

## Research Article

# Effects of Larger grain borer *Prostephanus truncatus* (Coleoptera: Bostrichidae) on nutrient content of dried staple roots and tubers

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**Abstract:** The effect of infestation and damage by Larger grain borer (LGB), *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) on nutrient content of some dried processed root and tuber crops (cassava, yam, sweet potato and cocoyam) were investigated in the laboratory at 25-30 °C and 70-90% R.H. Thirty five grams each of the chips from two varieties of sweet potato, cassava, cocoyam and a variety of yam were separately placed in a 950 ml sized glass jar. The Test Host Crops (THC) were artificially infested with one, two and three pairs of adult LGB. The experiment was conducted using a completely randomized design with each treatment replicated three times and kept for 90 days. Data were taken on final population of adult LGB, weight of powder and percentage weight loss. Data on proximate analysis of LGB-infested THC after 90 days was also collected. The response of roots and tubers to infestation by LGB on the THC was significantly different. Percentage loss in quantity of root and tuber crops after 90 days of infestation showed that THC infested with two pairs of the insect had higher weight loss of the crops. The THC infested with two pairs of LGB had higher moisture content and least crude protein was recorded on the THC infested with one pair of LGB while the ones infested with three pairs of LGB had higher crude fat content. Uninfested THC had higher carbohydrate content. The findings of this study show that LGB is a serious threat to stored roots and tubers and to food security. The nutritional value of root and tuber crops was adversely affected by infestation of LGB in storage.

**Keywords:** *Prostephanus truncatus*, proximate analysis, infestation, density, nutritional composition

## Introduction

Root crops are underground plant structures formed from modified roots which are edible and energy rich while tuber crops are edible energy rich crops formed wholly or partly from underground stem storage organs (Eke-Okoro *et*

*al.*, 2014). They form a major staple food crop in most developing countries of Africa (Anderson *et al.*, 2004), Latin America and Asia (Ugwu, 2009). Cassava *Manihot esculenta* Crantz, potato *Solanum tuberosum* L., sweet potato *Ipomea batatas* L., cocoyam *Colocasia esculenta* L., yam *Dioscorea* spp and ginger *Zingiber officinales* L. are among the most popular root and tuber crops (Ugwu, 2009). Cassava, potato and sweet potato rank among the top 10 food crops produced in developing countries and have become the subject of increasing attention

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among scientist (Scott *et al.*, 2000). They are major sources of nutrient, income and play important roles in livelihood and food security for over 2 billion people in developing countries particularly in Nigeria (Alexandratos, 1995; Scott *et al.*, 2000; Aberoumand and Deokule, 2009; Sanni *et al.*, 2009; Eke-Okoro *et al.*, 2014).

In the time past, root crops were left in the ground for storage after maturity and harvested when needed. However, the high pressure on land to produce food for the growing population is believed to have led to the processing and storage of root and tuber crops (Stumpf, 1998). In a bid to prevent post-harvest losses, root and tuber crops are now dried and processed to reduce the high risk of attack by fungi, bacteria, nematodes and insect pests (Ofor, 2011; Onyenwoke and Simonyan, 2014) with about 42% of cassava root in West and East Africa being processed into dried chips (Stumpf, 1998; Ognakossan *et al.*, 2010). However, agricultural produce and products from root and tuber crops are still being infested by insect pests during sun drying and when in store (Oke and Bolarinwa, 2011).

Larger grain borer is widely known as one of the most destructive pests of dried cassava and stored maize in Africa (Boxall, 2002). It is highly voracious and can cause up to 40% post-harvest loss in stored maize grains in six months and 75% in fermented cassava roots in four months (Osipitan *et al.*, 2011). The insect is a primary pest of major crops causing reduction in weight and nutritional quality of infested grains (Lale, 2002; Schneider, 2004). Adult boring activities have been reported to cause weight loss of 37 - 63%, reduce dried cassava roots to dust (Popoola and Hassan, 2011) and degrade quality that result in price discounts and economic losses (Naziri *et al.*, 2014).

Recent researches have shown that different root and tuber crop products and different varieties of each product respond differently to stored product pest infestation (Osipitan *et al.*, 2008; Atijegbe *et al.*, 2014). This study attempts to provide baseline information on the effects of larger grain borer on nutrient content of dried staple roots and tubers and their

attendant level of infestation due to *P. truncatus* infestation and damage in storage.

## Materials and Methods

The experiment was conducted under uncontrolled temperature and humidity at the Crop and Soil Major Laboratory of the Faculty of Agriculture, Department of Crop and Soil Science, University of Port Harcourt, located on the latitudes 4° 52'N and 4° 55'N and longitude 6° 554'E and 6° 56'E with an elevation of approximately 20 m above sea level (Zakka *et al.*, 2013). *Prostephanus truncatus* adults were obtained from the Entomology Laboratory of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria and left to breed on dried cassava chips until enough number of adults were obtained. Chips from two varieties of sweet potato, cassava, cocoyam and a variety of yam were collected from National Root Crops Research Institute Umudike, Abia State, Nigeria (Table 1).

**Table 1** Roots and tuber test host crops and their breeding codes.

No.	Root and tubers substrates	Varietal breeding code
1	Sweet potato	UMU SP0/1
2	Sweet potato	UMUSP0/3
3	Cassava	UMUCASS36
4	Cassava	TME419
5	Yam	TDa/98/1168
6	Cocoyam	NCE011
7	Cocoyam	NCE003

The Test Host Crops (THC) were kept in the refrigerator 72 h at 5 °C before the start of the experiment to disinfect them from mites and any insect pest present. After three days, the chips were kept for 24 h in the open laboratory to acclimatize and 35g of each of the 7 THC were weighed using an electric weighing balance (Model MP2001) into a 950ml sterilized glass jar covered with fine nylon net held in place by a band to allow free flow of air.

The substrates were then inoculated with one, two and three pairs (male and female) of 3-4 days teneral adult *P. truncatus*. Sexing was done by viewing their morphological characteristics under binocular microscope where the clypeal tubercles are more prominent in the females than the males (Shires and McCarthy 1976). The sexed male and female insects were allowed to breed and feed on the substrate for a period of 90 days after which the content of each jar was poured into a plastic tray and all adults (both dead and alive) were removed, counted and recorded. The experiment was conducted using a completely randomized design (CRD) with each of the treatments replicated 3 times.

Data on the percentage loss, number of emerged adult and proximate analysis were collected. The powder obtained from each variety was used in calculating the percentage loss (modified after Compton and Sherington, 1999) as:

$$\text{Weight loss (\%)} = \frac{(PW1 - PW2)}{PW1} \times 100$$

Where: *PW1* = initial weight of sample before infestation, and *PW2* = final weight sample after infestation

The proximate analyses on moisture, carbohydrate, crude protein, ash and crude fat content of the samples were carried out at the laboratory of the Department of Biochemistry, Nigerian Stored Products Research Institute, Port Harcourt, Nigeria using AOAC protocols (AOAC, 2010). Data were subjected to analysis of variance (ANOVA) using Minitab 17 Statistical Software. The relationship and differences between treatment means ( $\pm$  SE) were determined using Tukey's test at 5% level of probability.

## Results

### Effect of different roots and tubers on the population of *P. truncatus*

The response of roots and tubers to infestation by *P. truncatus* emerging from the different THC was significantly different. UMUSP0/1a variety of sweet potato had the highest number of adult progeny (65.22) while the least number of adult *P. truncatus* emerged in NCE011Cocoyam (Table 2). Percentage loss in quantity of the roots and tubers due to *P. truncatus* infestation after 90 days shows that UMUSP0/1, a variety of sweet potato and cassava varieties UMUCASS36 and TME 419 had significantly ( $p < 0.05$ ) higher loss than the other varieties and least percentage loss was recorded in THC NCE011cocoyam and TDa/98/1168yam (Table 2).

The effect of *P. truncatus* density on the number of adult emerging from root and tuber crop after 90 days of infestation shows that THC infested with three pairs had significantly higher adult progeny than THC infested with one or two pairs. The least number of adults emerged from root and tuber crop THC infested with only one pair of *P. truncatus*. It is obvious from table 3 that UMUSP0/1 Sweet potato Test Host Crop supported significantly higher adult progenies than the other varieties and that the least was recorded on NCE011cocoyam. The interaction effect of *P. truncatus* density on the number of adults that emerged from root and tuber crops shows that UMUSP0/1 infested with three pairs had significantly higher numbers of adult progeny than the number that emerged from the same THC infested with two pairs. The least number of adult developed in root and tuber crop THC obtained from NCE011cocoyam (Table 3).

**Table 2** Number of adult *Prostephanus truncatus* emergence and loss of root and tuber crops after 90 days of infestation.

Identity sample	Crop type	No. of adults	Loss (%)
UMUSP0/1	Sweet potato	65.22 <sup>a</sup>	22.64 <sup>a</sup>
UMUSP0/3	Sweet potato	34.22 <sup>b</sup>	14.25 <sup>b</sup>
UMUCASS36	Cassava	36.56 <sup>b</sup>	21.00 <sup>a</sup>
TME419	Cassava	30.00 <sup>b</sup>	18.61 <sup>ab</sup>
TDa/98/1168	Yam	0.22 <sup>c</sup>	2.74 <sup>c</sup>
NCE003	Cocoyam	1.56 <sup>c</sup>	5.68 <sup>b</sup>
NCE011	Cocoyam	0.00 <sup>c</sup>	2.12 <sup>c</sup>

Means in a column with the same letter (s) are not significantly ( $p \leq 0.05$ ) different by Turkey's test.

**Table 3** The effect of *Prostephanus truncatus* density on the number of adult emerging from root and tuber crop after 90 days of infestation.

<i>P. truncatus</i> Density	Number of adults per jar							Mean adult emergence
	UMUSP0/1 Sweet potato	UMUSP0/3 Sweet potato	UMUCASS Cassava	TME419 Cassava	TDa/98/1168 Yam	NCE003 Cocoyam	NCE011 Cocoyam	
1 Pair	53.00 <sup>a-c</sup>	15.67 <sup>b-c</sup>	35.33 <sup>a-c</sup>	27.67 <sup>a-c</sup>	0.00 <sup>c</sup>	0.67 <sup>c</sup>	0.00 <sup>c</sup>	19.00
2 Pairs	67.67 <sup>ab</sup>	40.33 <sup>a-c</sup>	32.67 <sup>a-c</sup>	53.00 <sup>a-c</sup>	0.00 <sup>c</sup>	0.00 <sup>c</sup>	0.00 <sup>c</sup>	27.67
3 Pairs	74.33 <sup>a</sup>	46.67 <sup>a-c</sup>	41.67 <sup>a-c</sup>	27.33 <sup>a-c</sup>	0.67 <sup>c</sup>	4.00 <sup>c</sup>	0.00 <sup>c</sup>	27.81
Mean adult emergence	65.22	34.22	36.56	36.00	0.22	1.57	0.00	

Means in a column with the same letter(s) are not significantly ( $P \leq 0.05$ ) different by Turkey's test.

### Proximate analysis of chips of different root and tuber crops

The effect of *P. truncatus* infestation on the percentage moisture content of each root and tuber crops shows that THC infested with two pairs had higher % moisture content than THC infested with three pairs (Table 4). The least % moisture content was recorded in a control. It is obvious from the table 4 that the yam variety TDa/98/1168 had significantly higher % moisture content though not different from the % moisture content recorded on UMUSP0/3 and the least was recorded on NCE011cocoyam. The interactive effect of *P. truncatus* density and the host crops on % moisture content shows that UMUSP0/3 infested with two pairs had significantly higher % moisture content though not different from the result obtained on same THC infested with three pairs and TDa/98/1168yam infested with two or three pairs of *P. truncatus*.

The effect of *P. truncatus* infestation on the % carbohydrate content of each root and tuber crop shows that the uninfested host crops had higher % carbohydrate content than the infested host crops with one or two pairs of *P. truncatus* (Table 5). The least % carbohydrate content was recorded in substrate infested with three pairs of *P. truncatus*. It is obvious from table 5 that 419Yam variety recorded significantly higher % carbohydrate content and the least was recorded on the two cocoyam varieties. The interaction effect of *P. truncatus* density and the Test Host Crops on % carbohydrate content shows that TME419 cassava substrate infested with three pairs *P. truncatus* had significantly higher % carbohydrate content than same THC infested with two pairs of *P. truncatus*

and the un infested THC of UMUCASS cassava variety. The least % carbohydrate content of the substrate and insect density were recorded on NCE003 Cocoyam THC infested with three pairs of *P. truncatus* though not different from UMUSP03 sweet potato substrate infested with two pairs of *P. truncatus*.

The effect of *P. truncatus* infestation on the percentage (%) crude protein of each root and tuber crop shows that uninfested THC had higher % crude protein than THC infested with two pairs (Table 6). The least % crude protein was recorded on Test Host Crops infested with one pair of *P. truncatus*. It is clear from table 6 that NCE003Cocoyam THC recorded the highest % crude protein and the least was recorded in 419cassava. The interaction effect of *P. truncatus* infestation and the THC on % crude protein shows that NCE011cocoyam infested with three pairs had significantly higher % crude protein and the least % crude protein was recorded on 419cassava variety.

*Prostephanus truncatus* infestation and its role on the percentage (%) ash content of each root and tuber crop shows that THC infested with one pair of *P. truncatus* had higher % ash content than THC infested with two pairs, while THc infested with three pairs of *P. truncatus* had the least % ash content (Table 7). NCE003cocoyam THC recorded significantly higher % ash content while the interaction effect of *P. truncatus* density and the THC on % ash content shows that NCE011cocoyam infested with one pair had significantly higher % ash content and the least % ash content was recorded on TME419 cassava substrate.

The least % crude fat was recorded on THC infested with two pairs of *P. truncatus*. Interaction effect of *P. truncatus* density and the THC type on % crude fat shows that the control (uninfested) TDa/98/1168yam had

significantly higher % crude fat and the least % crude fat was recorded on NCE011cocoyam uninfested (control) though not different from NCE003cocoyam (Table 8).

**Table 4** Effect of *Prostephanus truncatus* density on the moisture content (MC) (%) of the substrates after 90 days infestation.

<i>P. truncatus</i> Density	Moisture content (%) (Mean ± SE)							Overall mean
	UMUSP0/1 Sweet potato	UMUSP0/3 Sweet potato	UMUCASS Cassava	TME419 Cassava	TDa/98/1168 Yam	NCE003 Cocoyam	NCE011 Cocoyam	
Control	12.05 ± 0.02 <sup>k</sup>	13.58 ± 0.05 <sup>j</sup>	12.05 ± 0.04 <sup>k</sup>	12.49 ± 0.04 <sup>k</sup>	14.73 ± 0.02 <sup>i</sup>	13.96 ± 0.02 <sup>ij</sup>	14.6 ± 0.01 <sup>i</sup>	13.35c ± 0.05
1 pair	16.01 ± 0.05 <sup>gh</sup>	16.97 ± 0.03 <sup>ac</sup>	16.06 ± 0.06 <sup>fh</sup>	16.15 ± 0.01 <sup>fh</sup>	16.76 ± 0.28 <sup>bg</sup>	16.03 ± 0.07 <sup>gh</sup>	14.1 ± 0.23 <sup>ij</sup>	16.01b ± 0.05
2 pairs	16.85 ± 0.01 <sup>af</sup>	17.59 ± 0.08 <sup>a</sup>	16.55 ± 0.10 <sup>ch</sup>	15.85 ± 0.03 <sup>h</sup>	17.32 ± 0.06 <sup>ac</sup>	16.25 ± 0.01 <sup>ch</sup>	16.26 ± 0.03 <sup>ch</sup>	16.67a ± 0.03
3 pairs	16.56 ± 0.04 <sup>eh</sup>	17.15 ± 0.03 <sup>ad</sup>	16.21 ± 0.01 <sup>eh</sup>	16.15 ± 0.07 <sup>fh</sup>	17.45 ± 0.04 <sup>ab</sup>	16.23 ± 0.08 <sup>eh</sup>	16.38 ± 0.01 <sup>dh</sup>	16.59a ± 0.02
Mean % MC	15.37 ± 0.17	16.32 ± 0.14	15.22 ± 0.16	15.17 ± 0.14	16.56 ± 0.17	15.62 ± 0.08	15.34 ± 0.09	

Means with the same letter(s) in table are not significantly ( $P \leq 0.05$ ) different by Turkey's test.

**Table 5** Effect of *Prostephanus truncatus* density on the carbohydrate (CHO) content (%) of the substrates after 90 days infestation.

<i>P. truncatus</i> Density	Carbohydrate content (%) (Mean ± SE)							Overall mean
	UMUSP01 Sweet potato	UMUSP03 Sweet potato	UMUCASS Cassava	TME419 Cassava	NCE011 Cocoyam	NCE003 Cocoyam	TDa/98/1168 Yam	
Control	78.77 ± 0.34 <sup>bc</sup>	71.22 ± 0.07 <sup>cf</sup>	80.09 ± 0.04 <sup>ab</sup>	79.24 ± 0.07 <sup>bc</sup>	66.69 ± 0.07 <sup>hi</sup>	65.91 ± 0.19 <sup>ij</sup>	69.52 ± 0.21 <sup>fg</sup>	73.12 ± 0.28
1 pair	73.02 ± 0.05 <sup>de</sup>	66.01 ± 0.78 <sup>j</sup>	78.22 ± 0.15 <sup>b</sup>	78.18 ± 0.11 <sup>bc</sup>	67.34 ± 0.46 <sup>hi</sup>	67.23 ± 0.06 <sup>hi</sup>	73.87 ± 0.18 <sup>d</sup>	71.99 ± 0.24
2 pairs	73.32 ± 0.25 <sup>de</sup>	64.12 ± 0.07 <sup>jk</sup>	77.11 ± 0.10 <sup>c</sup>	79.59 ± 0.58 <sup>ab</sup>	66.81 ± 0.07 <sup>hi</sup>	68.55 ± 0.12 <sup>gh</sup>	71.9 ± 0.09 <sup>d</sup>	71.63 ± 0.25
3 pairs	71.77 ± 0.18 <sup>d-f</sup>	68.49 ± 0.09 <sup>gh</sup>	79.01 ± 0.09 <sup>bc</sup>	81.77 ± 0.06 <sup>a</sup>	65.37 ± 0.05 <sup>ij</sup>	62.82 ± 0.48 <sup>k</sup>	73.1 ± 0.08 <sup>d</sup>	71.76 ± 0.31
Mean (CHO) content	74.22 ± 0.24	67.46 ± 0.25	78.61 ± 0.10	79.70 ± 0.13	66.55 ± 0.08	66.14 ± 0.19	72.20 ± 0.13	

Means with the same letter(s) in table are not significantly ( $P \leq 0.05$ ) different by Turkey's test.

**Table 6** The effect of *Prostephanus truncatus* density on the crude protein (CP) (%) of the substrates after 90 days infestation.

<i>P. truncatus</i> Density	Crude protein (%) (Mean ± SE)							Overall mean
	UMUSP0/1 Sweet potato	UMUSP0/3 Sweet potato	UMUCASS 36 Cassava	TME419 Cassava	TDa/98/1168 Yam	NCE003 Cocoyam	NCE011 Cocoyam	
Control	6.1 ± 0.31 <sup>ij</sup>	9.4 ± 0.04 <sup>d-f</sup>	1.78 ± 0.04 <sup>k</sup>	1.99 ± 0.10 <sup>k</sup>	10.01 ± 0.21 <sup>c-e</sup>	12.2 ± 0.08 <sup>b</sup>	10.7 ± 0.07 <sup>cd</sup>	7.45 ± 0.19
1 pair	7.5 ± 0.07 <sup>g-i</sup>	8.75 ± 0.24 <sup>e-g</sup>	2.5 ± 0.04 <sup>k</sup>	2.06 ± 0.04 <sup>k</sup>	5.88 ± 0.08 <sup>j</sup>	11.18 ± 0.04 <sup>bc</sup>	11.1 ± 0.09 <sup>bc</sup>	6.99 ± 0.17
2 pairs	5.88 ± 0.29 <sup>j</sup>	11.02 ± 0.13 <sup>bc</sup>	1.99 ± 0.20 <sup>k</sup>	1.54 ± 0.07 <sup>kl</sup>	6.99 ± 0.11 <sup>h-j</sup>	9.77 ± 0.04 <sup>c-e</sup>	12.5 ± 0.11 <sup>b</sup>	7.10 ± 0.19
3 pairs	6.76 ± 0.15 <sup>h-j</sup>	8.16 ± 0.12 <sup>fh</sup>	1.61 ± 0.04 <sup>kl</sup>	0.22 ± 0 <sup>l</sup>	5.88 ± 0.08 <sup>j</sup>	14.11 ± 0.45 <sup>a</sup>	12.42 ± 0.04 <sup>b</sup>	7.02 ± 0.23
Mean % CP	6.56 ± 0.07	9.33 ± 0.10	1.97 ± 0.04	1.45 ± 0.07	7.19 ± 0.15	11.82 ± 0.15	11.68 ± 0.07	

Means with the same letter(s) in table are not significantly ( $P \leq 0.05$ ) different by Turkey's test.

**Table 7** Effect of *Prostephanus truncatus* density on the ash content (%) of the substrates after 90 days infestation.

<i>P. truncatus</i> Density	Ash content (%) (Mean $\pm$ SE)							Overall mean
	UMUSP0/1 Sweetpotato	UMUSP0/3 Sweetpotato	UMUCASS Cassava	TME419 Cassava	TDa/98/1168 Yam	NCE003 Cocoyam	NCE011 cocoyam	
Control	1.2 $\pm$ 0.05 <sup>kn</sup>	2 $\pm$ 0.00 <sup>fi</sup>	2.87 $\pm$ 0.18 <sup>bc</sup>	0.7 $\pm$ 0.02 <sup>n</sup>	1.57 $\pm$ 0.02 <sup>ik</sup>	2.57 $\pm$ 0.2 <sup>ce</sup>	2.27 $\pm$ 0.02 <sup>d-g</sup>	1.89 $\pm$ 0.04
1 pair	1.53 $\pm$ 0.04 <sup>li</sup>	3 $\pm$ 0.00 <sup>bc</sup>	2.17 $\pm$ 0.05 <sup>eh</sup>	0.9 $\pm$ 0.04 <sup>mm</sup>	1.8 $\pm$ 0.04 <sup>gj</sup>	2.97 $\pm$ 0.04 <sup>bc</sup>	3.57 $\pm$ 0.10 <sup>a</sup>	2.29 $\pm$ 0.04
2 pairs	1.7 $\pm$ 0.04 <sup>jk</sup>	2.63 $\pm$ 0.05 <sup>a</sup>	2.23 $\pm$ 0.04 <sup>dh</sup>	1 $\pm$ 0.00 <sup>ln</sup>	1.4 $\pm$ 0.03 <sup>im</sup>	3.17 $\pm$ 0.03 <sup>ab</sup>	2.53 $\pm$ 0.13 <sup>c-f</sup>	2.24 $\pm$ 0.04
3 pairs	1.57 $\pm$ 0.02 <sup>ik</sup>	2.97 $\pm$ 0.04 <sup>bc</sup>	1.72 $\pm$ 0.00 <sup>hk</sup>	0.7 $\pm$ 0.02 <sup>n</sup>	1.5 $\pm$ 0.03 <sup>il</sup>	3.13 $\pm$ 0.03 <sup>ab</sup>	2.77 $\pm$ 0.04 <sup>b-d</sup>	2.05 $\pm$ 0.04
Mean % ash content	1.52 $\pm$ 0.02	2.90 $\pm$ 0.05	2.24 $\pm$ 0.04	0.85 $\pm$ 0.01	1.58 $\pm$ 0.02	2.96 $\pm$ 0.02	2.78 $\pm$ 0.05	

Means with the same letter(s) in table are not significantly ( $P \leq 0.05$ ) different by Turkey's test.

**Table 8** Effect of *Prostephanus truncatus* density on the crude fat (%) of the substrates after 90 days infestation.

<i>P. truncatus</i> Density	Fat content (%) (Mean $\pm$ SE)							Overall mean
	UMUSP0/1 Sweet potato	UMUSP0/3 Sweet potato	UMUCASS Cassava	TME419 Cassava	TDa/98/1168 Yam	NCE003 Cocoyam	NCE011 Cocoyam	
Control	0.7 $\pm$ 0.01 <sup>ef</sup>	0.25 $\pm$ 0.02 <sup>gh</sup>	0.31 $\pm$ 0.01 <sup>gh</sup>	0.21 $\pm$ 0.01 <sup>h</sup>	1.9 $\pm$ 0.00 <sup>a</sup>	1.67 $\pm$ 0.01 <sup>ab</sup>	0.07 $\pm$ 0.01 <sup>h</sup>	0.72 $\pm$ 0.03
1 pair	0.93 $\pm$ 0.03 <sup>ce</sup>	0.26 $\pm$ 0.01 <sup>gh</sup>	0.21 $\pm$ 0.00 <sup>h</sup>	1.73 $\pm$ 0.03 <sup>ab</sup>	0.23 $\pm$ 0.0 <sup>gh</sup>	0.31 $\pm$ 0.0 <sup>gh</sup>	1.49 $\pm$ 0.11 <sup>b</sup>	0.74 $\pm$ 0.03
2 pairs	0.83 $\pm$ 0.03 <sup>ce</sup>	0.8 $\pm$ 0.01 <sup>ce</sup>	0.83 $\pm$ 0.0 <sup>ce</sup>	0.31 $\pm$ 0.0 <sup>gh</sup>	0.76 $\pm$ 0.04 <sup>ef</sup>	0.21 $\pm$ 0.0 <sup>h</sup>	0.12 $\pm$ 0.0 <sup>h</sup>	0.55 $\pm$ 0.01
3 pairs	1.06 $\pm$ 0.03 <sup>cd</sup>	0.83 $\pm$ 0.01 <sup>ce</sup>	0.51 $\pm$ 0.07 <sup>fg</sup>	0.23 $\pm$ 0.0 <sup>gh</sup>	0.83 $\pm$ 0.0 <sup>ce</sup>	0.78 $\pm$ 0.0 <sup>d-f</sup>	1.1 $\pm$ 0.03 <sup>c</sup>	0.76 $\pm$ 0.01
Mean % crude fat	0.87 $\pm$ 0.01	0.54 $\pm$ 0.02	0.46 $\pm$ 0.02	0.62 $\pm$ 0.06	0.93 $\pm$ 0.05	0.74 $\pm$ 0.05	0.70 $\pm$ 0.06	

Means with the same letters in table are not significantly ( $P \leq 0.05$ ) different by Turkey's test.

## Discussion

The study showed that *P. truncatus* can survive and breed on all the root and tuber crops tested except on NCE011cocoyam where no *P. truncatus* adult emerged. This ability of *P. truncatus* to breed on sweet potato, cassava and yam corroborates the earlier findings of Osipitan *et al.* (2008) that larger grain borer (LGB) has the ability to breed on the crops. However, inability of *P. truncatus* to breed and survive on cocoyam agrees with the earlier findings by Hill (2002) that *P. truncatus* cannot survive on cocoyam. This assertion is not in agreement with the findings of Osipitan *et al.* (2008) and Isah *et al.* (2009) which indicated the ability of *P. truncatus* to breed on the crop. This may be due to the differences in varieties of cocoyam used in both studies as reported by Zakka (2012) that hybrid maize was more susceptible to *Sitophilus zeamais* when compared to the local varieties. Larger grain borer is a known pest of yam (Akunne 2008), however, very low number of adults (0.22) was

recorded in TDa/98/1168 yam variety, and hence, the variety can be suggested to be resistant to *P. truncatus* infestation. Such resistance was observed by Atijegbe *et al.* (2014) in two varieties of yam (Ame and Adaka) reported as not being at risk of infestation by *P. truncatus*.

In this study, the percentage loss in the roots and tuber crops offered as hosts to LGB ranged from 0.91 in NCE011 cocoyam variety to 21.64 in UMUSP0/1 sweet potato variety within 90 days infestation. This suggests that *P. truncatus* is capable of causing high damage in root and tuber crops in store when left unprotected as earlier reported by Hodges *et al.* (1985), Nansen *et al.* (2015) and Popoola *et al.* (2015) that *P. truncatus* is a highly voracious pest of stored root and tuber crops and that weight loss increased with increasing infestation. The continuous feeding by *P. truncatus* in storage has been implicated as the cause of such weight loss in root and tuber crops (Popoola *et al.* 2015). Low percentage loss observed in cocoyam and yam varieties suggests that the

crops are not suitable hosts to *P. truncatus* and might not support its biological activity. This agrees with earlier reports by Isah *et al.* (2009) and Osipitan *et al.* (2008) who observed minimal weight loss in cocoyam but found sweet potato and cassava as the most preferred host. The high percentage weight loss recorded in sweet potato UMUSP0/1 variety indicates the ability of *P. truncatus* to cause heavy infestation on such products and if left unprotected can result in a 100% destruction of chips when stored longer than 90 days; this was earlier reported by Osipitan *et al.* (2015).

The number of adult *P. truncatus* progeny that developed in the roots and tubers increased with increase in their initial density and further increased as the number of pairs increased to three. This result is at variance with what Osipitan *et al.* (2015) observed with a rapid multiplication of *P. truncatus* in cassava THC from the initial 10 adults to 380.0 in 01/1368 and 277.0 in 92B/00068 of *P. truncatus* adults. Such sharp differences could be attributed to the age of the insect used for the experiment, environmental factors such as temperature and relative humidity and diet since *P. truncatus* has high fecundity and high reproductive ability in preferred host (Tefera *et al.* 2011). Although only few adults emerged from the various host crops evaluated, the relatively low initial numbers of adult *P. truncatus* resulting in higher density is supported by (Chijindu *et al.* 2008) who infested 150g cassava chips with 15 pairs of *P. truncatus* and recorded a higher mean number of up to 407 teneral adults. Test Host Crops infested with two pairs produced larger quantity of powder which implies that the presence of *P. truncatus* even at low population density could be a threat to stored root and tuber crops as earlier reported by Torreblanca *et al.* (1983).

The present work assessed the effect of *P. truncatus* on the nutrient content of dried processed roots and tubers. The result obtained from the proximate analysis revealed that *P. truncatus* affected the moisture content by increasing the overall moisture content of all the root and tuber crops screened. Chinjudu *et*

*al.* (2008) reported no clear relationship between moisture content of Test Host Crops and the reproductive rate of *P. truncatus* and that LGB thrives well in both THC with low and high moisture content. However, it can be deduced that the overall increase in the moisture content of the THC may have attributed to the increased rate of damage of the root and tuber crops evaluated. Such observations agree with the findings of Nwankwo (2013) who opined that moisture content positively influenced the amount of damage to the nutrient value of maize grains in storage and Onyeike *et al.* (1995) that root and tuber crops with low moisture content were less susceptible to *P. truncatus* infestation, although Christain *et al.* (2004) reported that moisture alone cannot explain *P. truncates* reproductive rates on its hosts.

*Prostephanus truncatus* decreased the carbohydrate content of some varieties of root and tuber crops. Positive relationship between carbohydrate contents of root and tuber crops and total adult population of *P. truncatus* was observed. Test Host Crops with high carbohydrate contents had higher infestation level. This suggested that the amount of carbohydrate in sweet potato and cassava might have influenced the damage and survival rate of *P. truncatus* bred on them. This observation agrees with the report of Chijindu and Boateng (2008) who reported the amount of starch in the chips of cassava as a factor that influenced the survival and damage rates of the chips by adult *P. truncatus*. Detmers *et al.* (1993) reported that breeding of *P. truncatus* was dependent on the high starch content of cassava. Oyewole and Odunfa (1989) observed that low starch content in a variety of fermented cassava reduced the population density of insect since the process of fermentation reduces the starch. High starch content of sweet potato and cassava therefore might have affected the oviposition rate of *P. truncatus* and the high adult emergence of *P. truncatus* recorded on TME419 cassava and UMUSP0/3 a variety of sweet potato may therefore be related to their high carbohydrate content as Ajayi (2015) reported that in stored

products such as cereals, starch, energy and non-reducing sugars decrease with increasing infestation.

Crude protein is one method to determine the protein content of a specific food. The overall result on the proximate analysis showed that *P. truncatus* can reduce the protein content of root and tuber crops especially cassava where over 85% reduction was observed after 90 days of infestation. The reduction of crude protein in cassava shows that the presence of *P. truncatus* can reduce the crude protein in those THC considerably. This result agrees with similar observation by Osipitan and Odebiyi (2007) that *P. truncatus* can reduce the nutritional composition of grains infested with *P. truncatus* particularly amino acids, lysine, tryptophan and the level of viability significantly (Ajayi, 2015). Furthermore, the high protein content in an unsusceptible variety like cocoyam which thus far may serve as an inhibitor, may have decreased the performance and feeding of *P. truncatus* on these varieties but this does not agree with the report of Nwanko (2013) who is of the opinion that high protein content in a susceptible variety of maize grain (Western Yellow) may have enhanced the performance and feeding of *P. truncatus*.

Sweet potato, cocoyam and cassava appeared to be very good sources of minerals and the result obtained from this study shows that *P. truncatus* increased the ash content of the different root and tuber crops except for cassava where the ash content reduced as the density of *P. truncatus* increased. The implication of the finding is that crops with high ash content were less susceptible to *P. truncatus* infestation and this result agrees with that of Osipitan *et al.* (2008) that ash and its crude content of the cassava varieties correlated positively with number of dead *P. truncatus* adult in their experiment and further suggested that ash and crude content likely played a key role in the adult mortality.

Crude fat aids digestion, storage and transport of fat soluble vitamins and provides vital fatty acids (Hussain *et al.* 2006) and in this study *P. truncatus* increased the crude fat of

sweet potato and cassava varieties evaluated. The overall proximate analysis showed that *P. truncatus* decreased the crude fat content of root and tuber crops especially yam and cocoyam with over 50% in crude fat reduction after 90 days infestation. It is therefore possible that the increase in crude fat content observed in sweet potato and cassava in this study was obviously beneficial to the insect and could have increased the level of damage by the pest. The reduction in the percentage of crude fat from 1.9 to 0.83 and from 1.67 to 0.78 in yam and cocoyam respectively might have affected the overall performance of the pest where fewer adults emerged from the THC.

## Conclusion

The findings of this study have shown that larger grain borer can breed on sweet potatoes, cassava, yam and cocoyam chips and cause significant damage within short period of infestation if not controlled. The presence of *P. truncatus* even at low population density caused high damage and weight loss in the crops and affected their nutritional composition.

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## تأثیر سوسک دانه خوار بزرگ (*Prostephanus truncatus* (Coleoptera: Bostrichidae) روی ترکیبات غذایی ریشه و غده‌های خشک مواد انباری

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**چکیده:** در این پژوهش تأثیر سوسک دانه‌خوار بزرگ (*Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae) روی ترکیبات غذایی ریشه و غده‌های کاساوا، یام، سیب‌زمینی شیرین و کوکویام در آزمایشگاه در دمای ۲۵ تا ۳۰ درجه سلسیوس و رطوبت نسبی ۷۰ تا ۹۰ درصد بررسی شد. بدین‌منظور ۳۵ گرم از قطعات ریشه و غده‌های کاساوا، یام، سیب‌زمینی شیرین و کوکویام به‌طور جداگانه در ظروف شیشه‌ای به حجم ۹۵۰ میلی‌لیتر قرار داده شد. این مواد توسط یک، دو و سه جفت حشرات بالغ آلوده شدند. این آزمایش در قالب طرح کاملاً تصادفی در ۳ تکرار و در مدت ۹۰ روز انجام گرفت. در پایان آزمایش تعداد حشرات کامل شمارش شد و وزن پودر تولید شده و درصد کاهش وزن مواد انباری تعیین گردید. نتایج نشان داد که اختلاف معنی‌داری میان تیمارها وجود دارد. درصد وزن ریشه در مدت ۹۰ روز به میزان قابل‌توجهی کاهش یافت. در تیمار آلوده‌سازی با ۲ جفت حشره مواد انباری بالاترین رطوبت را داشتند. در تیمار یک جفت حشره کم‌ترین میزان پروتئین به ثبت رسید. درحالی‌که تیمارهای آلوده با ۳ جفت حشره بالاترین درصد چربی را داشتند. تیمارهای شاهد غیرآلوده بیش‌ترین میزان کربوهیدرات را داشتند. نتایج این پژوهش نشان داد که سوسک دانه‌خوار بزرگ به‌عنوان یک آفت مهم امنیت ریشه و غده‌های ذخیره شده در انبار را تهدید می‌نماید. به‌طوری‌که ارزش غذایی ریشه و غده‌ها در انبارهای آلوده *P. truncatus* به‌شدت تحت تأثیر قرار می‌گیرد.

**واژگان کلیدی:** *Prostephanus truncatus*، تجزیه، آلودگی، تراکم آفت، ترکیبات غذایی