



Assessment of Qualitative and Quantitative Damage by Coffee Bean Weevil (*Araecerus fasciculatus*) on Selected Dried Chips

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Abstract

Insect pests are important biotic organisms that cause significant damage to food crops. In a bid to prevent deterioration, farmers processed them into dried chips and thereafter consumed or stored. Coffee bean weevil, *Araecerus fasciculatus* is a major insect pest causing severe economic losses during storage in Nigeria. The study investigated the qualitative and quantitative damage of selected dried chips due to attack of *A. fasciculatus*. Quantitative weight loss of cassava, potato, water yam, white yam and plantain was assessed by placing two sets of 200g sample of each dried chips materials in 2 litres capacity Kilner jars, covered with muslin cloth for aeration and to stop other pests from infesting them. In the first set, twenty-day old adult *A. fasciculatus* were introduced into the Kilner jars and the sets up arranged in the laboratory using a Completely Randomized Design (CRD), at temperature of 27±3°C, 65±5% relative humidity and 12 hours photophase. The second sets up were left uninfested to serve as control. The experiment was replicated four times. The set up were reweighed at 30, 60 and 90 days after infestation to determine the weight loss in percentage. Qualitative loss was evaluated through proximate and mineral analyses. The frass amount generated by the *A. fasciculatus* was measured after 90 days of infestation. Plantain and cassava experienced highest percentage damage as well as highest amount of frass production due to preference, texture and their composition. Proximate and mineral analyses of the dried chips after 90 days of infestation showed significant reduction in the content of ash, crude fibre, dry matter, calcium, potassium, iron, phosphorus and increase in fat, crude protein and moisture content compared to initial contents. *Araecerus fasciculatus* caused significant damage to dried chips due to continuous feeding on them and also showed highest preference for plantain and cassava while the least preference was on sweet potato.

Keywords: *Araecerus fasciculatus*, Qualitative, Quantitative, Damage, Dried chips.

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INTRODUCTION

Cassava, yam and sweet potatoes are tuber and root crops, as well as fruit crop like plantains, are among the most significant staple foods in Sub-Sahara region of Africa (Osei *et al.*, 2009). These are important in the diets of the vast majority of African population. They also play major roles in

reducing food crises in Africa because they supply the bulk of energy in human and livestock diets, their availability all year round, tolerance to harsh environmental conditions and easy fit into the Africa farming systems (Sanginga, 2015; Ferraro *et al.*, 2016). In tropical places around the world, tuber and roots crops are essential agricultural sources of energy after cereals. Sweet potatoes, cassava and yams from several botanical groups are among the examples. In Sub-Saharan Africa, various varieties of white

yam, cassava, sweet potato, water yam, and plantain are grown (Isah *et al.*, 2012). Exotic food like sweet potato and plantain have established themselves in Sub-Saharan Africa, utilized to alleviate food shortages. (Asuming-Brempon *et al.*, 2011). Tuber and root crops as basic foods have a number of agronomic advantages, including their ability to adapt to a variety of soils, different environmental conditions, and farming systems with few agricultural inputs (Chandrasekara and Kumar, 2016). Africa produces the majority of root and tuber crops and is mostly produced by small scale farmers who rely on traditional non-mechanized methods (CABI, 2005). Most of the crops produced in Africa suffer high yield losses due to the numerous diseases and pests infestation. The world needs abundant food for survival but insect pests remain an important factor to field and storage production. In storage, insect pests infest commodities; resulting in losses in terms of quality, such as lower nutritive and market values, as well as the growth of mold and quantitative losses weight losses of over 30% in about one month of storage (CABI, 2005). Storage losses of dried chips vary according to region, environmental conditions, main pests, storage structure and method of storage (Kossou and Bosque-perez, 1998).

Storage conditions play a big role in large-scale root and tuber crop production. Fresh tubers are perishable owing to microbial decomposition, physiological activities including sprouting, respiration and transpiration, and are influenced by the environment conditions, particularly relative humidity and temperature (Sanni *et al.*, 2009). According to Ferraro *et al.* (2016), in most cases, the storage stage results in significant losses, it can account for up to 25% of the total weight. In storage, infestation by insect is the leading cause of damages. Weight loss in preserved produce has been linked to a variety

of insects that depend directly on the dried chips (Osunde, 2008). Some of the insect pests that are associated with dried tubers and chips include *Araecerus fasciculatus*, *Prostephanus truncatus*, *Rhysopertha* and *Dinoderus* species. Among these insects, the Coffee bean weevil, *A. fasciculatus*, is major concern and it poses problems to many agricultural produce and products (Archibald and Chalmers, 1983). Research has shown that this weevil is polyphagous as it infests coffee, cocoa, groundnut, maize grains dried fish and chips of cassava, water yam, sweet potato, plantain and white yam (Alba-Alejandre *et al.*, 2018). As described by Arbogast *et al.* (2002) *A. fasciculatus* has ability to damage a variety of high-value agricultural goods and products, such as coffee, cocoa, and nut megs, dried yams and cassava chips, Brazil nuts, groundnuts, maize. Rees (2007) also described *A. fasciculatus* as a major insect pest that can attack healthy cowpeas, allowing other pests to attack them, reports on damage and weight loss assessment of *A. fasciculatus* on cassava, white yam, water yam, sweet potato and plantain is lacking, hence there is a need to study the qualitative and quantitative damage by *A. fasciculatus* on different hosts.

MATERIALS AND METHODS

Sample procurement and preparation

The food crops used for this study were Cassava, Sweet potato, Water yam, White yam and Plantain. They were obtained from Bodija market, Ibadan and were taken to the Entomology Research Laboratory of the Department of Crop Protection and Environment Biology (CPEB), University of Ibadan. Traditional post-harvest processing was done to prepare dried chips. The food crops were peeled and cut manually with sharp stainless-steel kitchen knife into 3 x 1 x 1 cm size chips, they were cleaned properly to eliminate any dust, sand and dirt (Plate 1 and

2). Different processing methods were engaged in before drying, preparation of cassava was done followed the method described by Diop and Calverley (1998), which involved soaking the cassava in water for 48h to reduce hydrogen cyanide present and for fermentation to occur, thereby spread in a perforated tray. Water Yam was drenched in liquid for 12h, White Yam and Potatoes were blanched in hot water (93 to 100°C) for 2 minutes. Sliced plantain, water yam, fermented cassava and other blanched chips was later oven dried at 70°C for five days till there was a uniform weight of each sample.

Experimental Setup

Two sets of 200g sample of each dried chips materials were placed in 2 litres capacity Kilner jars, which were covered with muslin cloth for aeration and to stop other pests from infesting them. Experiments were carried out at temperature of $27\pm 3^\circ\text{C}$, $65\pm 5\%$ relative humidity and 12 hours photophase. In the first set, twenty-day old adult *A. fasciculatus* were introduced into the Kilner jars and the sets up arranged in the laboratory using a CRD. The second sets up were left uninfested to serve as control. The experiment was replicated four times. The set up were reweighed at 30, 60 and 90 days after infestation. Determination of weight loss in percentage was calculated by subtracting infested (damaged) from uninfested (undamaged) chips as a fraction of the uninfested displayed in percentage.

$$WL = \left\{ \frac{W_c - W_t}{W_c} \right\} \times 100$$

Where:

WL = weight loss in percentage

Wc = uninfested chips weight

Wt = infested chips weight

The powdery wastes on the quantitative damage were analyzed for mineral element, using the established techniques by the AOAC (2005). The frass amount generated by

the *A. fasciculatus* was measured after 90 days of infestation on all the samples by emptying each jar of all insects as all the samples were emptied into trays, sieved to remove the powder from the infested chips. The powders that pass through the sieve are known as insect frass, the frass collected was then weighed. The procedures were repeated for all replicates. Data collected on weight loss, frass weight, and mineral element and proximate analyses data obtained were analyzed using DSAATAT and treatment means when significant were separated using Tukey HSD test at $\alpha = 0.05$.

Determination of Crude Protein

Determination of crude protein in cassava, potato, wateryam, white yam and plantain were determined by using the procedure of the routine semi-micro Kjeldahl. The steps involved are Digestion, Distillation and Titration.

(i) **Reagents:** 40% (W/V) NaOH, Kjeldahl Catalyst tablet, 2% Boric Acid Solution, ConC. H₂SO₄, 0.01NHCl, Methyl Red – Bromocresol green mixed indicator.

(ii) **Digestion:** 0.5g of each powder of dried chips sample of cassava, potato, wateryam, white yam and plantain were weighed into Kjeldahl digestion tubes, 10ml of ConC. H₂SO₄ and 1 Kjeldahl catalyst tablet were added and carefully ensured that all the chips samples reached the bottom of the tubes. Samples was replicated three times and carefully arranged in the Digestion Block Heaters for 4 hours, until when a clear and clean solution without any colour was obtained. It was left to cool and later emptied into 100ml capacity volumetric flask.

(iii) **Distillation:** Markham Distillation Apparatus was used for the distillation; the samples were steamed for ten minutes. To extract condensed water, the steam generator was disconnected from the source of heat and connected to the full developing vacuum. 5 ml portion of the already digested samples were poured with small funnel opening into the apparatus body, 5ml of 40% (W/V) NaOH was added, mixed and heat for 2 minutes into a 50ml conical flask and add 10ml of 2% Boric Acid

plus blended indicator solution, then put at the condenser's receiving tip. Boric Acid colour with the solution turned green, indicating trapping of all the liberated ammonia.

(iv) **Titration:** A 50ml Burette was used to titrate the resulting green color solution against 0.01N HCl. The green color changes to wine in the end, indicating that all of the Nitrogen held as Ammonium Borate $[(\text{NH}_4)_2\text{BO}_3]$ has been released as Ammonium Chloride. (NH_4Cl) .

The nitrogen percentage was estimated as:

$$\%N = \frac{\text{Titre Value} \times \text{Normality}}{\text{Molarity of HCL} \times \text{Atomic mass of N} \times \text{Vol. of flask containing the digest}} \times \frac{100}{1}$$

For steam distillation, multiply the sample weight digested in milligrams by the volume of the digest, content of the crude protein is calculated by multiplication of nitrogen percentage by a fixed factor of 6.25 i.e. $\% \text{ CP} = \% \text{ N} \times 6.25$.

Determination of Crude Fat

(i) **Apparatus:** Analytical balance, Soxhlet apparatus, oven and desiccators.

(ii) **Reagents:** Petroleum spirit or Ether (40° – 60°C b.pt).

Dried sample (1 gram each) of cassava, potato, wateryam, white yam and plantains were weighed and softly pugged with cotton wool in a fat-free extraction thimble. Inside the extractor the thimble was put and equipped with a reflux condenser and a 250 ml soxhlet flask that had been oven dried, chilled in the desiccators and weigh again. After that, Petroleum ether (b.pt.40°–60°C) was added to the soxhlet flask to fill it to $\frac{3}{4}$ content. The condenser and extractor were heated. The Ether is allowed to siphon for times, 10 –12 times, until it runs out. The

thimble carrying the material is then withdrawn and it was dried on the kitchen worktop using a mirror glass. The condenser, extractor and flask, and are all changed, distillation process proceeds till when the flask is almost completely dry. The container that holds the fat is removed, cleaned, and oven dried. The initial weight of the dry soxhlet flask is W_0 , and the final weight of the oven dried is W_1 , the percentage fat can be calculated using the formula:

$$= \frac{W_1 - W_0}{\text{Wt. of sample taken}} \times \frac{100}{1}$$

Dry Matter and Moisture Determination

A 2g of the sample of cassava, potato, water yam, white yam and plantain were measured into a crucible. The crucible, together with the sample collected, was then oven dry to a consistent weight, set at 1000°C for 24 hours. The sample and crucible were brought out of the oven after 24 hours and placed in desiccators to cool for 10 minutes before being weighed.

Empty crucible weight is W_0
 Crucible weight plus sample is W_1
 Crucible weight plus oven-dried
 sample W_3

$$\% \text{ Dry Matter} = \frac{W_3 - W_0}{W_1 - W_0} \times \frac{100}{1}$$

$$\% \text{ Moisture} = \frac{W_1 - W_3}{W_1 - W_0} \times \frac{100}{1}$$

Ash Content Determination

A 2 g sample was placed in a ceramic crucible and put in the muffle furnace, which was heated to 550°C, and left for 4 hours. It was changed to ash white. The content in the crucible and its components were weighed after cooling to about 100°C. This was carried out twice. The ash percentage was determined as following:

$$\text{Ash Content} = \frac{\text{Wt. of Ash}}{\text{Original Wt. of sample}} \times \frac{100}{1}$$

Fibre Content Determination

In the fibre flask, 2g of the material was properly weighed, and was added 100ml of 0.255N H_2SO_4 . With the heating mantle, it was heated for 1 hour under reflux. The heated mixture was filtered using a fibre filter cloth. The filtrate was discarded, and the remaining was returned to the fibre flask, which was then filled with 100ml of (0.313N NaOH) and heated for one hour under reflux. To dissolve any organic constituents, 10ml acetone was administered after the solution was sieved using a fibre filter cloth. Before being put into a crucible, it was rinsed with 50ml hot water using the filter. To remove moisture, both the residue and crucible were oven-dried overnight at 105°C. The weight was determined by using a dessicator to cool the dried crucible with the residue and then weighing it (W_1). It was later placed in the muffle furnace for 4 hours at 550°C for ashing. In the desiccators, a crucible holding white or grey ash was cooled and weighted

(W_2). The fibre weight is the subtraction between $W_1 - W_2$.

The fibre % was estimated as:

$$\% \text{ Fibre} = \frac{W_1 - W_2}{\text{Wt. of sample}} \times \frac{100}{1}$$

Calcium and Potassium Determination

Each samples of the ash in the crucible was digested by mixing 5ml of 2 M HCL to it and drying it on a heater. To the mixture was 5ml of 2 MHCL was poured again, brought to a boil, and filtered into a 100ml volumetric flask through a Whatman No. 1 filter paper. The filtrate was prepared up to the mark with distilled water stoppered and set aside for reading calcium and potassium concentrations on the Jenway Digital Flame Photometer (PFP7 Model) with the appropriate filter for each mineral element. The concentrations of each element were determined using the formula:

$$\% \text{ Ca} = \frac{\text{Meter Reading (MR)} \times \text{Slope} \times \text{Dilution factor}}{1000}$$

$$\% \text{ K} = \frac{\text{Meter Reading (MR)} \times \text{Slope} \times \text{Dilution factor}}{1000}$$

Phosphorus Determination (Spectrophotometric method):

The ash from each of the samples was added an HCl solution as indicated above for calcium assessment. 10 mL filtrate was poured into a 50 mL standard flask, 10 mL vanadate yellow solution was added, distilled water was used to fill flask and allowed to stay for 10 minutes for total yellow colour. The quantity of phosphorus was determined using a Spectronic 20 spectrophotometer or colorimeter at a wavelength of 470 nm to measure the optical density (OD) or absorbance of the solution. Using the formula, the proportion of phosphorus was calculated:

$$\% \text{ Phosphorus} = \frac{\text{Absorbance} \times \text{Slope} \times \text{Dilution factor}}{1000}$$

Determination Iron (Fe) using buck 200

AAS:

The iron ash digest was rinsed and was marked in a 100ml volumetric flask with distilled water. Through the suction tube, this diluent was sucked into the Buck 200 Atomic Absorption Spectrophotometer (AAS). It was later read at its wavelengths with hollow cathode lamps applying the proper fuel and oxidant mixture.

RESULTS

The percentage weight loss of the dried chips due to *A. fasciculatus* continuous activities on them showed definite preference for different dried chips. The percentage weight loss significantly (P<0.05) varied across the food hosts and the length of storage. Percentage damage by *Araecerus fasciculatus* on cassava was from a low of 9% to a high 44.38% length of storage, while percentage damage on sweet potato was from low of 9% to a high of 28.75%. Water yam has a percentage damage of 10.75% to a high of 38.75%, white yam has 10.63% to a high of 36.88% and plantain 13.25% to a high of

52.75%. Percentage damage on plantain was significantly higher (13.25%, 37.13%, 52.75%) across the dried chips and the length of storage, potato was the least susceptible (9.00±0.61, 15.63±1.20, 28.75±0.72), both across the dried chips and the length of storage (Table 4.27). After 30 days there exists no difference significantly on the level of damage on cassava, potato, white yam and water yam, (9.13±0.6, 9.00±0.6 10.63±0.5 and 10.75±0.6) however, plantain had the highest damage which differed statistically from cassava, potato and white yam but not from water yam. Mean weight loss on selected dried chips due to *A. fasciculatus* infestation after 60 days revealed that plantain (37.13±1.1) recorded maximum weight loss, which was significantly higher than all other dried chips (P < 0.05). There was no difference statistically (P > 0.05) in the damages recorded on cassava, white yam and water yam (20.63±1.2, 21.5±0.7 and 21.5±0.7). Potato had the least weight loss (15.63±1.2). Percentage damage after 90 days of storage was significantly (P < 0.05) different among plantain, cassava, white yam, water yam and potato (52.75±0.8, 44.38±1.6, 38.75±0.7, 36.88±1.2 and 28.75±0.7). Table 1.

Table 1: Mean weight loss (%) ± S.E of selected dried chips after *Araecerus. Fasciculatus* infestation

Treatment	% weight loss		
	30 Days	60 Days	90 Days
Cassava	9.13±0.60 ^b	20.63±1.20 ^b	44.38±1.60 ^b
Potato	9.00±0.60 ^b	15.63±1.20 ^c	28.75±0.70 ^d
Water Yam	10.75±0.60 ^{ab}	21.5±0.70 ^b	38.75±0.70 ^c
White Yam	10.63±0.50 ^b	23.5±0.90 ^b	36.88±1.20 ^c
Plantain	13.25±0.60 ^a	37.13±1.10 ^a	52.75±0.80 ^a
CV%	10.91	8.73	5.27

Tukey's HSD Test at α = 0.05 finds no significant differences between means within a column with the same letter(s)

At 30 and 60 days the same trend was observed in frass weight obtained, the highest mean weight of frass was obtained on cassava (30 days: 33.75g, 60 days: 76.50g) and plantain (30 days: 33.25g, 60 days 83.75g), white yam (30 days: 25.75g, 60 days: 67.50g) and water yam (30 days: 27.25g, 60 days: 64.25g) had the same level of significant, the least frass weight at 30 and 60 days was

produced on sweet potato (15.75g, 55.00g respectively). At 60 days the highest mean weight of frass was produced on cassava (111.75g) which was statistically higher than all other chips, this was followed by cassava (103.50g) > white yam (87.5g) > water yam (86.25g). The lowest frass was recorded on potato (78.75g) (Table 2).



Plate 1: Damaged dried chips caused by exit holes and feeding activities of *A. fasciculatus*
 A: Dried chips showing damages caused by exit holes
 B: Frass

Table 2: Weight of frass (g) \pm S.E of *A. fasciculatus* infested dried chips

Treatment	Weight of frass		
	30 Days	60 Days	90 Days
Cassava	33.75 \pm 0.75 ^a	76.50 \pm 2.03 ^a	103.50 \pm 1.3 ^b
Sweet potato	15.75 \pm 0.85 ^c	55.00 \pm 1.23 ^c	78.75 \pm 1.5 ^d
Water yam	27.25 \pm 0.48 ^b	64.25 \pm 1.0 ^b	86.25 \pm 0.8 ^c
White yam	25.75 \pm 0.48 ^b	67.50 \pm 1.04 ^b	87.5 \pm 1.04 ^c
Plantain	33.25 \pm 0.48 ^a	83.75 \pm 2.30 ^a	111.75 \pm 2.7 ^a
CV%	4.64	4.93	3.43

Tukey's HSD Test at $\alpha = 0.05$ finds no significant differences between means within a column with the same letter(s)

Furthermore, proximate analysis (Table 3) indicated the effect of *A. fasciculatus* infestation on stored dried chips. Storage durations significantly influenced proximate parameters of the selected chips. At the beginning of storage period, there exists significant increase ($P < 0.05$) in amount of ash. Water yam, plantain and cassava (3.10 ± 0.1 , 3.01 ± 0.1 , 2.80 ± 0.1) (g/100 g) had the highest significant content of ash. At 90 days after storage, the ash content decreased and also varied significantly on all dried chips examined, plantain (2.70 ± 0.2) was higher than other dried chips while cassava (0.82 ± 0.1) (g/100 g) and white yam (1.67 ± 0.4) (g/100 g) were not statistically different from one another, yet they were much lower than what was obtained on water yam (2.19 ± 0.2) (g/100 g) and sweet potato

(1.20 ± 0.1) (g/100 g). At the beginning of storage period, crude protein level was not higher statistically ($P > 0.05$) on water yam, white yam, plantain and sweet potato (3.82 ± 0.0 , 3.62 ± 0.5 , 3.45 ± 0.1 , and 3.17 ± 0.0) (g/100 g) respectively, while crude protein in cassava (1.62 ± 0.1) (g/100 g) was the lowest. Different trend was observed in storage after 90 days, a substantial difference in crude protein was found (7.70 ± 0.1 , 5.20 ± 0.1 , 4.50 ± 0.1 , 3.80 ± 0.1 and 1.90 ± 0.1) (g/100 g) on water yam, white yam, potato, plantain and cassava respectively. When dried chips were stored for 3-month, storage period and feeding of insects on them significantly ($P < 0.05$) decreases the crude fibre and amount of dry matter. During storage, however, the quantity of crude protein, fat, and moisture increased statistically ($P < 0.05$) (Table 3).

Table 3: Effect of *A. fasciculatus* infestation on proximate composition of dried chips g/100 g

Treatment	Storage Duration	Ash	Crude Protein	Fat	Crude Fibre	Dry Matter	Moisture Content
Cassava	0	2.80 ± 0.10^a	1.62 ± 0.10^b	1.20 ± 0.20^b	2.50 ± 0.10^a	93.00 ± 0.10^{ab}	3.80 ± 0.40^d
	90	0.82 ± 0.10^c	1.90 ± 0.10^d	1.26 ± 0.20^c	2.00 ± 0.10^a	82.50 ± 0.00^c	$4.90 \pm 0.40_d$
Potato	0	1.73 ± 0.10^c	3.17 ± 0.00^a	1.98 ± 0.60^b	1.70 ± 0.10^b	93.50 ± 0.00^a	5.10 ± 0.10^c
	90	1.20 ± 0.10^{bc}	4.50 ± 0.10^{bc}	2.13 ± 0.20^{ab}	1.30 ± 0.10^b	92.70 ± 0.10^a	6.30 ± 0.30^{cd}
Water Yam	0	3.10 ± 0.10^a	3.62 ± 0.50^a	2.10 ± 0.10^a	1.80 ± 0.10^b	92.50 ± 0.10^{bc}	6.40 ± 0.20^b
	90	2.19 ± 0.20^{ab}	5.20 ± 0.10^b	2.57 ± 0.20^a	1.40 ± 0.10^b	91.90 ± 0.10^{ab}	8.10 ± 0.10^{ab}
White Yam	0	2.30 ± 0.10^b	3.82 ± 0.00^a	2.47 ± 0.10^a	2.00 ± 0.10^b	92.10 ± 0.10^c	6.40 ± 0.20^b
	90	1.67 ± 0.40^c	7.70 ± 0.10^a	2.73 ± 0.10^a	1.70 ± 0.10^{ab}	90.80 ± 0.60^b	7.70 ± 0.40^{bc}
Plantain	0	3.01 ± 0.10^a	3.45 ± 0.10^a	1.37 ± 0.10^b	1.90 ± 0.20^b	93.10 ± 0.10^a	7.90 ± 0.40^a
	90	2.70 ± 0.20^a	3.80 ± 0.10^c	1.67 ± 0.10^{bc}	1.60 ± 0.10^{ab}	92.40 ± 0.10^a	9.40 ± 0.30^a

Tukey's HSD Test at $\alpha = 0.05$ finds no significant differences between means within a column with the same letter(s)

Mineral content was significantly affected by content steadily decreased with continuous storage and infestation duration of all the dried feeding of insect on them (Table 4). chips. After 3 months in storage, all the mineral

Table 4: Effect of *A. fasciculatus* infestation on mineral element of dried chips g/100 g

Treatment	Storage duration (days)	Calcium (Ca)	Potassium(K)	Iron (Fe)	Phosphorus(P)
Cassava	0	0.05±0.00 ^a	1.82±0.00 ^a	2.20±0.10 ^{bc}	2.20±0.00 ^{bc}
	90	0.04±0.00 ^a	0.90±0.10 ^b	2.10±0.10 ^a	0.20±0.00 ^b
Potato	0	0.05±0.00 ^a	0.84±0.00 ^c	2.38±0.20 ^b	2.40±0.10 ^b
	90	0.04±0.00 ^a	0.70±0.00 ^b	1.80±0.10 ^b	0.20±0.00 ^b
Water Yam	0	0.02±0.00 ^b	1.45±0.00 ^b	1.75±0.10 ^c	1.80±0.00 ^c
	90	0.02±0.00 ^c	1.17±0.00 ^a	0.80±0.10 ^c	0.40±0.00 ^a
White Yam	0	0.03±0.00 ^b	1.00±0.10 ^c	1.77±0.10 ^c	1.80±0.00 ^{bc}
	90	0.02±0.00 ^{bc}	0.73±0.10 ^b	1.00±0.00 ^c	0.40±0.00 ^a
Plantain	0	0.05±0.00 ^a	0.90±0.10 ^c	5.81±0.10 ^a	5.80±0.00 ^a
	90	0.04±0.00 ^{ab}	0.73±0.00 ^b	1.10±0.00 ^c	0.20±0.00 ^b

Tukey's HSD Test at $\alpha = 0.05$ finds no significant differences between means within a column with the same letter(s)

DISCUSSIONS

Araecerus fasciculatus was able to bore into all the dried chips and reduced the quality because of the presence of exit holes, confirming its polyphagous status. These agrees with the reports of various researchers; Siswanto (1987) reported that *A. fasciculatus* was able to bore into nutmeg seeds and caused significant reduction in the quality of the seeds. Abo and Ja (2014) reported that *A. fasciculatus* was able to bore holes into yam and cassava. Eduku (2014) also reported *A. fasciculatus* caused significant damage on cocoa beans in storage. These findings also corroborate the reports of Hill (1990) who reported ability of *A. fasciculatus* to pierce, burrow, and grow on many food hosts, as well as its potential to inflict significant damage to dry chips during longer periods of infestation.

The feeding activities of *A. fasciculatus* caused significant weight loss on all the dried chips. It was also noted that *A. fasciculatus* preferred cassava and plantain. After 90 days of infestation, percentage

weight loss was highest on plantain (52.75%) > cassava (44.38%) > water yam (38.75%) > white yam (36.88%). The least weight loss was recorded on sweet potatoes (28.75%). This corroborates the findings of Danjuma (2002) who reported that *A. fasciculatus* caused a weight loss of above 40% in cassava products after 90 days of infestation.

The ability of *A. fasciculatus* to feed on different food substrates corroborate the findings of Caasi-Lit *et al.*, (2011), which described coffee bean weevil as primary pest of stored product that generally infests a wide variety of dry materials. The result is similar with the findings of Isah *et al.*, (2012) who discovered that *Prostephanus truncatus* was able to penetrate potato and cassava and cause higher percentage loss than other food materials used. The preference which led to higher loss of cassava and potato might be due to the composition and physical texture of the dried chips which facilitates the higher infestation of the insects, researcher like Papadopoulos (2006) and Kohno *et al.*,

(1986), have reported the susceptibility of cassava and potato to insect infestation. The mean weight of frass produced by *A. fasciculatus* after 30, 60 and 90 days respectively varied among the dried chips. Insects reared on plantain chips (33.25g, 83.75g and 111.75g) respectively and cassava (33.75g, 76.50g and 103.50g) respectively produced the greatest amount of frass, whereas the lowest amount of frass was recorded on sweet potato chips (15.75g, 55g and 78.75g) respectively.

There were considerably reductions in the level of proximate contents of the chips before and after *A. fasciculatus* infestation for 90 days. Total protein, moisture contents and fats contents increases, but ash contents, crude fibre and dry matter decreases after *A. fasciculatus* infestation this is similar with the reports of Babarinde *et al.*, (2018) who reported that *Tribolium castaneum* infestation causes physical and biophysical damage of stored plantain chips (*Musa sapientum* L.) and also corroborate the findings of Chijindu (2008) who reported that *Araecerus fasciculatus* prefers and damages processed cassava chips. Mineral contents greatly decreased after 90 days of infestation by *A. fasciculatus*. This agrees with the report of Rajamma *et al.*, (1996) and Chijindu (2008) who reported that stored products insect causes significant qualitative losses.

CONCLUSION

In conclusion plantain and cassava experienced highest percentage damage as well as highest amount of frass production due to preference, texture and their composition. Proximate and mineral analyses showed reduction of ash, crude fibre, dry matter, calcium, potassium, iron, phosphorus and increase in fat, crude protein and moisture content due to continuous feeding of insects on them

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