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Effects of Balanite, Chilli Pepper and Ginger Powders as Protectants against Ephestia Cautella (Moth) on Stored Millet Grains in Gujba, Yobe State, Nigeria

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Abstract: *The experiment was carried out in the Laboratory of the Department of Agricultural Technology College of Agriculture Science and Technology Gudjiba, Yobe State Nigeria, This research work was carried out to determine the efficacy of balanite, chilli pepper and ginger powder as protectants against Ephestia cautella on stored millet, to determine the effective concentration of balanite, chilli pepper and ginger powder in the control of Ephestia cautella on stored millet and Repellence of balanite, chilli pepper and ginger powder on Ephestia cautella on stored millet. The insect (Ephestia cautella) was been subject to the treated millet using balanite powder, chill pepper and ginger powder on main plot and each of the application rate of 0.0, 0.5, 1.0 and 1.5g per 200g of millet on sub-plot. Each application rate of both the plant extracted were been replicated three (3) times. The experiment was laid out in split plot design. Data were collected on seed damage, weight loss, progeny production, adult mortality of millet weevil, repellency, palatability of millet after storage and germination test. The data were subjected to analysis of variance (ANOVA) and the means were separated by Least Significant Difference (LSD). The results showed that, there were significant differences (P≤0.05) among the plant powder used with chilli pepper proved over other plant powder on insect mortality. At 4 days in storage, there were highly significant difference (P≤0.01) among the different concentration used, 1.5 g had highest mortality of 45.6 % and the least was recorded from control (0.00 %) insects' mortality. Further extensive studies should be carried out on the persistence and hazards that might be associated with the plant powder, chilli pepper should be used for storage of seed and grains against the use of chemicals,and further ascertain, should be carried out using different plant produce, to confirm the results of present stud.*

Keywords: *Ephestia Cautella, Balanite, Chillipepper, Ginger and Millet*

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INTRODUCTION

Millets are one of the major cereal grains consumed worldwide, especially in arid and semi-arid areas of Africa and Asia (India and China). They are of great interest because of their high nutritive value and agro-industrial importance (Saleh *et al*., 2013; Zhu). Millets are generally of seven types with different colors, shapes, sizes, and cultivation areas. These grains are the oldest, and probably the first cereal grain, known to human for domestic use; they are small-seeded, round shape cereals and belong to the Poaceae family (Food Agricultural Organization (FAO), 2020).

Finger millet, also known as *Eleusine coracana* L., is grown in parts of India and Africa. Taking production statistics into account, it secures the sixth position in India among major cereal grains following wheat, rice, maize, sorghum and bajra (Devi *et al*., 2014). It can thrive at higher temperatures and in soils with higher salinity compared to other cereal crops. Optimum conditions for growing finger millet are temperatures ranging from 11 to 27◦C, soil pH of 5 to 8.2, and medium rainfall (Upadhyaya *et al.*, 2008).

Many global health organizations have recommended a variety of plant-based foods to improve health status and prevent chronic diseases (Hou *et al*., 2018). However, specific attention to the nutritional quality and cultivation of millets can provide an overall solution to the existing challenges of hunger and malnutrition. Millet can be used to produce commercial foods such as puffed millet, millet juice, and millet noodles. In general millets contain about 7–12% protein, 2–5% fat, 65–75% carbohydrates and 15–20% dietary fiber. They also have a noticeable number of vitamins, minerals, and phenolic compounds (Hasan *et al*., 2019) millets can induce several potential health benefits, such as antioxidant and anti-microbial activities (Singh and Sarita, 2016).

In developing countries, food grain production and consumption often dropped below demand as a result of postharvest loses caused by pest and other spoilage agent. Insect pest attack to stored grain result to major economic loses and in Africa subsistence grain production support livelihoods of majority of the population. Grain losses caused by storage pest such as *E. cautella* and *sitophillus zeamais* threatens food security. This problem is more serious in developing countries in the tropics due to the favorable climate condition and poor storage structures (Bekele *et al*., 1997). There are huge losses in food storage and its quality by warehouse insects; amongst the *Ephestia cautella,* which create a center of attention to many researchers of its economic importance. In fact, with its physiological adaptability it one of the most destructive insects of stored materials such as dried fig, wheat-flour, chocolate dried fruits, nuts, grain and dates (Singh and Moore, 1985). Larvae cause considerable damage by feeding and/or by contaminating stored food with dead bodies and their own products, e.g. excreta, webbing, silk and feces while no damage from adults as they feed on liquid food and/or do not feed at all, in contrast their bodies can become undesirable. To reduce these losses certain control measures must be taken on insect pest in stored produce normally reduced this heavily to resist used of fumigants and residual control insecticides (Obeng-Ofari,1997) The implication of these are serious problem of toxic residues health and environmental hazard, development of insect strains resistance to insecticides increase cost of application due to erratic supply of safer chemical in the developing countries due to foreign exchange constrains (Bekele *et al* .,1997) more than 500 arthropods pest species have become resistance to one or more insecticides(Bill,2001) resistance of cotton bollworm *helicoptera xylostella* to all classes of insecticides, resistance of diamondback moth, *plutallaxylostella*. Grains constitute the most important staple foodstuff for the ever-growing population in the tropics. but a wide range of insect pests attack stored products with the commonest among them being beetles and moths (Obeng-Ofori *et al.,* 1997).

The use of bioactive natural products or plant derived compounds as promising alternatives to synthetic insecticides in controlling insect pests of stored products (Ohazurike *et al*., 2003).The use of bioactive natural products or plant derived compounds as promising alternatives to synthetic insecticides in controlling insect pests of stored products (Ohazurike *et al*., 2003).Botanical preparation utilization for the protection of stored produce by small scale

farmers is anchored on their safety to the environment, affordability, availability and effectiveness. The effectiveness of plant products in controlling Bruchids infestation is also well documented (Anonymous 1996). effective killing of adult beetle with application of brown pepper, reduced egg laying by application of fresh palm oil and vegetable oils. Several plant products have been shown to possess insecticidal properties against a wide range of insects, particularly agricultural pests (Yahaya and Abubakar, 2004)

Synthetic insecticides like orgnochloride, organophotascabomates and synthetic pyrethroids commonly used to control stored grain pest but, this reduce quality of grain, creates smelly, odor hazardous to human health causing bio-magnification – 80, to use plant products have several advantages over synthetic insecticides insect over increasing attention and interest among the proponents of a friendly, safe and integrated environmental development. At present, bio insecticides are successfully introduced in agriculture and horticulture to control, prevent or delay the development of pest. An additional advantage of bio pesticide is the fact that they appear to be safe during accidental with high animals' e.g. mammals (Copping *et al.,* 2000).

Botanical insecticides have long been recommended as alternatives to synthetic chemical insecticides the reasons botanical insecticide became Herbs cause little risk to human health, the cost of production and processing is slow and easy also studies were the toxicity of fumigants extracted from oils obtained from a human of plant the focus was one the fumigants potential application against stored product insect (Shaaya *et al.*, 1997) Bio pesticides in the form of essential oils e.g pyrethrum (Trevir) or neem oil from *azadirachta inidica* are well known on the market (Belnian, *et al.,*2001).

Ginger rhizome is also effective against many diseases and pests of cultivated crops (Stoilova *et al*., 2007). The balanite powder also exerted significant repellent effect of 72.7 % on the pest larvae and significantly reduced sorghum damage by 30 % (Elamin and Satti, 2013).The effectiveness of plant products in controlling Bruchids infestation is also well documented by Anonymous (1996), who reported effective killing of adult beetle with application of chilli pepper, reduced egg laying. Therefore in this research, the plant powder been used are chilli pepper, balanite and ginger.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted in the Laboratory of the Department of Agricultural Technology, College of Agriculture Science and Technology Gujba, Yobe State Nigeria. It is located at latitude $11^0 44^l$ 49.09" N and longitude 11^0 57' 38.99" E.

Materials Used

Clean un-infested millet, Tray and Sieve, Masking tape, Permanent marker, 300ml capacity jar glass, Insect (*Ephestia cautella*), Muslim cloth, Balanite powder, Chilli pepper powder, Ginger powder, Book and pen, Robber band, poultry mash (wheat bran + honey + glycerin + yeast), grain, liquid soap, petri-dish, aspirator, white filter paper, pipette, sieve, hand lens, and digital weighing scale.

Source of Seed grain

Millet grain were, obtained from grain market at Damaturu Yobe State, Nigeria and it was cleaned distracted to remove dirts and hidden infestation respectively

Sources of Plant powders

Chilli pepper, balanite and ginger were purchased from Damaturu main market Yobe State. The balanite, chilli pepper and ginger powders were been dried at room temperature (26-28 ^{O}C) for seven days and ground separately using a grinder to get powder form.

Experimental Design and Treatments

The insect **(***Ephestia cautella*) were subject to the treated millet using balanite powder, chill pepper and ginger powder as main plot and each of the application rate of 0.0, 0.5, 1.0 and 1.5g per 200g of millet as sub-plot. Each application rate of both the plant powder were replicated in a three (3) jar and 200g of millet. The container of jar was shaked vigorously to achieve uniformity. Each of the thirty-six (36) jars, twenty (20) adult of *Ephestia cautella* was introduced and the jars were capped and kept in the laboratory for twenty-one (21) days of exposure period. The content of one replicate of each application rate was gently put on a tray after each of the exposure period and the dead and live insects were counted and recorded.

The *Ephestia cautella* experiment was carried out in the laboratory in Split Plot Design.

METHODS

Culturing of insects

The tropical warehouse moth *Ephestia cautella* were obtained from the Grain Store in Damaturu Market, Yobe State and were reared in Crop Production Laboratory at Department of Agricultural Technology, College of Agriculture Science and Technology Gujba, Yobe State. Insect culture technique (rearing): *Ephestia cautella* were successfully reared in laboratory cultures on standard diet composed of a mixture of a half part of crushed millet, one-part barley, one and a half parts of broiler feed and one-and-a-half-parts layer feed (by weight) as described by Al-Azab, (2007). With aid of aspirator, 30 unsexed *E. cautella* were used to infest the mesh. The glass jar were covered with perforated lid but scaled with a mesh to facilite ventilation of the culture and to keep out mites and other unwanted insects from contaminating the cultures while the desired insects are kept into the jars. The jars were kept on trays smeared with oil to prevent insects from crawling into the cultures. Adult *Ephestia cautella* were sieved out with mesh after one week of oviposition. The emerging adults were used to infest the grain.

Insect Bioassay

Portions of 0.5 g, 1.0 g and 1.5 g of Balanite powder, chilli pepper and ginger powders were mixed with clean undamaged and uninfected millet in 250 ml of glass jar. The seeds in the controls contained no plant powders. The glass jars with their contents were gently shaken to ensure thorough admixture of the millet seeds and treatment powders. Twenty pairs of adults *E. cautella* was introduced to each of the glass jar and covered. Three replicates of the treatments and untreated controls were laid out in split plot design. The adult mortality was assessed after every 24 hrs for 4 days. Adults were considered dead when probed with sharp objects and there were no responses. On day 5, all insects, both dead and alive were removed from each container and the seeds returned to their respective glass jar. Progeny emergence (F1) was then recorded at 6 weeks (42 days). The containers were sieved out and newly emerged adult weevils were counted with an aspirator. At week 6, the grains were reweighed by using weighing balance and the percentage losses in weight were determined as follow:

Percentage (%) weight loss = $\frac{Initial\ weigh\ -final\ weig}{Initial\ weight}$ x 100

After re-weighing, the numbers of damaged grains were evaluated by counting wholesome and bored or seed with weevil emergent holes. Percentage seed damaged was also calculated as follows:

Percentage (%) Seed damage = $\frac{Number\ of\ \ perforated\ grains}{Total\ number\ of\ grains\ counted}$ x 100

Mortality on Treated Millet

Two hundred grams of millet were placed in five glass jars each. The grains were treated with different concentrations of chilli pepper powder and ginger powder 0.5g, 1.0g and 1.5g per 100g of millet. The control was not treated and each treatment were replicated three times in split plot design. Twenty adult *Ephestia cautella* of 3 – 5 days old of mixed sexes were been used to infest the millet. The jars were been covered with mesh or white thin cloth held with rubber bands. Dead insects in the treatments were counted after 24, 48, 72 and 96 hours. Data were been collected for mortalities in the control by using Abbott's formula (Boateng and Kusi, 2008).

Tests for Oviposition

The method adopted by Maina and Lale, (2004) were used in conducting this experiment. Two hundred grams of millet was weighed into five glass jars. Three of the jars were been treated with different concentration of balanite powder, chilli powder and ginger powder and the other were treated with a solvent only as control. Each treatment were been replicated three times. The treated millet was kept for hours to allow the solvent to evaporate. With the aid of an aspirator, 20 adult *Ephestia cautella* of 2- 4 days' old mixed sexes were introduced into the jars containing the grain. All treatments were arranged in a split plot design. Adult insects were been sieved after oviposition period of three days. The number of eggs laid was counted and recorded.

Progeny Assessment

In this experiment, 20 adult unsexed 2-4 days old *Ephestia cautella,* was introduced into five containing millet (200 g) treated with different concentration of the balanite powder, chilli pepper powder and ginger powder 0.5g, 1.0g and 1.5g and control at 0 g. Each were been replicated three times. The culture was left undisturbed for period of six weeks. The adult insects that emerged in both treated and control jars were been counted and recorded (Maina and Lale, 2004).

4Seed germination test

The germination test adopted by Rahman and Talukder, (2006) were been used to test the viability of the seeds. Millet were been separately treated with balanite powder, chilli pepper powder and ginger powder 0.5 g, 1.0 g and 1.5 g while the control were been left untreated. The treated and control seeds were been left untreated. The treated and control seeds were been air-dried for 2-3 hours. The seeds were been placed separately in glass jars and stored under laboratory conditions for 3 months. Each treatment was replicated three times. Twenty (20) seeds from each jar were placed on moist filter paper in petri dishes. The dishes were been kept under laboratory conditions for 10 days after which the germinated seeds were counted and recorded.

Repellency

The repellent action of the balanite powder, chilli pepper and ginger powder on E. *cautella* were been assessed using the method adopted by Obeng-Ofori and Reichmuth (1997). The repellent action of the plant extracts on *E. cautella* were been done with filter paper divided each

into half-moon in petri dishes, the one site where been treated and allow other half as control, 10 larva of *E. cautella* were been released at center of each filter paper. The petri dishes were been covered and each treatment were been replicated three times. The number of insects present on control (Nc) and treated sides (Nt) were been observed and recorded after one 1, 24, 48, and 72 hours respectively.

PR = [(Nc – Nt)/(Nc+Nt)] X 100.

Where:

PR = Per cent repellency
Nc = Number of insects present on control
Nc = Number of insects present on treated side

Palatability test

The sensory evaluation of stored millet were been determined in terms of colour, flavor, test, firmness and reported as overall acceptability using a nine-point hedonic scale according to Larmond (1977) by a semi- trained panel consisting of ten members which included staff of the laboratory and the students. The scores were been assigned from 9 to1. Samples was randomly drown from each experimental treatment and served to the panelists in a sensory laboratory. Potable water was been provided to each panelist for rinsing the mouth before testing each sample.

Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA) using 5 % level of probability and differences were separated using Least Significant Differences (LSD).

RESULTS

Effects of Plant Powders and Concentrations on Adult Mortality of *Ephestia cautella*

Table 1 shows the results on effects of different concentrations of plant powder on morality of *E. cautella*. From the analysis of variance, there were significant differences (P≤0.05) among the plant powder used on the mortality of insect all through the sample periods. At1 day in storage, chilli pepper recorded the highest percentage insect mortality of 19.8 %, followed by ginger (10.2 %) and the least was recorded by balanite with the mortality of 9.4 %. Similar trend was observed in 2 and 3 days in storage throughout the sample periods. At 4 DIS, there were highly significant differences (P≤0.01) among the plant powder used on insect mortality. Chilli pepper recorded the highest insect mortality of 46.7 %, followed by ginger (35.4 %) and the leasr insect mortality was recorded from balanite (1.20 %).

In regard to different concentrations used for the study, the result revealed that there were highly significant differences (P≤0.01) among the concentration used on insect mortality, 1.5 g concentration of plant powder recorded the highest insect mortality of 25.6 %, followed by 1.0 g (20.0 %) while the least value for mortality (0.0 %) was recorded from control at 0.0 g. Similar trend was observed in 2, 3 and 4 days in storage throughout the sample periods.

Table 1: Effect of Plant Powder on Mortality of *Esphestia cautella*

	% Mean Mortality			
Treatments	**1 DIS**	**2 DIS**	**3 DIS**	**4 DIS**
Plant Powder				
Balanite	9.4	6.7	2.0	1.20
Chilli pepper	19.8	30.0	37.9	46.7
Ginger	10.2	19.1	25.4	35.4
P≤F	0.027	0.016	0.032	0.002
LSD	6.41	7.46	5.51	7.13
Concentration				
0.0 g	0.0	1.7	1.70	0.00
0.5 g	6.7	18.9	25.0	34.4
1.0 g	20.0	30.0	37.2	38.7
1.5 g	25.6	37.7	47.2	45.6
P≤F	0.001	0.001	0.001	0.001
LSD	6.82	12.54	12.97	7.64
Interaction				
Plant Powder x Conc	0.001	0.010	0.005	0.001

Key : P<f = Probability of F

Effects of Plant Powder and Concentrations on Weight Loss of Stored Millet

Table 3 shows the effects of plant powders and concentrations on weight loss of stored millet. From the analysis of variance (Appendix II) there was no significant difference (P≥0.05) among the plant powder used on weight loss of stored millet. In term of different concentration used for the study, the result revealed that there were highly significant differences (P≤0.01) among the concentration used. The least weight loss was recorded from 1.5 g concentration of plant powder on weight loss of 8.83 %, followed by 1.0 g (14.46 %) while the highest weight loss (18.42 %) was recorded from control at 0.0 g.

Effects of Plant Powder and Concentrations on Percentage Damage

Table 2 shows the results on effects of plant powder and concentrations on percentage damage of stored millet. From the analysis of variance, there was no significant difference (P≥0.05) among the plant powder used for the grain damage of stored millet on percentage damage, chilli pepper recorded the highest grain damage of 14.46 %, followed by balanite (18.83 %) and the least was recorded from ginger with weight loss of 23.90 %. In term of different concentration used for the study, there were highly significant differences (P≤0.01) among the concentration used on grain damage, 1.5 g concentration of plant powder recorded the least percentage damage of 6.33 %, followed by 1.0 g (16.62 %) while the highest grain damage (36.41 %) was recorded from control at 0.0 g.

Effects of Plant Powder and Concentrations on the Oviposition of *Ephestia cautella*

Table 3 shows the effects of plant powder and concentrations on ovipositions of *E. cautela* from the analysis of variance (Appendix II) there was no significant difference (P≥0.05) among the

plant powder used on oviposition. In term of different concentration used for the study, there were highly significant differences (P≤0.01) among the concentration used on number of oviposition. The least oviposition was recorded from millet treated with 1.5 g plant powder (7.67), followed by 1.0 g (9.78) while the highest oviposition (17.56) was recorded from control at 0.0 g.

Effects of plant Powder and Concentrations on Progeny of *E. cautella*

Table 2 shows the results on effects of plant powder and concentrations on progeny of *E. cautella*. From the analysis of variance (Appendix II) there was significance difference (P≤0.05) among the plant powder used on progeny of *E. cautella*. Chilli pepper recorded. the least number of progeny of 7.17, followed by ginger (9.50) and the least number of progeny was recorded from balanite (13.17). In term of different concentration used for the study, there were highly significant difference (P≤0.01) among the concentration used on number of progeny, 1.5 g concentration of plant powder recorded the least number of progeny of 6.56, followed by 1.0 g (7.44) while the highest number of progeny (16.78) was recorded from control at 0.0 g.

Table 2: Effect of Plant Powder on % Weight loss, % Damage, Oviposition and Number Progeny Emergence

Treatments	% WL	% Damage	Oviposition	No. Progeny
Plant Powder				
Balanite	12.48	18.83	14.33	13.17
Chilli pepper	11.7	14.46	10.58	7.17
Ginger	16.01	23.90	12.42	9.50
P≤F	0.194	0.141	0.27	0.039
LSD	4.413	8.181	2.93	5.684
Concentration				
0.0 g	18.42	36.41	17.56	16.78
0.5 g	14.59	19.56	10.0	8.67
1.0 g	14.46	16.62	9.78	7.44
1.5 g	8.83	6.33	7.67	6.56
P≤F	0.001	0.001	0.001	0.001
LSD	2.005	5.247	2.103	3.499
Interaction				
Plant Powder x Conc	0.018	0.016	0.206	0.001

Key : P<f = Probability of F, WL= Weight loss

Effects of Plant Powder and Concentration on Repellency of *E. cautella*

Table 3 shows the results on effects of plant powder and concentrations on repellency of *E. cautella*. From the analysis of variance, there was highly significance differences (P≤0.05) among the plant powder used on repellency throughout the hours of study. At 1hr of repellency, chilli pepper recorded the highest repellency of 35 %, followed by ginger (25 %) and the least on repellency was observed from balanite (17.08 %). Similar trend was observed in 2, 3 and 4 days on repellency. In term of different concentration used for the study, there were highly significant

differences (P≤0.01) among the concentrations used on repellency throughout the hours. At 1 hr of repellency, 1.5 g concentration of plant powder recorded the highest repellency of 51.67 %, followed by 1.0 g (30.0 %) while the least repellency (0.00 %) was recorded from control at 0.0g. Similar trend was observed in 2, 3, and 4 hrs on repellency. Interaction between plant powder and different concentrations for repellency had highly significant difference (P≤0.01) among the plant powder and different concentration.

Table 3: Effects of Plant Powder on Repellency of *Esphestia cautella*

	% Mean Repellency with time			
Treatments	**1hr**	**2hrs**	**3hrs**	**4hrs**
Plant Powder				
Balanite	17.08	17.08	17.08	45.8
Chilli pepper	35.42	35.42	35.42	53.3
Ginger	25.0	25.0	25.0	44.6
P≤F	0.001	0.001	0.001	0.002
LSD	3.66	3.66	3.66	7.13
Concentration				
0.0 g	0.00	0.00	0.00	0.00
0.5 g	21.67	21.67	21.67	21.67
1.0 g	30.0	30.0	30.0	30.0
1.5 g	51.67	51.67	51.67	51.67
P≤F	0.001	0.001	0.001	0.001
LSD	4.235	4.24	4.235	4.235
Interaction				
Plant powder x Conc	0.001	0.001	0.001	0.001

Key : P<f = Probability of F

Effects of Plant Powder and Concentrations on Germination of Stored Millet

Table 5 shows the effects of plant powders and concentrations on percentage germination of stored millet. From the analysis of variance (Appendix I) there were highly significant differences (P≤0.01) among the plant powder used on germination percentage of stored millet. At 5 day in germination, chilli pepper recorded the highest germination percentage of 25.75 %, followed by balanite (20.42 %) and the least was recorded from ginger (17.0). Similar trend was observed in 6 and 7 days in germination.

In term of different concentration used for the study, there were highly significant differences (P≤0.01) among the concentration used on germination percentage of stored millet. At 5 DIG, 1.5 g concentration of recorded the highest germination percentage of 24.89 %, followed by 1.0 g (22.56 %) while the least on germination percentage was recorded from control at 0.0 g (16.22 %). Similar trend was observed in 6 and 7 DIG.

Table 4: Effect of Plant Powder and Concentrations on Germination percentage

	% Mean Germination with days after treatment		
Treatments	**5 DIG**	**6 DIG**	**7 DIG**
Plant Powder			
Balanite	20.42	46.0	68.8
Chilli pepper	25.75	59.8	84.6
Ginger	17.0	29.9	56.3
P≤F	0.008	0.004	0.001
LSD	3.778	11.04	7.25
Concentration			
0.0 g	16.22	36.0	58.2
0.5 g	20.56	42.2	71.1
1.0 g	22.56	47.8	72.4
1.5 g	24.89	55.0	77.7
P≤F	0.001	0.001	0.001
LSD	3.159	7.56	6.29
Interaction			
Plant Powder x Conc	0.001	0.481	0.087

Key : P<f = Probability of F

Effects of Plant Powder and Concentration on Palatability of Stored Millet

Table 5 presents the results of palatability of pap prepared from stored millet. From the analysis of variance, there were significant difference (P≤0.05) among the plant powder used on aroma, chilli pepper recorded the highest on aroma of 7.167, followed by ginger (6.90) and the least was recorded from balanite (6.67). In term of color, there were highly significant differences(P≤0.01) among the plant powder used on colour, chilli pepper recorded the highest on color of 7.18, followed by ginger (6.80) and the least was recorded from balanite (6.76).Similar trend was observed in taste and overall acceptance. In term of different concentration used for the study, there were no significant differences (P≤0.05) among the concentration used for aroma during palatability test, 1.5 g concentration of plant powder recorded the highest (6.97), followed by 1.0 g (6.88) and the least was recorded from control at 0.0 g of 6.37. At colour, there were highly significant difference (P≤0.01) among the difference concentrations, 1.5 g recorded the highest for colour with 7.31, followed by concentration of 1.0 g (7.06) and the least for colour was recorded from control at 0.0 g of 6.63. Similar trend was observed in teste and overall acceptability.

Table 5: Effect of Plant Powder on Palatability of Stored Millet

	Palatability test parameters			
Treatments	**Aroma**	**Colour**	**Taste**	**Overal Acceptability**
Plant Powder				
Balanite	6.67	6.76	6.60	6.93
Chilli pepper	7.167	7.18	6.99	7.11
Ginger	6.90	6.80	6.82	6.81
P≤F	0.016	0.001	0.001	0.11
LSD	0.265	0.076	0.062	0.072
Concentration				
0.0 g	6.37	6.63	6.45	6.60
0.5 g	6.58	6.66	6.82	6.91
1.0 g	6.88	7.06	6.63	6.79
1.5 g	6.97	7.31	7.05	7.49
P≤F	0.851	0.001	0.003	0.001
LSD	0.386	0.26	0.31	0.21
Interaction				
Plant Powder x Conc	0.85	0.023	0.088	0.002

Key : P<f = Probability of F

DISCUSSION

Effects of Plant Powder and Concentrations on Mortality of *Ephestia cautella*

The effects of plant powder and concentration on mortality of *Ephestia cautella* studied in this trial are similar to that report by other authors. Weissen berg *et al*.(1986) which stated that chilies contain the compound capsaicin, which reduced the growth of the spiny bollworm, *Earias insulana*, Oleoresin from capsicum has been reported to be effective as a repellent against cotton pests (Mayeux*et al*., 1996). Capsaicin has also been reported to kill insects by causing membrane damage and metabolic disruption and to affect the nervous system of invertebrates (Gervais, 2014). In addition, Huang *et al.*(2000) reported that garlic contains the compounds methylallyl disulfide and diallyl trisulfide.Many insecticides of plant origin are used against adult *E. cautella* and its developmental stages. Sunarti (2003) reported that based on LD_{50} and LD_{90}, LC_{50} andLC_{90} treatments for 28 hours, ginger (Zingiber officinate Roscoe), neem (A. indica), oregano (Coleus amboiecus Lour) and castor (Ricinus communis Linn.) were found to be toxic to *E. cautella.* The application of LC_{50} 's of their oils on cocoa beans deterred larval feeding, with neem oil having 92 % followed by 68 % with castor oil (Sunarti, 2003).

Effects of Plant Powder and Concentrations on Percentage Weight loss and Damage of Stored Millet

Natural plant produces have been found to be cheap, humanly safe and ecologically tolerant to control measures of reducing the infestations of stored product pests especially in the tropics (Adedire and Ajayi, 1996).This is also corroborated by Ofuya (1986) which submitted that, inhibition of oviposition and reduction in adult emergence are two common mechanisms which

have been observed as basis for low damage by *C. maculatus* to seeds protected by many other plant materials. Similar result was reported on repellency and oviposition deterrence by some powdered chilli pepper fruits against the brunchid by Lale (1994).

Effects of Plant Powder and Concentrations on Oviposition on *Ephestia cautella*

The assertion of Ogunwolu and Odunlami (1996) and Yusuf and Galadima (2009) that, the properties required in any chemical for controlling biting, chewing or boring insects include toxicity to adults, reduction of oviposition, ovicidal activity and toxicity to immature stages.The findings in this experiment are similar to those of Cowles *et al*.(1989) who revealed that powdered chili pepper deterred the onion fly from laying eggs on the base stem of onion. Plant powder is not an instant killer (Raguraman and Singh, 2008) but have strpng ovicidal and antifeedant effect which inhibited the development of eggs and larvae of *E. cautella* in to adults. Nwaogu *et al.* (2013) reported that more than 50 % of the total eggs laid in treated samples died at various stages of development which inturn reduced the number of progenies. Yahaya and Sulaiman (2018) reported that, balanite oils effectively reduced the emergence among male bruchids from the seeds.

Effects of plant Powder and Concentrations on Progeny of *E. cautella*

Bouchelta *et al*. (2005) reported a toxic effect of pepper extracts on eggs and adults of the *tabaci* whitefly infesting solanaceous crops. Oparaeke *et al*. (2005) reported a reduced number of thrips, pod borers, and pod suckers on cowpea after treatment with chili pepper based extracts. Prior to these studies, other authors have reported a repellent effect of pepper extracts on the grain borer *Rhyzopertha dominica* (L.) (El-Lakwah *et al*., 1997) and the cowpea bruchids *Callosobruchus maculatus* (F.) (Onu and Aliyu, 1995). The toxicity of Capsicum spp on insects is thought to be the effects of secondary metabolites including alkaloids, saponins and flavonoid compounds of this plant (Bouchelta *et al*., 2005). The efficacy of these toxic compounds may be enhanced by combining chili pepper extracts with extracts from other plants such as cashew nutshell and garlic bulb to create a synergistic effect between their respective toxic compounds (Oparaeke *et al*., 2005). However, in these studies only the individual plant powders were tested.

Effects of Plant Powder and Concentrations on Germination of Stored Millet

The findings of Kang *et al*. (2013) who reported that after 3 to 6 months of storage, cowpea seeds treated with powdered pepper had the highest germination percentage while the untreated cowpea had the lowest germination percentage. Similar reports by Ivibrajo and Agbaje (1986) indicated that, surface treatment of cowpea with Piper guineense and *Capsicu*m spp. did not affect the germinative potential of the seeds compared with the control. Yusuf and Galadima (2009) also reported similar findings on the use of neem (*Azadirachta indica*) seed powder, mahogamy (Khaya senegalensis) bark powder and actellic dust (2%) on maize grains against *Sitophilus zeamais* (Mots) as well as Rahman and Tahkder (2006) which showed that plant materials (ginger and turmeric rhizomes, karate, red pepper and pepper fruits) tested against *C. maculatus* did not show any visible adverse effect on emergence capacity of the cowpea seeds.

CONCLUSION

The results obtained suggested that, there is good potential for the use of chilli pepper, balanite and ginger. The study shown that, chilli pepper powder was effective against *E*. *cautella.* The results showed that, there were significant differences (P≤0.05) among the plant powder used with chilli pepper proved over other plant powders on insect mortality. At 4 days in storage,

there were higly significant difference (P≤0.01) among the different concentration used, 1.5 g had highest mortality of 45.6 % and the least was recorded from control (0.00 %) insects mortality.

Recommendations

- Further extensive studies should be carried out on the persistance and hazards that might be associated with the plant powder.
- Chilli pepper should be used for storage of seed and grains against the use of chemical
- Further investigations, should be carried out using different plant products or plant materials, to confirm the results of the present study

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