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Efficacy of Three Protectants, Primiphos Methyl, *Piper guineense* and *Eugenia aromatica*, against *Tribolium castaneum* (Herbst) (Coleoptera Tenebrionidae) on Stored Chips of Three *Musa* spp

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Abstract *Musa* spp are highly perishable crops with serious storage problems. Transformation to chips and flour has been identified as the only means of keeping them for a relatively longer period of time. This transformation, however, exposes them to attack by many storage pests including *Tribolium castaneum* Herbst. To get protection from these pests, in the past, synthetic pesticides were used with some measure of success. However, residue accumulation, toxicity to man and pest resistance caused by arbitrary use of synthetic pesticides have inspired this research into a healthy and less toxic alternative control measures for stored produce pests of chips. This experiment was conducted at the Department of Crop Science Research Laboratory, University of Nigeria, Nsukka (06^o 52 N, 07^o 24 E; 447.26m a.s.l.), Nigeria from February to May, 2012 to compare the efficacy of powdered extracts of two botanical materials (Guinea pepper seeds (*Piper giuneense* Schum & Thonn) and Cloves flower buds (*Eugenia aromatica* Baill.) and a synthetic pesticide (Primiphos methyl 2% dust) against the red flour beetle, *Tribolium castaneum* Herbst. (Coleoptera Tenebrionidae) on chips of three *Musa* spp (*Agbagba*, *Obino'l ewai* and Cooking banaana). The experiment was laid out as 8 × 3 factorial (8 levels of protectants by 3 levels of chips) in completely randomised design (CRD) with three replications. Results revealed that actellic (Primiphos methyl) had significantly ($p < 0.05$) higher mortality effect on adult *T. castaneum* than the other protectants. Chips treated with 2g cloves had significantly ($p < 0.05$) lower percentage loss and lower rate of damage than all the protectants but its effects was similar to that of actellic. 2g cloves therefore compared favourably with the synthetic pesticides against *T. castaneum* in chips storage.

Keywords: *Musa chips, powdered plant extracts, synthetic pesticide, protectants, T. castaneum, damage*

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1. Introduction

It is no gain saying that safe keep of farm produce is as important as their production. According to Narong (2003), it is misleading to measure productivity at the point of production rather than at the point of consumption. *Musa* spp are among the major food crops in the humid and sub-humid parts of Africa and major sources of energy for millions of people in these regions (Isah *et al.*, 2009). Post harvest losses constitute major problems limiting their availability in most producing regions of Sub-saharan Africa (Sugri and Johnson, 2009). Although recent researches have evolved methods of storing fresh produce, they are still under trial and have kept these produce for a few days (Akanonwur and Sodie, 2005). *Musa* spp can only be stored for relatively long period of time in the form of dried chips or fried (Fayemi, 1999). Processing crops to chips helps to increase their shelf life, reduce transport cost by reducing bulkiness, improve handling quality, remove non-edible and unmarketable parts and make producers earn higher income by helping them keep their produce till the season of scarcity (Eze *et al*., 2006). Raw materials are also made available for the agro-industries (Amusa, 2001). Despite the above advantages, chips storage have been faced with the problem of pests and moulds (Chijindu and Boateng, 2008; Isah *et al.*, 2009). Dry stored products are attacked by many pests that cause serious damages to the products. It is necessary therefore to render proper importance to such pests, since cares and expenditures for pest control in field crops would be of no use if the products will be attacked and damaged when stored. The reduction of post harvest food losses is therefore a complementary means of increasing food production.

The red flour beetle, *Tribolium castaneum* is one of the primary pests infesting dry stored produce worldwide (Garcia *et al.*, 2005). Infestations cause significant losses due to direct consumption of produce, reduction of nutrients and increase in temperature and moisture conditions that lead to accelerated growth of molds, including toxigenic species (Chijindu and Boateng, 2008). The adults are long lived and may live for more than three years (Walter, 1990). They have high rate of population increase because the adult female can lay large number of viable eggs throughout their life (Hill, 1990; Campbell and Runnion, 2003). *T. castaneum* has been reported to resist many insecticides used for its control (Richards *et al*., 2008). Because of the great economic importance of this pest, many studies and researches have been going on for its control. Currently, different kinds of preventive and curative control measures are being tried. Among these, chemical pesticides have been used for a long time with some measure of success but with serious setbacks (Gupta *et al.*, 2001). These setbacks include; pest resistance and resurgence, residue in food and feed etc. (Iloba and Ekrakene, 2006).

Plants are rich sources of bioactive compound which might act deadly on the insect physiological system (Kim *et al*., 2003; Daoubi *et al.*, 2005). These bioactive compounds belonging to various categories (alkaloids, glycosides, tannins, proteic amino acids, steroids, phenols, flavonoids, glucosinolates, quinones, terpenoids etc.), which have behavioral and physiological effects on pests have already been identified (Gonzalo, 2009). Many of these plant compounds have also been recognized to be effective as potential health promoters in humans (Khan *et al.*, 2012). They are low in cost, locally available and have proved to be very effective for the control of insect pests (Igbal *et al*., 2011). Mahdi and Rahman (2008) reported that black gram seeds treated with cloves and black pepper could suppress F_1 progeny production in C. maculatus, which might imply ovicidal action of these extracts. Umeozor and Pessu (2003) also found out that when the larvae of *C. maculatus* bored into grains, it was difficult to control them using *P. guineense* and *D. tripetala* extracts because of the contact property of these materials. Adedire and lajide (1999) also reported that *Eugenia aromatic* powder has significant contact and fumigant action against *Callosobruchus maculatus*. The mechanism of its action according to the report was by inhibition of oviposition and direct toxicity to adults and eggs (ovicidal). *Eugenia aromatic* has also been reported to retain insecticidal activity four years after the flower buds were powdered (Ofuya *et al*., 2002). Lale and Mustapha (2000) found no significant difference in the efficacy of neem seed oil and pirimiphos-methyl in reducing oviposition, adult emergence and seed damage in treated cowpeas by *C. maculatus*. According to Lale (1995), the oil extract (10.38 mg/cm^3) of *Syngizium aromaticum* (*Eugenia aromatica*) applied on filter paper showed 70% repellency against *T. castaneum*. Moreover, Eugenol and Methyl salicylate essential oils isolated from leaf buds of *Eugenia aromatica* have shown significant toxicity potential against *Pediculus capitis* (Yang *et al*., 2003). These reports confirm that there are different compounds in plants possessing different bioactivities. According to Emeasor, 2004 and Ravi and Gayatri, 2007, the effectiveness of these plant extracts as protectants are highly dosage dependent. Therefore, evaluating and using botanical pesticides, either as crude or formulated extracts, has proved an alternative strategy of insect pest management. The objective of this study therefore was to compare the effectiveness of two botanicals with a synthetic pesticide as protectants to sun dried *Musa* chips against *T. castaneum*.

2. Materials and Methods

2.1. *Tribolium castaneum* Culture

Adult *Tribolium castaneum* was obtained from stock reared in the Dept of Crop Science Research Laboratory, University of Nigeria, Nsukka, in plastic containers (2000ml). These were maintained in wheat flour mixed with brewers yeast (19: 1) at an ambient temperature of 27 - 30°C and relative humidity 75 ± 5%. The *Tribolium* were sexed as pupa by examining the genital lobe or papillae under a light microscope. At the very end of the pupa are two pointed structures called urogomphi. The genital lobes are two finger-like structures just anterior to the pointed urogomphi. This papillae are much larger, longer and prominent in females while they appear like finger tips in males (Ludovic *et al.*, 2001). Males and females were kept separately until used. The containers were covered with muslin cloth for aeration and to prevent the insects from escaping.

2.2. Processing of Chips

Plantain and cooking banana used for this study were procured from markets around Nsukka and processed into chips. The fingers used were collected from the second to fourth hand of a fully mature (Round full maturity stage) but unripe bunch (Baiyeri, 2004). The fingers were washed, peeled and cut into small round pieces under water and sun dried for about one week. The processing was done during the dry season from January to February and the chips stored in air-tight containers at room temperature (27-30°C) and relative humidity (75 ± 5%) until they were used.

2.3. Plant Material Collection

Cloves (*Eugenia aromatica*) and Guinea pepper (*Piper guineense*) used for this study were collected from markets around Nsukka, Enugu state and Jos, Plateau state all in Nigeria. These plant materials selected for this study are common spices used in the preparation of food in Nigeria. They have also been reported by local people as well as researchers as good for the treatment of various body ailments and lethal to pests. These samples were taken to appropriate taxonomists on collection for proper identification. The plant materials were purchased in dry form and further dried in well ventilated room. They were thereafter milled into fine powder using Thomas Wiley Laboratory mill, Model 4 with 1mm sieve, made by Arthur, H Company, Philadelphia PA, USA. The plant powders were stored in polyethylene bags and used within 24 hours of milling to avoid loss of potency.

2.4. Mortality, Progeny Production and Damage Assessment

Each of these two powdered plant extracts were weighed out at three different rates; 0.5g, 1.0g and 2.0g, equivalent to 2.5%, 5% and10% w/w. Each rate was used to treat 20g chips of each of the three *Musa* spp (*Bluggoe*, *Agbagba* and *Obino'l* Ewai) in plastic containers. The control experiment was set up as checks in which 20g of each type of *Musa* chips was treated with 0.50g primiphos methyl dust and another 20 g was untreated. The chips were mixed thoroughly with the powdered extracts and arranged on the laboratory bench using 8 × 3 (8 levels of protectants by 3 levels of chips) factorial in CRD with three replications. Ten adult *T. castaneum* (1 – 7days old) were introduced, comprising 5 males and 5 females. They were allowed to mate freely and reproduce. The following data were collected; Weight of chips before infestation. Survival counts of beetles on the 7th, 14th and 21st day after infestation. Total no of live adult produced after 91 days of infestation. Weight of powder produced after 91 days of infestation. Weight of chips left after 91 days of infestation.

3. Calculations

1) Percentage survival, given by the fomular

$$\frac{\text{Number of live beetles}}{\text{Number introduced}} \times \frac{100}{1}$$

2) Percentage weight loss by chips, given by;

$$\frac{\text{weight lost}}{\text{Initial weight}} \times \frac{100}{1}$$

3) Rate of damage was calculated by dividing the weight lost by the storage time.

3.1. Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) using Genstat System for Window Version 8. Differences amongst treatment means were separated using Fishers least significant difference (F-LSD) as outlined by Obi (2002).

4. Results

4.1. Mortality of Adult Insects

All the protectants had little or no effect on the mortality of beetle 2 days after treatment except actellic with the highest mortality of 10.93% (Table 1) which was significantly ($p < 0.05$) higher than other protectants and control. At 7th day after treatment, actellic maintained the highest mortality of 10.36%. This was statistically similar to the mortality caused by 2.0g cloves but differed significantly ($p < 0.05$) from other protectants. On the 14th day after treatment, mortality of beetles as a result of treatment with various protectants did not differ significantly. However, cloves had the highest mortality (9.39%) and was closely followed by actellic (9.21%). Total mortality after 21 days of treatment was highest in actellic treated chips (14.89%). This was significantly higher than other protectants followed by 2.0g cloves. The least was 0.5g *uziza* and control each with 7.10% mortality.

Table 1. Mean mortality (%) of adult *T. castaneum* exposed to various protectantson the 2nd, 7th and 14th day after treatment

Protectants	Day 2	Day 7	Day 14	Total mortality
0.5g Uz	7.10	7.10	7.10	7.10
0.5g Cl	7.67	8.24	7.10	8.82
1.0g Uz	7.10	7.10	8.07	8.07
1.0g Cl	8.07	7.10	7.67	8.64
2.0g Uz	7.67	7.10	7.67	8.24
2.0g Cl	7.10	9.78	9.39	11.89
Actellic	10.93	10.36	9.21	14.89
Zero treatment	7.10	7.10	7.10	7.10
Maen	7.84	7.99	7.91	9.34
F – LSD (0.05)	1.59	1.72	Ns	2.65
Fpr	< 0 .001	< 0 .001	0.086	< 0 .001

Cl = cloves (*Eugenia aromatica*), Uz = *Uziza* (*Piper guineense*), Ns = Not significant.

Table 2. Main effects of protectants on means of number of adults found, weight of chips left, weight of powder produced, % weight loss and rate of damage of different *Musa* chips 91 days after infestation

Protectants	Mean number of adults found	Mean weight of chips left (g)	Mean weight of powder produced (g)	Mean % weight loss	Mean rate of damage (mg/day)
0.5g Uz	11.22	17.5	0.92	12.51	27.5
0.5g Cl	11.44	17.26	1.06	13.71	30.12
1.0g Uz	11	17.6	0.84	12.01	26.39
1.0g Cl	10	17.68	0.61	11.62	25.54
2.0g Uz	10.11	17.75	0.68	11.24	24.71
2.0g Cl	7.56	19.82	0.17	0.9	1.98
Actellic	8.33	19.63	0.18	1.83	4.03
Zero treatment	12.78	17.46	0.81	12.68	27.86
Maen	10.31	18.09	0.66	9.56	21.02
F – LSD (0.05)	1.68	0.28	0.23	1.4	3.06
Fpr	< 0.001	< 0. 001	< 0.001	< 0.001	< 0.001

Cl = cloves (Eugenia aromatica), Uz = Uziza (Piper guineense)

4.2. Adult Emergence, Damage and Weight Loss

The protectants significantly influenced the number of adults found on chips at the end of the experimental period. Chips treated with 2.0g cloves gave the least number of beetles (7.56) which was statistically similar to the number found in actellic (8.33) (Table 2). Zero treatment on the other hand had significantly ($p < 0.05$) highest number of beetles compared to all the protectants (12.78). It was however followed by 0.5g cloves (11.44). 2.0g cloves showed the highest protection of the chips as it recorded significantly ($p < 0.05$) higher weight (19.82g) than other protectants at the end of the experimental period but similar to actellic (19.63g). The least was 0.5g cloves (17.26g). The weight of powder produced had an inverse relationship with the weight of chips left. Admixtures with 0.5g cloves had the highest powder weight (1.06g). It was statistically similar to 0.5g *Uziza* (0.92g) and 1.0g *Uziza* (0.84g) but significantly ($p < 0.05$) higher than other protectants and control. The least

powder was produced by 0.2g cloves (0.17g) and this was similar to actellic (0.18g). The mean percentage weight loss of chips as a result of treatment with various protectants showed that 0.5g cloves had significantly ($p < 0.05$) higher weight loss (13.71%) than other protectants. The least weight loss was recorded by 2.0g cloves (0.90%) which was statistically similar to actellic with 1.83% loss. Rate of damage as expected followed the same trend as the percentage weight loss. Chips treated with 0.5g cloves recorded significantly higher rate of damage than chips treated with other protectants except 5.0g *uziza* which had similar rate of damage.

There were no significant differences among the chips of different *Musa* spp in their susceptibility to attack by *T. castaneum*. This was shown in their statistical similarity in the number of beetle found, weight of chips left, weight of powder produced, percentage weight loss and rate of damage on chips 91days after treatment (Table 3). However, *agbagba*, had the highest percentage loss of 9.92% and the highest rate of damage (21.81mg/day) while cooking banana recorded the least powder weight (0.60g), sustained the least weight loss (9.09%) and recorded the least rate of damage (19.79mg/day) than other chips even with the highest number of beetles.

Table 3. Main effect of species on means of number of adults found, weight of chips left, weight of powder produced, % weight loss and rate of damage of dried chips 91 days after infestation

Chips	Mean number of adult beetles found	Mean weight of chips left	Mean weight of powder produced	Mean % weight loss	Mean rate of damage (mg/day)
Agbagba	10.12	18.02	0.62	9.92	21.81
Cooking banana	10.79	18.18	0.60	9.09	19.79
"*Obino'l Ewai*"	10.00	18.07	0.66	9.68	21.27
Mean	10.31	18.09	0.63	9.56	21.02
F- LSD (0.05)	Ns	Ns	Ns	Ns	Ns
Fpr	0.26	0.14	0.48	0.14	0.14

Note: Ns = Not significant.

The combined effect of protectants and chips type on the number of beetles found was not statistically significant ($p > 0.05$). All chips types in combination with 0.5g cloves and 0.5g *uziza* produced almost the same number of adult beetle with the control (Table 4). The least number was recorded by all chips types in combination with 2.0g cloves followed by actellic. The weight loss by chips was also not affected significantly by interaction of chips type and protectants but the trend was same as on the number of beetles found. All chips types in combinations with 0.5g cloves lost the highest weight followed by 0.5g *uziza* and the weight loss was as much as those of the untreated. All combinations of chips types with 2.0g cloves gave more protection so retained the highest weight. It was followed by actellic. As usual, the interaction effect on the weight of powder produced was inversely related to the weight of chips left. All cases where 0.5g cloves and 0.5g *uziza* were combined with chips produced the highest powder which was almost equal to that of the control. Similarly, all chips types in combinations with 2.0g cloves and actellic had the lowest powder weight. The percentage weight loss and the rate of damage also followed the same trend as the weight of powder.

Table 4. Interaction effect of protectants by species on means of number of adults found, weight of chips left, weight of powder produced, % weight loss and rate of damage of dried chips 91 days after infestation

Treatment	Mean number of adult	Mean weight of chips left	Mean weight of powder produced	Mean % weight loss	Mean rate of damage (mg/day)
Pa × 0.5g Uz	12.00	17.40	1.03	12.98	28.53
Pa × 1.0g Uz	10.33	17.66	0.71	11.69	25.68
Pa × 2.0 Uz	8.33	17.56	0.64	12.20	26.81
Pa × 0.5g Cl	11.33	17.14	0.92	14.28	31.39
Pa × 1.0g Cl	10.33	17.48	0.65	12.60	27.69
Pa × 2.0g Cl	7.33	19.82	0.13	0.98	1.98
Pa × 0.5g Act	8.00	19.56	0.17	2.18	4.80
Pa × Zero	13.33	17.49	0.67	12.55	27.58
Pc × 0.5g Uz	11.67	17.58	1.03	12.12	26.63
Pc × 1.0g Uz	11.33	17.83	0.87	10.97	23.88
Pc × 2.0g Uz	10.67	17.78	0.72	11.12	22.89
Pc × 0.5g Cl	13.00	17.37	1.16	13.15	28.90
Pc × 1.0g Cl	10.67	17.81	0.61	10.97	24.11
Pc × 2.0g Cl	7.00	19.80	0.14	0.98	2.16
Pc × 0.5g Act	8.00	19.69	0.18	1.55	3.41
Pc × Zero	13.33	17.47	0.96	12.65	27.80
Po × 0.5g Uz	10.00	17.51	0.70	12.43	27.32
Po × 1.0g Uz	11.33	17.31	0.94	11.30	29.60
Po × 2.0g Uz	10.67	17.78	0.72	11.12	24.43
Po × 0.5g Cl	10.00	17.26	1.10	13.68	30.07
Po × 1.0g Cl	9.00	17.74	0.57	11.30	24.83
Po × 2.0g Cl	8.33	19.84	0.23	0.82	1.80
Po × 0.5g Act	9.00	19.65	0.19	1.77	3.88
Po × Zero	11.67	17.43	0.82	12.83	28.20
Mean	10.30	18.08	0.66	9.56	21.02
F – LSD (0.05)	Ns	Ns	Ns	Ns	Ns
Fpr	0.47	0.93	0.88	0.93	0.92

Note: Ns = Not significant.

5. Discussion

The result obtained from this study indicated that *Eugenia aromatica* (cloves) can be substituted for the synthetic pesticide, primiphos methyl, for the control of *T. castaneum* infestation on chips. The effect of this plant powder though did not cause significant mortality of the adult beetles, discouraged its population growth by either hindering oviposition or causing egg toxicity. This agrees with the work of Mahdi and Rahman (2008) which reported that black gram seeds treated with cloves and black pepper could suppress F_1 progeny production in *C. maculatus*, which might imply ovicidal action of these extracts. Primiphos methyl had some measure of instantaneous mortality effects on *T. castaneum* after treatment and this was significantly higher than all the protectants. The toxicity of 2.0 g cloves build up with exposure time while that of primiphos methyl decreased with time. *E. aromatica* therefore showed longer lasting effects than the synthetic chemical. This agrees with the report of Ofuya *et al*. (2002) that *E. aromatica* can retain insecticidal activity for as long as four years after the flower buds were powdered. Generally the various protectants had low direct toxicity on *T. castaneum* and this agrees with the report of Richards *et al*. (2008) that many species of *T. castaneum* at their adult stage are resistant to many insecticides used for its control. The efficacy of these powdered plant extract was based on dosage since lower doses of *E. aromatica* (0.5g, 1.0g) were not as effective as 2.0g. This corroborates the work of Emeasor (2004) and Ravi and Gayatri (2007). *E aromatica* reduced the emergence of adult beetles from the chips treated with it. This could be attributed to its fumigant activity so it penetrated inside the crevices made on the chips by the pests to destroy the eggs or hindered oviposition of *T. castaneum*. This finding was in consonance with the observation of Adedire and Lajide (1999) that *E. aromatica* powder has significant contact and fumigant action against *Callosobruchus maculatus* and its mechanism of action is by inhibition of oviposition and direct toxicity to eggs (ovicidal). The highest dosage of *P. guineense* used (2.0g *uziza*) was not effective in controlling infestation on chips. This could be attributed to its contact effects. A lot of research has reported that *P. guineense* act as a contact insecticide and so could not control the developmental stages of *T. castaneum* since eggs are laid inside the chips and the larva and pupal stages remained inside until adults develop. While inside the chips, larvae continue to cause destruction. This is in agreement with the findings of Umeozor and Pessu (2003), that when the larvae of *C. maculatus* bored into the grains, it was difficult to control them because of contact property of *P. guineense* and *D. tripetala* used in their control. Generally, *E. aromatica* at 2.0g dosage performed better than both *P.guineense* and the synthetic primiphos methyl against *T. castaneum* in *Musa* chips storage though the difference in the efficacy of *E. aromatica* and primiphos methyl was not statistically significant. This result showed that botanical extracts can be as effective as synthetic pesticides in chips control. This also agrees with the report of Lale and Mustapha (2000) who found no significant difference in the efficacy of neem seed oil and pirimiphos-methyl in reducing oviposition, adult emergence and seed damage in treated cowpeas by *C. maculatus*.

6. Conclusion and Recommendation

The results obtained from this work confirmed that botanical extracts can be as effective as synthetic primiphos methyl in chips storage. This was seen clearly as *E. aromatica* compared favourably with primiphos methyl in chips protection from *T. castaneum* attack. *E. aromatica* is therefore recommended for chips storage since its fumigant activities can penetrate the crevices made by the pests on chips to affect the hiding stages. However further research should be encouraged to standardise dosage and find out methods of extraction of the active ingredients so that it could possibly be produced in the industries for easier accessibility to farmers and store keepers. These will help to encourage wider adoption and use, avoid wastage and encourage greater economy of use.

References

[1] Adedire C. O. and Lajide, L Toxicity apnd oviposition deterrency of some plants extracts on cowpea storage bruchid, *Callosobruchus maculatus* (F). *J. Plant Dis. Protect.* 106: 647-653. 1999.

[2] Akaninwor, J. O. and Sodie, M..Effect of storage on the nutrient composition of some Nigerian foodstuffs. *Journal of Applied Sciences and Environmental Management.* 9(2): 9-11, 2005

[3] Amusa, N. A.,. Fungi Associated with Yam Chips in Storage and the Effects on the Chips Nutrient Composition. *Moor. Journal of Agricultural Research*.2: 35-39. 2001

[4] Baiyeri, K. P. Variable light transmission through four polyethylene colours used for planntain (*Musa* sp. AAB) fruits storage as influencing its postharvest and culinaryqualities. *International Agrophysis.* p.19 2004.

[5] Campbell, J. F. and Runnion, C. Patch exploitation by female red flour beetles, *Tribolium castaneum*. *Journal of insect Science*, Vol. 3, p 20. 2003.

[6] Chijindu, E. N. and Boateng, B. A. Effect of Nutritional content of processed cassava Chips on Development of *Prostephanus truncates* (Horn). *World Journal of Agricultural Sciences* 4(3): 404-408. 2008.

[7] Daoubi M., A. Deligeorgopoulou, A. J. Macias-sanchez, R. Hermamdez-galan, P. B. Hitchcock, J. R. Hanson and I. G. Collado. Antifungal activity and biotrans formation of diisophorone by Botrytiscinerea. *J. Agric. and Food Chemistry* 53: 6035-6039, 2005.

[8] Garcìa M., O. J. Donael, C. E. Ardanaz, C. E. Tonn and M. E. Sosa. Toxic and repellent effects of *Baccharis salicifolia* essential oil on *Tribolium castaneum*. *Pest Management Sci.* 61: 612-618. 2005.

[9] Gonzalo S. Botanical Insecticides. Faculty De Agronomia, University de concepcion Avenida Vicente Mendez Chile 595. 2009

[10] Gupta, A.; Upadhyay, R. K. and Saxena, P. N., Toxicity evaluation of certain blood biochemical parameters in *Passer domesticus* (Linn.*). Journal of Scientific and Industrial Research*, 60, 668-674. 2001.

[11] Emeasor, K. C. A study on the Control of Cowpea Brunchid Callosobruchus maculates (Fabricius) Using Plant materials and varietal Resistance. *Ph.D. Research project*, University of Nigeria Nsukka. P 12. 2004.

[12] Eze, S. C. ; Asiegbu, J. E.; Mbah, B. N.; Orkwor, G. C. And Asiedu, R. Effect of four Agrobotanical extracts and three types of bags on the control of insect pests and moulds of stored yam chips. *Agro-Science, Journal of Agriculture, Food. Environment and Extension.* 5 (1): 8-12. 2006

[13] Fayemi, P. O. Nigerian Vegetables. *Heinemann Educational books* (Nigeria) Plc. P. 15-20. 1999.

[14] Hill, D.S., *Pests of stored products and their control.* CRC press, Boca Raton, Florida, USA. P 274. 1990.

[15] Iloba, B. N and Ekrakene, T. Comparative assessment of insecticidal effect of *Azadirachta indica, Hyptis suaveolens* and *Ocimum gratissimum* on *Sitophilus zeamais* and *Callosobruchus maculatus. Journal of Biological Sciences.* 6(3): 626-630. 2006.

[16] Iqbal M. F., M. H. Kahloon, M. R. Nawaz and M. I. Javaid Effectiveness of some Botanical Extracts on Wheat aphids. *The J. Anim. Plant Sci*, 21(1): 114-115. 2011

[17] Isah, M. D.; Ayertey, J. N. And Boateng, B. A. Susceptibility of Dried Chips of Plantain, Cocoyam, Yam and Cassava for the Development of the Large grain Borer (*Prostephanus truncates.*) Horn, Coleoptera: bosterichidae. *International Journal of Applied Sciences*. 3(4): 12-20. 2009.

[18] Khan M. A., M. Ajab. Khan, G. Mujtaba and M. Hussain Ethnobotanical Study about Medicinal Plants of Poonch Valley Azad Kashmir. *The J. Anim. Plant Sci.* 22(2): 493-500. 2012

[19] Kim SI, Roh JY, Kim DH, Lee HS, Ahn YJ. Insecticidal activities of aromatic plant extracts and essential oils against *Sitophilus oryzae* and *Callosobruchus chinensis*. *J. Stored Prod. Res*., 39: 293-303. 2003.

[20] Lale N. E. S. An overview of the use of plant products in the management of stored product coleoptera in the products. Post Harvest News Information 6: 69-75. 1995.

[21] Lale N. E. S and Mustapha A. Efficacy and acceptability of neem (*Azadirachta indica* A. Juss) seed oil and pirimiphos-methyl applied in three storage devices for the control of *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae). Zeitschrift fuer Pflanzenkrankheiten und Pflanzenschutz ; 107 (4): 399-405. 2000.

[22] Ludovic, A.; Haubruge, E. and Matthew, J. G. G. Morphology of *Tribolium casteneum* Male Genitalia and its Possible Role in sperm competition. *Belgian Journal of Zoology*. 131(2), 111-115. 2001

[23] Mahdi, S and Rahman, M. Insecticidal effect of some spices on *Callosobruchus maculatus* (Fabricius) in black gram seeds. *University Journal* of *Zoology*, *Rajshahi University*, 27: 47-50. 2008.

[24] Narong, C. Protection of stored products with special reference to Thailand. *Assumption University Journal. Thailand*. 7(1): 31-47. 2003.

[25] Obi I. U. Statistical method of detecting differences between treatment means and research methodology issues in laboratory and field experiment. A. P. Express publishing Company Ltd. Nsukka. Nigeria 8-22. 2002.

[26] Ofuya, T.I. and E.O. Dawodu. Aspects of Insecticidal action of *Piper guineense* Schum and Thonn fruit powders against *Callosobruchus maculatus* (F.) Coleoptera: Bruchidae). *Nig. J. Entomol*., 19: 40-50. 2002.

[27] Ravi K.U. and J. Gayatri. Evaluation of biological activities of *Piper nigrum* oil against *Tribolium castaneum*. Bulletin of Insectology 60: 57-61. 2007.

[28] Richards S., R. A. Gibbs, G. M. Weinstock, S. J. Brown, R. Denell, R. W. Beeman, R. Gibbs, R. G. Bucher, M. Friedrich and C. J. E. Grimmelikhuijzen. The genome of the model beetle and pest. *Tribolium castaneum*. Nature 452: 949-955. 2008.

[29] Sugri, I. and Johnson, P. N. T. Effect of Two Storage Methods on the keeping and sensory Qualities of four plantain varieties. *African Journal of food, Agriculture, Nutrition and Development*, 9 (4) 1091-110. 2009.

[30] Umeozor O. C. and P. O. Pessu. Insecticidal effects of *Dennettia tripetala* (bak.f.) and *Piper guineense* (thonn,) against immature *Callosobruchus maculatus* (Fab.) on stored cowpea, *Vigna unguiculata* (L) Walp. *Indian J. Agric. Res.*. 37: 169-174. 2003.

[31] Walter, V. E. Stored Product Pests. In Story, K. and Moreland, D. (eds) *Handbook of pest control.* p 526-529. 1990.

[32] Yang, Y. C.; Lee, S.H.; Lee, W.J.; Choi, D. H. and Ahn, Y. J. Ovicidial and Adultcidial Effects of *Eugenia caryophyllata* bud and leaf oil compounds on *pediculus capitis. Journal of Agricultural and food chemistry*, 51:4884-4888. 2003.