being placed in seven distinct plastic containers. Ten weevils that were separated from the Bambara nut grain infestation were placed into each plastic container and covered with a polythene net that was securely fastened with a rubber band. The parent weevils were removed from the Bambara nut grain-weevil combinations after they had been in the lab for four days to allow for mating and oviposition. The raising was allowed enough time (25–30 days) to produce new adult insects. The experiment employed adult weevils from the first filial generation, which were 1-2 days old upon emergence.

Toxicity Bioassay of Plants leaves' extracts

The toxicity effectiveness of the plants leaves extracts against Bambara nut weevils were measured using the protocol outlined by Dharmasena *et al*. (2001). The treatments were set up in a Randomized Complete Block Design (RCBD) and reproduced three times. The treatments included *Lantana Camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam, Mentha Aquatica L.* leaves extracts, each at doses of 83.33 mg/mL/ 200 g Bambara nut grains. 200 grams of healthy, fresh, clean, and undamaged Bambara nut grains were treated with 83.33 mg/mL of the plants leaves extracts and *plants leaves direct (dried leaves powder)* clean plastic bowls for each replicate. To guarantee even exposure of the grains to the extracts, the 200 g Bambara nut grains were placed into a conical flask with the extracts pipetted into it and shaken rapidly. The tubes were manually rocked for two minutes to make sure the grains were covered with the extracts. The grains were taken out of the tubes and left on clean papers for twenty-four hours to allow the solvent to completely evaporate. It was then moved into the bowl using the technique Singh *et al.* (2017) outlined. After that, ten (10) weevils were added to each bowl, which had been previously filled with grains from each lot. To stop insects from escaping and to allow for good air circulation, muslin material with a mesh size of 10 mm was placed over each container. No treatment was given to the control group.

Data Collection

For four months, information was gathered on the number of weevils, the number of uninfested and infested grains, and the quantity of eggs laid by *C. maculatus* at two-week intervals. Counting both live and dead insects allowed researchers to determine the overall population of insects. When an insect did not react to a brush stroke, it was deemed dead. To calculate the proportion of uninfested grain at each treatment, uninfested grains were counted. Bambara nut grains were deemed to be free of infestation if there was no obvious surface damage.

The approach outlined by Pervin (2019) was used to compute the percent oviposition deterrent effect (PODE).

$$\text{PODE} = \frac{[NE\ in\ control - NE\ in\ treated]}{NE\ in\ control} X\ 100$$

Index of egg laying (IE) was calculated according to the following method.

$$\text{IE} = \frac{[NE\ in\ control - NE\ in\ treatment]}{NE\ in\ control + NE\ in\ treatment} X\ 100$$

Where NE represents how many eggs were laid

Using the formula, the average feed consumption (K) in % was also determined.

$$\text{K (\%)} = \frac{K_2 + K_4 + K_6 + K_8 + K_{10} + K_{12} + K_{14} + K_{16}}{12} \text{ X } 100$$

Where K_2, K_4, K_6, K_8, K_{10}, K_{12}, K_{14} and K_{16} is the feed consumption (weeks),

While FDI was computed as follows:

$$\text{FDI (\%)} = \frac{C - T}{C} X\ 100$$

Where C represents the average feed consumption in the control group and T represents the feed consumption in the treatment group. Using the FDI criteria, the FDI value (%) was categorized in accordance with:

- FDI < 30% = no anti feedand effect (-)
- 50% > FDI ≥ 30% = anti feedand effect are weak (+)
- 70% > FDI ≥ 50% = anti feedand effect are medium (++)
- FDI ≥ 70% = anti feedand effect are strong (+++)

$$\text{\% Weevils mortality} = \frac{Number\ of\ dead\ weevils}{Total\ number\ of\ weevils} \text{ X } 100$$

Statistical Analysis

As suggested by Abbott, (1925), the acquired data were submitted to Analysis of Variance (ANOVA) using the statistical programs Minitab version 19. At the 5% probability level, means were separated using Fisher Pairwise Comparisons and Dunnett Multiple Comparisons (Zar, 1984; Finney, 1971).

RESULT AND DISCUSSION

The result of the Feeding Deterrent Index of Bambara nut weevils treated with different plants *(Lantana Camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam, Mentha Aquatica L)* leaves extracts for sixteen weeks was shown in Table 4.1.While the result of the effect of the plants leaves extracts and control on the percentage of uninfested Bambara nut grains against Bambara nut weevils over exposure time (weeks) in stored Bambara nut grains were shown in Figure1. Also the result of the effects of the plants leaves extracts on the percentage of oviposition deterrent effects in Bambara nut weevils over exposure time (weeks) in stored Bambara nut grains was shown in Figure 2. While Figure 3 showed the result of the effects of the plants leaves extracts and control on the Bambara nut weevils percentage of index of egg laying over exposure time (weeks) in stored Bambara nut grains.

The result of the effect of the plants leaves extracts and control on the percentage of weevils' mortality over exposure time (weeks) in stored Bambara nut grain was shown in Figure 4. While the result of the effect of the solvents used in plants leaves extraction and plants leaves direct (dry leaves powder) on the percentage of uninfested Bambara nut grains against Bambara nut weevils in stored Bambara nut grains were shown in Figure 5.

Table 1: The result of Feeding Deterrent Index (FDI %) of Bambara nut Weevils on Stored Bambara nut Grains Treated with the Plants Leaves Extracts

	Plant leaves extracts				
Exposure Time (Weeks)	L	A	H	M	Average
2	98.80 ± 2.67	97.71 ± 2.87	99.16 ± 2.62	97.89 ± 0.23	96 ± 0.46 [ab]
4	98.25 ± 0.98	98.00 ± 2.65	98.22 ± 0.59	98.60± 1.22	98.16 ±0.23[ab]
6	98.79 ± 1.75	98.64 ± 0.94	98.31± 3.23	98.96± 0.67	98.62± 0.24[a]
8	99.84 ± 0.75	98.83 ± 0.76	98.91± 073	99.00 ± 2.14	99.29 ±0.41[a]
10	99.89 ± 2.32	99.28± 0.69	99.19 ± 0.42	99.2± 0 .64	99.12 ± 0.31[a]
12	99.98 ± 0.99	99.16 ± 4.11	99.23± 0.65	99.31± 1.76	99.31± 0.27[a]
14	98.62 ± 0.58	95.89 ± 0.87	96.21 ± 2.40	98.62 ± 1.45	97.23± 1.38[a]
16	94.83± 1.54	95.07 ± 2.22	96.13 ± 1.12	97.93± 2.08	96.01 ± 1.35[ab]
Average	95.16 ± 5.23[a]	95.45 ± 3.09[a]	95.47± 4.20[a]	95.36± 8.13[a]	

Averages that do not share a letter on the same row/column are significantly different.
Where L, A, H and M are *Lantana camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam and Mentha Aquatica L* leaves extracts respectively

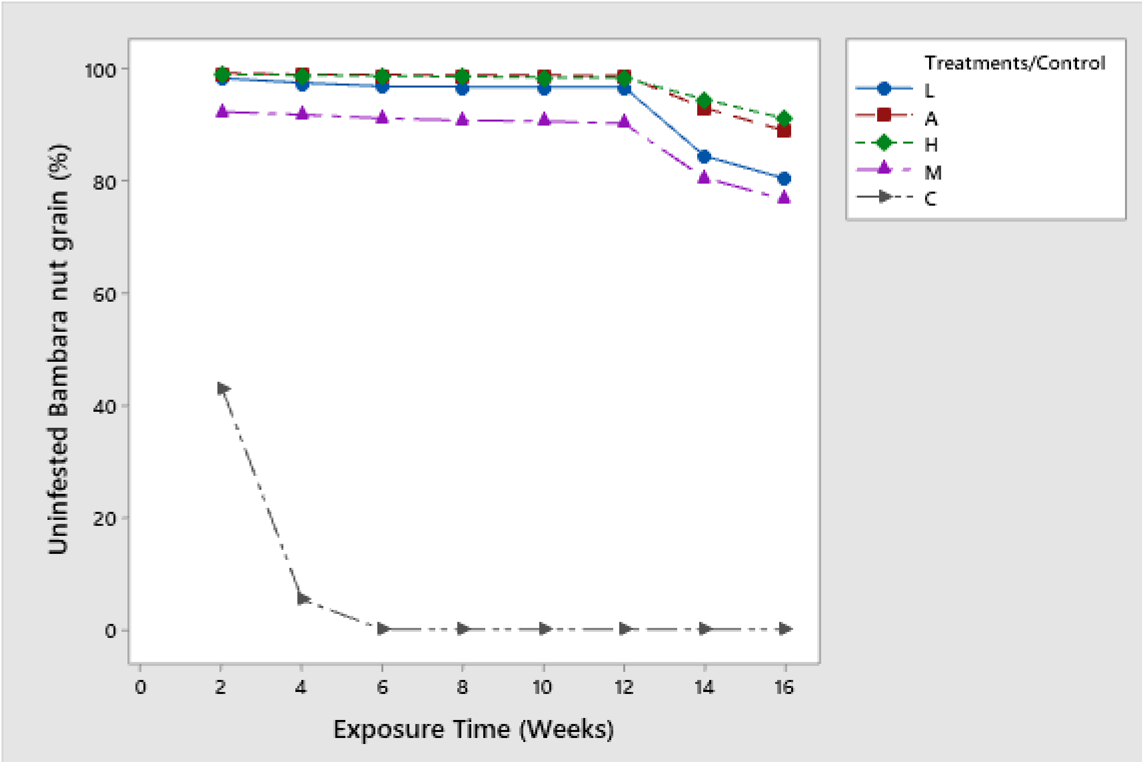

Figure1: The result of the effects of the Plants leaves extracts and control on the Percentage of Uninfested Bambara nut grains against Bambara nut Weevils over exposure time (weeks) in Stored Bambara nut grains

Where L, A, H, M and C are *Lantana Camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam and Mentha Aquatica L* leaves extracts (treatment) and Control respectively

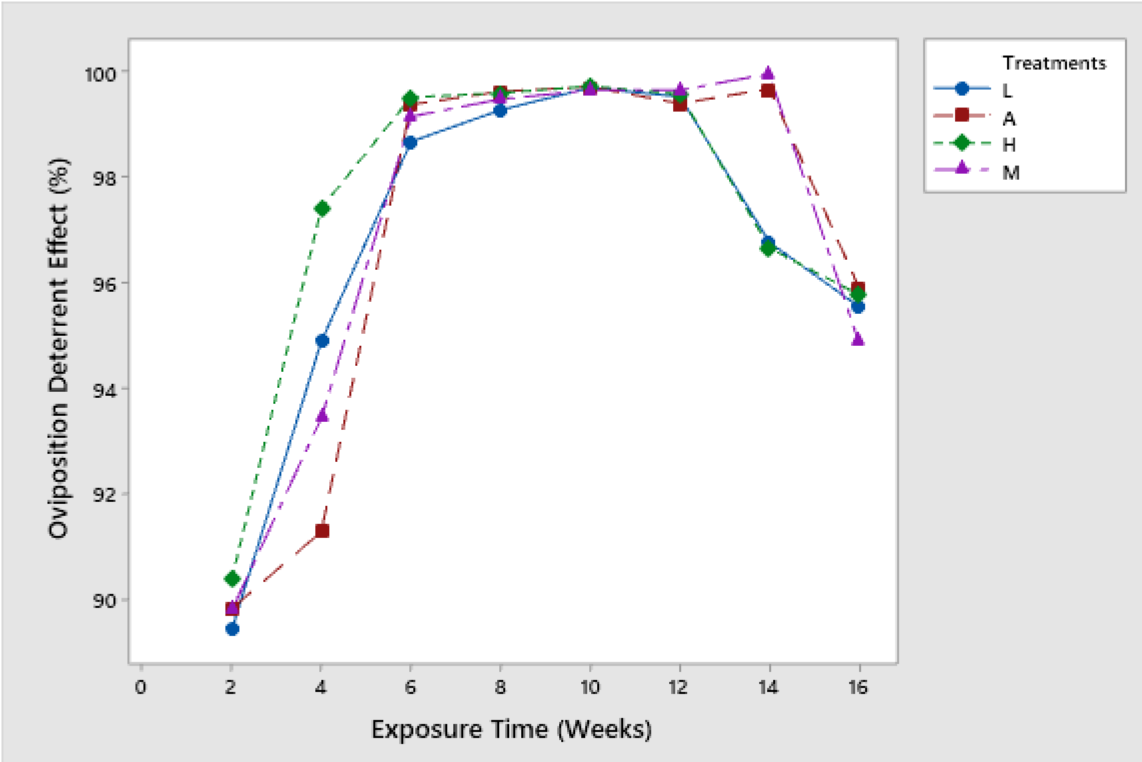

Fig 2: The result of the effects of the Plants leaves extracts on the Percentage of Oviposition deterrent effects in Bambara nut Weevils over exposure time (weeks) in Stored Bambara nut grains

Where L, A, H and M are *Lantana Camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam, and Mentha Aquatica L* leaves extracts (treatment) respectively

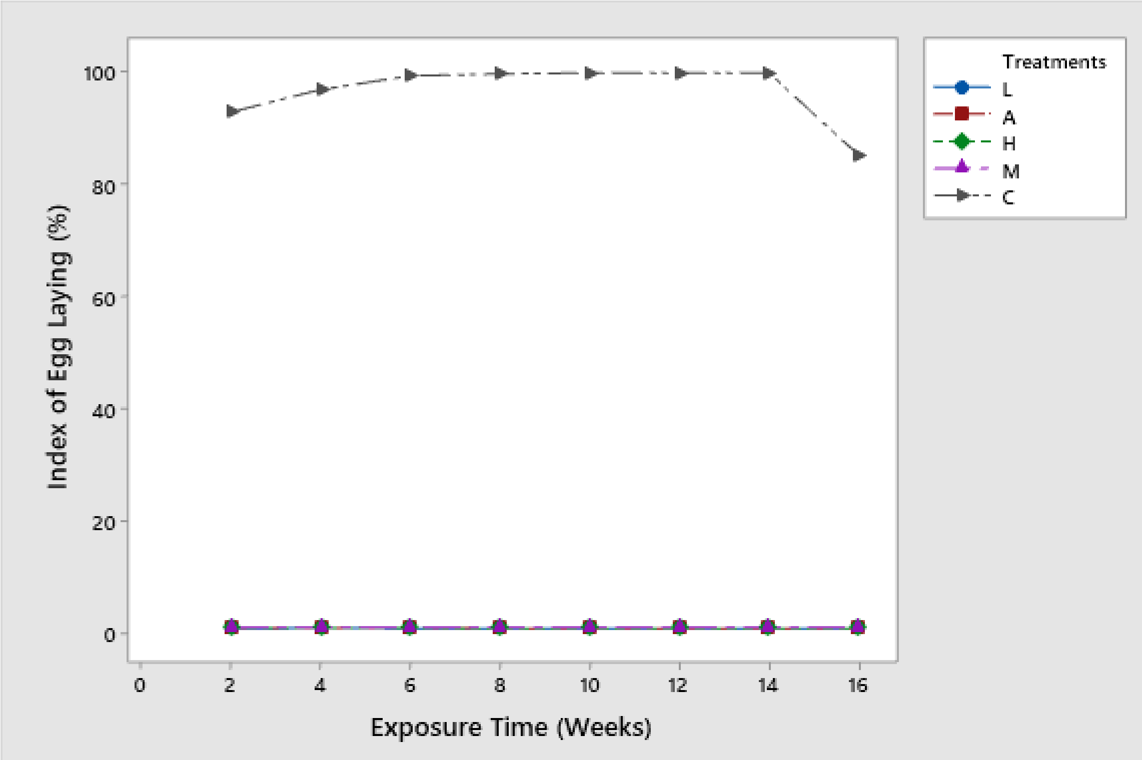

Figure 3: The result of the effects of the Plants leaves extracts and control on the Bambara nut Weevils' Percentage Index of Egg laying over exposure time (Weeks) in stored Bambara nut grains

Where L, A, H and M are *Lantana Camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam* and *Mentha Aquatica L* leaves extracts (treatment) and Control respectively

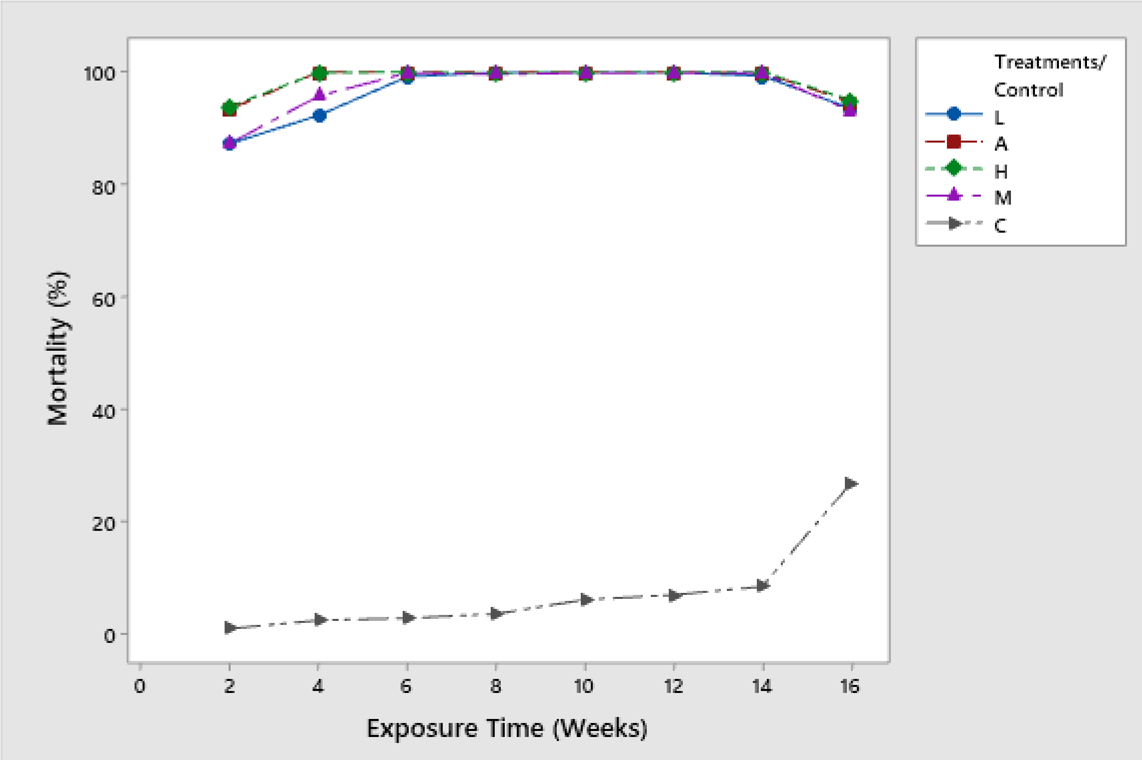

Figure 4: The result of the effects of the Plants leaves extracts and control on the Percentage weevils' mortality over exposure time (weeks) in Stored Bambara nut grains

Where L, A, H ,M and C are *Lantana Camara L*, *Ambrosia Artermisiifolia L*, *Hyptis Spicigera Lam*, *Mentha Aquatica L* leaves extracts (treatment) and Control respectively

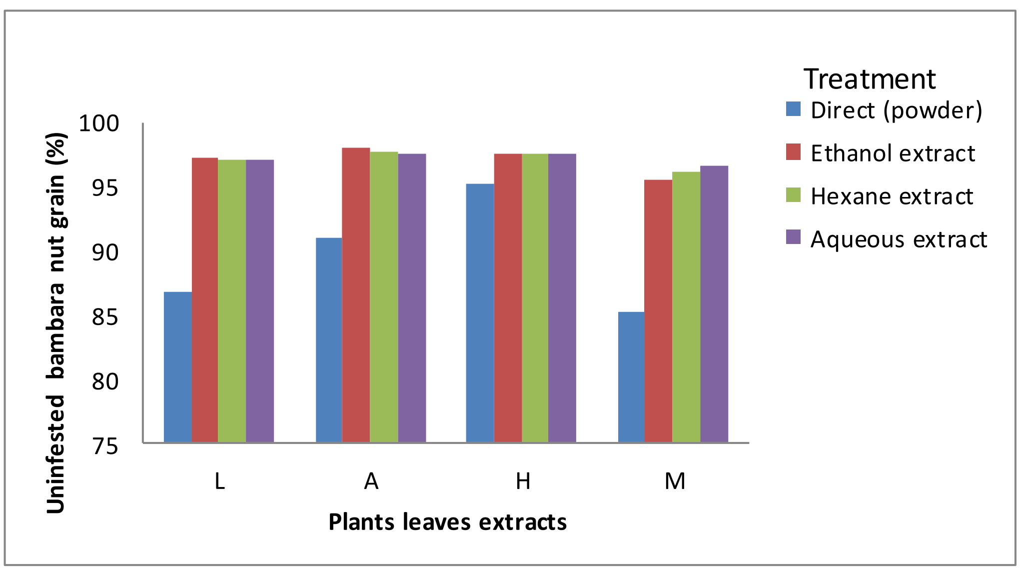

Figure 5: The result of the effect of the Solvents used in Plants leaves extraction and direct (Plants leaves powder) on Plants leaves extracts and the Percentage of Uninfested Bambara nut grain against Bambara nut weevils in stored Bambara nut grain

Where L, A, H and M are *Lantana Camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam, and Mentha Aquatica L* leave extracts (treatment) respectively

The Effects of the Plants leaves Extracts against Bambara nut Weevil (*Callosobruchus maculatus* F.), in Stored Bambara nut Grain

On stored Bambara nut grain, every plant leaf extract exhibited toxicity action against the *Callosobruchus maculatus* Bambara nut weevils:

Feeding Deterrent Index (FDI)

After feeding Bambara nut weevils with leaves extracts from four different plants (Lantana camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam, and Mentha Aquatica L) for sixteen weeks, the Feeding Deterrent Index (FDI) values ranged from 95.16±5.23 to 95.47±4.20%. The therapy with Hyptis Spicigera Lam leaf extract had the highest value, whereas the treatment with Lantana camara L. leaf extract had the lowest. The range of mean FDI values across exposure time was 96 ± 0.46 to 99.31± 0.27%. At 12 weeks of exposure, the highest was noted and at 16 weeks, the lowest (Table 1).

Generally speaking, the FDI for the study grew up to 12 weeks of exposure time, after which it decreased for the remainder of the study period. There was no significant difference ($p > 0.05$) in FDI between the treatments (plants leaves extracts). However, there is a significant difference ($p < 0.05$) in the exposure time. All plants leaves extracts FDI values consistently demonstrated a high (+++) antifeedant action (FDI > 70%).

The findings showed that, with an FDI of 95.47± 4.20 %, the leaf extract of Hyptis Spicigera Lam had the greatest feeding deterrent against the insect pest, C. *maculatus*. The extract from the leaf of Ambrosia Artermisiifolia L was the second most potent antifeedant, with FDI values of 95.45 ± 3.09, ahead of Mentha Aquatica L. (95.36± 8.13) and Lantana camara L. (95.16 ± 5.23 %).

Antifeedants are substances that prevent or interfere with insect feeding by making the treated materials unappealing or disagreeable. They are also known as "feeding deterrents" (Munakata, 1997; Saxena *et al.*, 1988). Glycosides of steroidal alkaloids, aromatic steroids, hydroxylated steroid meliantriol, triterpene hemiacetal, and other naturally occurring antifeedants are among the described antifeedants (Talukder and Howse, 2000). According to Isman *et al.* (1996), feeding deterrents are secondary metabolites found in plants that alter behavior by directly affecting the peripheral taste organs of phytophagous insects. This prevents the insects from feeding or ovipositing (David and Ananthakrishna, 2004).

The results of this investigation were in line with those of other researchers who have shown that some plants extracts can discourage insects from feeding in both field and lab settings. For example, research conducted by Huanga *et al*. (2000), Jeyasankar *et al.* (2010), and Kumarai *et al.* (2003) has shown that essential oils from medicinal plants and specific botanicals have antifeedant qualities against a variety of significant stored product insects. Additionally, Huanga *et al*. (2000) employed nutmeg (M. myristica) oil to discourage the red flour beetle and rice weevil Sitophulu zeamais from consuming food. Andy and Edema, (2019) have also reported on the antifeedant ability of several aromatic herbs against the Cowpea weevil.

The results of this investigation corroborate their findings and emphasize the previously unreported antifeedant properties of the leaves extracts of Lantana camara L, Ambrosia Artermisiifolia L, Hyptis Spicigera Lam, and Mentha Aquatica L. against the Bambara nut weevil (*Callosobruchus Maculatus*). Variations in the concentration of the active components in the extracts may account for variations in the insect responses or the degree of feeding deterrent exhibited by the plants. The four plants leaves that were extracted for this investigation all demonstrated a strong ability to shield Bambara nut grain from C. maculatus damage and attack while it is in storage.

The Effects of Plants leaves extracts on the Percentage of Uninfested Bambara nut Grains against Bambara nut Weevils in Stored Bambara nut grains

Over the course of two to twelve weeks of exposure, the percentage of uninfested Babara nut in the stored Bambara nut grain remained nearly consistent for all plants leaves extracts and reduced gradually for the remainder of the exposure period (Figure 1), which may have been brought on by the plants' leaves extracts losing its effectiveness over time. At the two weeks exposure period, the percentage of uninfested

Bambara nut grain in the control group (untreated Bambara nut grain) was highest and from there decreased dramatically to four weeks and decreased gradually to six weeks, where it reached zero uninfested Bambara nut grain for the remainder of the research time. The proportion of uninfested Bambara nut grain (%) varied considerably ($p < 0.05$) between all treatments (plants leaves extract) and the control (untreated) percentage of Bambara nut grain.

Throughout the investigation, all plant kinds' leaves extracts significantly ($p < 0.05$) protected the Bambara nut grains from attacks by the Bambara nut weevil (*C. Maculatus*) better than the control. A noteworthy ($p < 0.05$) variation was also seen between the treatments. The proportion of uninfested Bambara nut grain did not, however, alter significantly ($p > 0.05$) across the various exposure times, nor did the relationship between exposure duration and plants leaves extracts.

According to the study, the leaves extracts of Lantana Camara L., Ambrosia artemisiifolia L., Hyptis Spicigera Lam., and Mentha aquatic L. provided sufficient protection against the attack of Bambara nut weevils (C. maculatus) on the Bambara nut grains. This outcome is similar with earlier research by Aliyu and Ahmed, (2006), which treated cowpea for storage using X. aethiopica extracts at a rate of 2–8 mL/kg of cowpea and discovered that the treatment safeguarded the cowpea more effectively than the control. Schoohoven, (1982) discovered that C. millenii is an extremely effective plant when using its extract for cowpea storage.

The study shows that the extract from the leaves of Lantana Camara L., Ambrosia artemisiifolia L., Hyptis Spicigera Lam., and Mentha aquatic L. was effective in preventing C. maculatus from invading and damaging stored Bambara nut grains because it significantly decreased weevil population, oviposition, and Bambara nut grain damage. This outcome was also consistent with the findings of previous researchers that employed various essential oils to protect cowpea (Ofuya and Dawodu, 2002; Ivibijaro, 1990; Mbata *et al*., 1995; Shikaran and Uvah, 1992; Sanon *et al*., 2006; Abdel-Baky and Al-Soqeer, 2017). They reported that P. guineense oil was effective in preventing C. maculatus from invading and damaging stored cowpea seeds. They also found that adult C.maculatus is quickly destroyed, and that oviposition and subsequent adult emergence may be entirely avoided. Out of the four plants whose leaves extracts were employed for the investigation, it was discovered that the leaves of Ambrosia artemisiifolia L. and Hyptis Spicigera Lam. protected the Bambara nut grains the best (Figure 1). It was discovered that every plant leaf extract investigated had reliable insecticidal properties against Bambara nut weevil.

The Effects of Plants leaves Extracts on Oviposition deterrent Effects of C. maculatus

The oviposition-deterrent impact of leaves extracts for all plants rose with exposure duration, peaking at six weeks to twelve weeks for *Lantana Camara L and Hyptis Spicigera Lam and from six weeks to peak at fourteen weeks for Ambrosia Artermisiifolia L and Mentha Aquatica L* and declined for the remainder of the period of the study. Following that, all plant types' leaves extracts showed a dramatic fall in their ability to deter oviposition over the duration of the study (Figure 2). This could be due to a decline in the plants leaves extracts' ability to prevent oviposition. There was no significant difference ($P > 0.05$) in the oviposition deterrent effect between the plants leaves extracts and the interaction between the plants leaves extracts and exposure time. However, there was a significant difference ($p < 0.05$) in exposure time. Adi and Richard, (2014) observed similar things.

It was discovered that the plant leaves had a powerful oviposition-deterrent impact on C. maculatus. The extract from the leaves of *Ambrosia Artermisiifolia L and Mentha Aquatica L* had the strongest anti-oviposition action on C. maculatus. According to Pervin's, (2019) report, which examined the oviposition deterrent properties of extracts from M. alternifolia (Gammatol and Fungatol), T. parthenium, T. vulgare, A. vera, and J. regia, all of the plants extracts had a significant oviposition deterrent effect on C. maculatus. This study concurs with that report.

Other research using various plants extracts have also been carried out. For instance, Ocimum gratissimum L. and O. basilicum L. (Lamiaceae) extracts dramatically decreased C. maculatus oviposition behavior on cowpea, according to research by Yarou *et al*. (2018). Azadirachtin reduced C. maculatus's ability to deposit eggs. T. vulgare decreased Pieris rapae L. feeding on cabbage leaf disks. Additionally, the aqueous extract of T. vulgare was shown to decrease insect egg laying in the same study (Pervin, 2019).

The Effects of Plants leaves extracts on Index of Egg Laying

Egg-laying index was almost zero from week two to the remainder of the period of study for all the treatments (plants leaves extracts). However, the Index of egg laying for the control raise gradually from weeks two to four from there remain almost constant to the fourteen week from there it declined for the rest of the study period (Figure 3). This means at the beginning the population of the weevils were many and they lay many eggs but as the food are gradually finishing, their population reduced and so the lay less eggs. The egg-laying index varied considerably ($p < 0.05$) for each treatment (plants leaves extracts) compared to the control, but it did not alter significantly ($p > 0.05$) between treatments or exposure times.

This finding somewhat aligns with earlier research by Ito and Jacob, (2017), who examined the impact of different oil types on C. maculatus egg laying on stored cowpea grains over a 180-day period. Their findings reveal that there was no significant difference ($P > 005$) in the oils' activities during the first two months, but there was a significant difference ($P < 0.05$) in the third month between the oil types whose neen-moringa oil produced the fewest eggs. In the final three months, they also saw a significant decline in C. maculatus oviposition for all oil types.

The effect of plants leaves extracts on percentage of weevils' mortality

The percentage of weevil mortality for all treatments (plants leaves extracts) rose as exposure time increased from weeks two to six. From there, it maintained nearly constant levels until weeks fourteen and then began to decline (Fig. 4). This could be because the plants leaves extract's effectiveness began to wane. As their population grows, so does their natural mortality, so the percentage of weevil mortality in the control group increased gradually from week two to week fourteen, then sharply increased for the remainder of the study period (as the food is running out). In comparison to the control, the percentage of weevil mortality was significantly ($p < 0.05$) higher in all treatments (plants leaves extracts). Nonetheless, the proportion of weevil mortality did not differ significantly ($p > 0.05$) among the treatments (plants leaves extracts) and across exposure intervals, nor did the relationship between exposure time and plants leaves' extracts.

According to the current study, leaf extracts from every plant that was tested showed promise as a defense against C. maculatus. The findings of this investigation were somewhat consistent with the findings of other researchers, such as Opareke and Dike, (2005), Adedire *et al*. (2011), Mukanga *et al*. (2010), and Ileke and Oni (2011), who noted that some botanicals are highly toxic to pest storage insects, such as C. maculatus. The harmful effects of the compounds reported (Adedire *et al*., 2011; Mukanga *et al*., 2010) in plant species' leaf extract may have contributed to the observed C. maculatus death rates.

The extracts from all of the plants indicated potential as insecticides. Terpenoids function as a fumigant, which kills insects by producing starvation brought on by a sharp decrease in their respiratory activity. The rice and cowpea weevils are poisoned by the terpene 1, 8-cineole (Adi *et al*., 2014).

All four plants' leaves extracts, however, performed noticeably better than the untreated control group. The insecticidal efficiency of the leaves extracts of the four plant species is represented as follows when the mean percentage mortality is taken into account: Leaf extract from Hyptis Spicigera Lam, Ambrosia artemisiifolia L, Mentha aquatic L, and Lantana Camara L.

The **Effects of using different solvents for extraction and plants leaves (dry powder) on the Percentage of uninfested Bambara nut grains Stored with Different type of Plants leaves extracts**

When it came to defense against Bambara nut weevils (C. Maculatus), all of the plants leaves extracts considerably ($p < 0.05$) outperformed the straight plants leaves (dry powder) [Figure 5]. This could be as the result of contaminants in the powdered dried leaves, or it could be because the solvents were able to extract more and higher concentrations of the plant's leaves' toxic components. There was no significant difference ($p > 0.05$) in the percentage of uninfested Bambara nut among the extracts made with different solvents. Additionally, there was no significant difference ($p > 0.05$) in the impact of the interaction between plant type, leaf extract, and extraction solvent on the percentage of uninfested Bambara nut grain.

The outcome is consistent with the findings of Iloba and Ekrakene's, (2006) comparative study comparing the insecticidal effects of H. suaveolens, Ocimum gratissimum L, and Azadirachta indica A. Juss. They found that the extracts of these plants' leaves had a higher level of insecticidal action against C. maculatus than the direct (dried powder) method. Both the plants powder and extracts shown in this study had significant insecticidal efficacy at a respectable proportion

CONCLUSION

Generally, the outcome of the study proved that all the treatments (plants leaves extracts) protected the Bambara nut grain against Bmabara nut weevils in storage. Considering the mean percentage protection, the toxicity of the plants leaves extracts against Bambara nut weevils of the four plants species is indicated as follows: *Hyptis Spicigera Lam > Ambrosia artemisiifolia L > Mentha aquatic L > Lantana Camara L*. The statistical analysis showed that FDI did not differ significantly ($p > 0.05$) among the treatments (plants leaves extracts). However it differ significantly ($p < 0.05$) among the exposure time. Uninfested Bambara nut grain (%) in all the treatments (plants leaves extracts) differed significantly ($p < 0.05$) from the control (untreated). For all the treatments (plants leaves extracts), index of egg lying differed significantly ($p < 0.05$) from the control, but did not differ significantly ($p > 0.05$) among the treatments (plants leaves extracts) as well as among the exposure time.

Therefore all the plants extract can be used as toxic against Bambara nut Weevil *Callosobruchus maculatus* on Stored Bambara nut grain. We are surrounded by these ubiquitous, very aromatic plants that require little maintenance. The plants are inexpensive to get, and it is simple to extract their extract using a solvent or conventional method.

ACKNOLEDGEMENT

The authors wish to acknowledge tertiary education trust fund (TETFund) for financing the research .

REFERENCES

Abba, H.M., Umar, B. and Mohammed, I. (2018). Leaf epidermal anatomy of selected varieties of Bambara groundnut in Gombe, Nigeria. International Journal of Current Research in Biosciences and Plant Biology. 6. No 9. ISSN: 2349-8080. (online). DOI: https://doi.org/10.20546/IJCRBP.2019.609.006.

Abbott, W. S. (1925). A method for computing the effectiveness of an insecticide. J Econ. Entomol., 18: 265-267.

Andy O.E and Edema J.A. (2019). Antifeedant Potential of Some Aromatic Plants Against Cowpea Weevil, *Callosobruchus Maculatus*. *World J Agri & Soil Sci*. 2(5). WJASS.MS.ID.000546. DOI: 10.33552/WJASS.2019.02.000546.

Aliyu, M., and Ahmed, B. I. (2006). "Comparative efficacy of different rates of groundnut oil for the control of cowpea weevils Callosobruchus maculatus (F.) in stored cowpea (*Vigna unguiculata* (L.) Walp)," *Global Journal of Agricultural sciences*, vol. 5, no. 2, pp. 123–126.

Abdel-Baky, N. F., and Al-Soqeer, A. A. (2017). Controlling the 2nd instar larvae of Tuta absoluta meyrick (Lepidoptera: Gelechiidae) by Simmonds in extracted from Jojoba seeds in KSA. Journal of Entomology 14(2):73- 80. https://doi.org/10.3923/je.2017.73.80

Adi, B. and Richard, M. W. (2014). Oviposition Deterrent Activities of *Pachyrhizus erosus* Seed Extract and Other Natural Products on *Plutella xylostella* (Lepidoptera: Plutellidae) Inon Scharf *J. Insect Sci.* 14(244): DOI: 10.1093/jisesa/ieu106

Afolabi, F., Arotupin, D. J., Ojo, T. and Olowokere, T. (2018). Improving nutritive value of Fermented cereal porridge 'Ogi' by fortifying with Bambara nut. Croatian Journal of Food Science and Technology, 10(1), 51–57.

Aviara NA, Lawal AA, Atiku AA, Haque MA (2013). Bambara groundnut processing, storage and utilization in north Eastern Nigeria. Continental Journal of Engineering Sciences 8(1):28- 36.

Christiansen L (2017). Agriculture in Africa-Telling myths from facts: A synthesis. Policy Research Working Paper; No: 7979. World Bank, Washington, DC.

Dansi A, Rudebjer P, Hall R (2016). Bambaranut, a legume of choice for food security and industry. Policy Brief of the NUS Value Chain Project "Strengthening capacities and informing policies for developing value chains of neglected and underutilized crops in Africa. Available at: Bambara brief-design.pub (nuscommunity.org)

David, B. V., and Ananthakrishna, T. N. (2004). General and Applied Entomology 2nd Ed. Tata *McGraw Hill education private limited, New Delhi*, 1184 pp.

Dharmasena, C. M. D., Blaney, W. M. and Simmonds, S. M. J. (2001). Effects of storage on the efficacy of powdered leaves of *Annona squamosa* for the control of *Callosobruchus maculatus* on cowpea (*Vigna unguiculata*). *Phytoparasitica*, **29(3):** 31-35.

Edwin I. E, and Jacob I. E. (2017). "Bio-insecticidal potency of five plant extracts against Cowpea Weevil, Callosobruchus maculatus (F.), on Stored Cowpea, Vigna unguiculata (L)," *Jordan J Biol. Sci.*, 10(4):317-322.

Finney, D. J. (1971). *Probit Analysis*. Cambridge University Press; 333pp.

Huang, Y., Lam, S. L., and Ho, S. H. (2000). Bioactivities of essential oil from Elletaria cardamomum (L.) Maton. to Sitophilus zeamais Motschulsky and Tribolium castaneum Herbst. J Stored Prod Res. 36: 107-117.

Ileke, K. D., and Oni, M. O. (2011). Toxicity of some plant powders to maize weevil, *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae) on stored wheat grains (*Triticum aestivum*). *Afr J Agric Res*., 6(13): 3043-3048.

Ivibijaro, M. F. (1990). "The e fficacy of seed oils of Azadirachta indica , A. Juss and piper guineense Schum and Thonn on the control of Callasobruchus maculates," *Insect Science and Its Application,* 7(4): 521–524.

Iloba, B. N., and Ekrakene, T. (2006) Comparative assessment on insecticidal effect of Azadirachta indica, Hyptis suaveolens and Ocimum gratissimum on Sitophilus zeamais and Callosobruchus maculatus. *J Biol Sci* 6:626–630

Karunaratne, A. S., Walker, S. and Ruane, A. C. (2015). Modelling Bambara groundnut yield in Southern Africa: Towards a climate-resilient future. Climate Research, 65, 193–203. https://doi.org/10.3354/cr01300

Liambila R. N., Wesonga, J. M., Ngamau, C. N. and Wallyambillah W. (2021). Chemical composition and bioactivity of Lantana camara L. essential oils from diverse climatic zones of Kenya against leaf miner (Tuta absoluta Meyrick) *African Journal of Agricultural l.* 17(9): 1198-1208, DOI: 10.5897/AJAR2020.15243

Mbata, G. N., Oji, O. A., and Nwanna, I. E. (1995). "Insecticidal action of preparations from the brown pepper, piper guineese schum and Thonn seeds to Callosobruchus maculates (Fabricius)," *Discovery and Innovation,* 7(2): 139–142.

Manukata, K. (1977). Insect antifeedants of Spodoptera litura in plants. In: P. A. Hedin (Ed). Host Plant Resistance to Pests. ACS Symposium Series No. 62, *American Chemical Society, Washington. 62:* 185-196.

Mbah-Omeje, K.N. (2019). The Insecticidal Activity of Neem (*Azardirachata indica*) Against weevils in Stored Bambara Nuts (*Vigna subtteranea*) and Beans (*Phaseolus vulgaris*). American Journal of Biomedical and Life Sciences. 7, No. 2, pp 31-35.

Mubaiwa, J., Fogliano, V., Chidewe, C., Bakker, E. J. and Linnemann, A.R. (2018). Utilization of Bambara groundnut (Vigna subterranea (L.) Verdc.) for sustainable food and nutrition security in semi-arid regions of Zimbabwe. https://doi.org/10.137/journal.pone.0204817

Mukanga, M., Deedat, Y., and Mwangala, F. S. (2010). Toxic effects of five plant extracts against the larger grain borer, Prostephanus truncatus. Afr J Agric Res., 5(24): 3369-3378.

Musa M, Massawe F, Mayes S, Alshareef I, Singh A (2016). Nitrogen fixation and N-balance studies on Bambaranut (*Vigna subterranea* L. Verdc.) landraces grown on tropical acidic soils of Malaysia. Communications in Soil Science and Plant Analysis, 47(4):544-542.

Nuruzzaman M, Liu Y, Rahman M. M, Dharmarajan R, Duan L., Uddin A. F. M. J and Naidu R (2019). Nanobiopesticides: Composition and preparation methods. In Nano-Biopesticides Today and Future Perspectives. https://doi.org/10.1016/b978-0-12-815829-6.00004-8

Oballim G, Obura M, Mutio M.J, Isubikalu P, Opile W, Ochuodho O.J. (2022). Production and utilisation of Bambaranut (Vigna subterranea (L.) Verdc.) in Northern and Eastern Uganda. African Journal of Agricultural Research. https://doi.org/10.5897/AJAR2022.16158.

Vol.18(11), pp. 977-990

Ofuya, T. I., and Dawodu, E. O. (2002). "Aspects of insecticidal action of piper guineese Schum and Thonn fruit powders against Callosobruchus maculates (F) (Coleoptera: Bruchidea)," *Nigerian Journal of Entomology*, (19): 40–50.

Oparaeke, A. M., and Dike, M. C. (2005). Monodora myristica (Gaertn), (Myristicaceae) and Allium cepa (Lilliaceae) as protectants against stored cowpea seed Bruchid (Callosobruchus maculatus) infestation. Nig J Entomol., 22: 84-92.

Pervin, E. (2019). Oviposition deterrent activities of some plant extracts against tomato leaf miner, *Tuta Absoluta* meyrick (Lepidoptera: *Gelehiidae*) *J Ecol Nat Environ* 7 (6): 232 - 239

Singh V, Vermak. D. and Srivastav P. P. (2017). Food Grain Storage Structures: Introduction and Applications. https://www.*researchgate.net/publication*/329744040

Schoonhoven, L. M. (1982). Biological aspects of antifeedants. Entomologia Experimentalis et Applicata 31: 57–69

Saxena, R. C., Jilani, G. and Kareem, A. A. (1988). Effects of neem on stored grain insects. Focus on phytochemical pesticides," *Florida Entomology*, 1: 97–111.

Shikaran, T. O., and Uvah, I. I. (1992). "Effect of plant materials on progeny development in Callosobruchus maculatus F.," in Established Infestation on Cowpea Grain, Samaru, Nigeria. *African Journal of Biotechnology 9(5), 628-634.*

Sanon, A., Ilboudo, Z., Dabire, C. L. B., Nebie, R. C. H., Dicko, I. O. and Monge, J. P. (2006). "Effects of Hyptis spicigera Lam. (Labiatae) on the.behaviour and development of Callosobruchus maculatus F. (Coleoptera: Bruchidae), a pest of stored cowpeas," *Int. J Pest Manag*. 52(2): 117 – 123

Thompson, A. and Abba, H. M. (2021). Toxicity of Piper guineense Schum and Thonn and Chlorpyrifos Powders for the Control of Callosobruchus subinnotatus (Pic.) on Stored Vigna subterranea (L.) Verdcourt in Gombe State, Nigeria. FUDMA Journal of Sciences (FJS) online: 2616-1370 ISSN print: 2645 - 2944 Vol. 5 No. 2, June, 2021, pp 358-364

Yarou, B. B., Bawin, T. and Boullis, A. (2018). Oviposition deterrent activity of basil plants and their essentials oils against Tuta absoluta (Lep.:*Gelechiidae*). *Environmental Science and Pollution Research*. 25(30):29880– 29888.

Yusuf, S. Y., Musa, A. K., Adebayo, A. G. And Lawal, M. T.(2019). Suppression of Damaging Effects of *Callosobruchus Maculatus* (F.) (Coleoptera: Chrysomelidae) By Plant Powders *Agrosearch, 19(1): 1-12.*

Zar, J. H. (1984). *Biostatistical Analysis, 2nd ed*. Prentice-Hill Intl. Englewood Cliffs, N.J.