



Resistance of Dried Chips of Three Yam Cultivars to Damage by *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae)

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Abstract

Yam (*Dioscorea* spp) is one of the most common tuber crops consumed by man due to its nutritional benefits. Yam tubers are often processed into products like Dry Yam Chips (DYC) to minimize postharvest losses. The crop could be processed into other products to reduce perishability and scarcity at certain periods. The insect is mainly controlled with conventional insecticides. However, use of conventional insecticide in preserving DYC is contentious due to concerns about undesirable effects on consumers. This has necessitated the search for safer and more effective control strategies such as resistance traits that is innate. The study was therefore conducted to evaluate the resistance of three yam species (*Dioscorea cayenensis*, *D. rotundata*, and *D. alata*) used in making DYC to infestation and damage by Larger Grain Borer (LGB). Two hundred (200) g of parboiled DYC were weighed into 250 ml Kilner jars and separately infested with twenty adult LGB of 0-5 days old. The treatments were replicated four times and arranged on the experimental table using Completely Randomized Design (CRD). At 90 days post-infestation, the insects were sieved out to separate insects from DYC. Data were collected on weight loss of DYC, damage to DYC, adult mortality of LGB, dust of DYC, and number of emerged LGB. The percentage damage of LGB to DYC of *D. alata* and *D. rotundata* was 100.00% and 96.43%, respectively, which were not significantly ($p > 0.05$) different from each other. The percentage weight loss (70.61) of DYC of *D. alata* was significantly ($p < 0.05$) higher than the weight loss in *D. cayenensis* (28.63) and *D. rotundata* (46.27). The percent weight loss in the DYC of *D. cayenensis* was significantly ($p < 0.05$) lower than the weight loss in DYC of *D. alata* (70.61) and *D. rotundata* (46.27). The number of adult LGB (539.80) in the DYC of *D. alata* was significantly ($p < 0.05$) higher than the number of the insect in *D. cayenensis* (117.8) and *D. rotundata* (216.80). The number of adult mortality of LGB in the DYC of *D. alata* (38.50) and *D. cayenensis* (21.12) is comparable, but significantly lower than number of adult mortality of the insect in *D. rotundata* (41.50) DYC. The number of the insect larvae in DYC of *D. cayenensis* (4.25) was significantly ($p < 0.05$) lower than the number of the larvae of LGB in DYC of *D. alata* (30.00) and *D. rotundata* (21.00). DYC of *D. cayenensis* and *D. rotundata* were moderately resistant to damage by LGB and could be use in preparation of DYC to mitigate damage of LGB to DYC in storage before use.

Keywords: Dried Yam Chips, *Prostephanus truncatus*, *Dioscorea cayenensis*, *Dioscorea rotundata*, *Dioscorea alata*

INTRODUCTION

Prostephanus truncatus (Horn) (Coleoptera: Bostrichidae), often known as the larger grain borer (LGB), is a destructive insect pest that infests dried cassava chips and maize kept in farms (Hodges, 1986; Boxall, 2002). In Africa, LGB was first identified in 1981 (Dunstan and

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Magazini, 1981; Golob and Hodges, 1982) as the pest causing postharvest losses in agricultural produce in the Republic of Benin (Further, 1986), Ghana (Dick *et al.*, 1989), Guinea (Kalivogui and Muck, 1991), Burkina Faso (Bosque-Perez *et al.*, 1992), Nigeria (Pike *et al.*, 1992), and Malawi (Munthali, 1992). Severe losses were reported in stored maize in Tanzania and Eastern Africa. The insect

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Synthetic pesticides are primarily used to control

insect pests on the field and in storage because of their effectiveness. They are effective, but have drawbacks, such as high cost, environmental persistence, high toxicity to mammals, health concerns, toxic residues on food, negative impacts on non-target organisms and pest resistance (Gamon *et al.*, 2003; Shalaby and Abdou, 2010). These limitations informed search for alternative control options that have little or no harmful effects on the ecosystem, man and mammals. Host Plant Resistance (HPR) is an eco-friendly and relatively cheaper method of insect pest control that depends on the host's natural ability to resist or reduce damage by insect pests. Host plant resistance is easy to apply, relatively cheaper and economical, reliable, environmentally friendly and long-lasting (Throne and Ebubanks, 2001).

Yams are found in the tropics and subtropics and are part of the 600 species that make up the genus *Dioscorea* (Wilkin *et al.*, 2005; Darkwa *et al.*, 2020; Sugihara *et al.*, 2021). Several wild species of yam are valued for their bioactive chemicals that can be used in pharmaceuticals, while eleven species are predominantly cultivated for food and profit (Obidiegwu *et al.*, 2020; Darkwa *et al.*, 2020; Price *et al.*, 2020; Lebot *et al.*, 2022). Yam is an important component of staple food for Nigerians and indigenes of other West African countries. The crop contributes more than 200 calories per person per day for more than 150 million people in West Africa and also provide sustainable income for Africans.

Yam is an attractive crop and is easy to plant and maintain by farmers with limited resources. The crop is rich in starch, available all year round and can be prepared in many ways. These characteristics make yam a preferred food and a

culturally important food security crop in some sub-Saharan African countries

To minimize postharvest loss of yams in storage, they are commonly processed into dried chips (Akissoé *et al.*, 2001; Hounhouigan *et al.*, 2003) that could be milled into yam flour for preparing “Amala” in Nigeria (Akissoe *et al.*, 2003). This research was therefore designed to assess the resistance of three yam species processed into DYC to population build-up and damage by LGB.

MATERIALS AND METHODS

Location of the Experiment

The experiment was conducted in the Research Laboratory of Crop Protection Department, College of Plant Science and Crop Production, Federal University of Agriculture (FUNAAB), along Alabata road, Abeokuta in Odeda Local Government Area of Ogun State, South West Nigeria.

Culture of *Prostephanus truncatus*

Several Larger Grain Borer (LGB), *P. truncatus* were obtained from stocks maintained in the laboratory of the Department of Crop Protection, Federal University of Agriculture, Abeokuta and cultured in the laboratory. The insects were cultured in 500 cm³ Kilner glass jars using dried yam chips as food for the insects. Several adults of LGB mixed sexes and unknown ages were introduced into the cultural media. Frass generated by the feeding activities of the insects was sieved out every week using a 0.25 mm mesh sieve to prevent moisture build up in the product and mould growth. The culture medium was rejuvenated every month to replace depleted ones, and adults were sieved out to set up a new culture to guarantee the regular source of insects (Osipitan, 2011).

Source of yam tubers and processing into yam chips (“Gbodo”)

The three yam species used for the study, namely *D. rotundata*, *D. cayenensis*, and *D. alata*, were sourced from Oke-Ogun in Oyo State and Kaiama in Kwara State. The yam tubers were washed with water, peeled with a knife, and subsequently cut into slices of 10 cm long by 3 cm thickness (Osipitan *et al.*, 2008). The yam chips were placed in a pot containing water drained from fermented maize paste and parboiled at 60°C (about 20 mins) (Achi and Akubor, 2000) and left in the water for 24 h to absorb water and were removed (Akintunde and Ige, 1981). The chips were spread on clean polythene sacks for eight weeks to sun dry them.

to attain a safe moisture content of about 10% (Babajide *et al.*, 2007). The dry chips were collected and kept in polyethylene bags in the laboratory at room temperature. The DYC were sterilized for two hours at 105°C to destroy any hidden insects and their eggs. They were then allowed to cool for an hour at room temperature before use (Oni and Omoniyi, 2012)

Damage assessment of Dried Yam Chips and Adult mortality of Larger Grain Borer

Two hundred (200g) of parboiled dried yam chips were weighed into 250 ml Kilner jars and separately infested with twenty insects of larger grain borer of 1-5 days old. The treatments were replicated four times and arranged on the experimental table using Completely Randomized Design (CRD) for 90 days. The insects were sieved out from the dried yam chips at 90 days after infestation and the following parameters were recorded:

- (i) Number of larvae and adult insects: The number of dead and living larvae and adults of LGB were visually counted.
- (ii) The percentage of damaged chips and percentage weight loss of DYC were calculated as follows:

Percentage of damaged chips =

$$= \frac{\text{Weight of damaged chips}}{\text{total weight of chips}} \times 100 \%$$

% Weight loss of yam chips =

$$\frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100 \%$$

Statistical Analysis

Data collected were subjected to Analysis of Variance (ANOVA) using SAS's General Linear Model Procedure (SAS Institute 2015). Significant means ($p < 0.05$) were separated using the Student-Newman-Kuels Test (SNK). All insect count data were transformed using the square root transformation, and percentage data were transformed using arcsine transformation before subjection to ANOVA.

RESULTS

Percentage damage and weight loss in dried yam chips infested with *Prostephanus truncatus*

The percentage damage of LGB to DYC of *D. alata* and *D. rotundata* was 100.00 and 96.43, respectively, and are not significantly ($p > 0.05$) different from each other. The percentage damage to DYC of *D. cayenensis* by LGB was 80.98, and it was significantly ($p < 0.05$) lower than the percentage damage caused by the insect to DYC from *D. alata* (100.00) and *D. rotundata* (96.43) (Table 1)

The percentage weight loss (70.61) of DYC of *D. alata* was significantly ($p < 0.05$) higher than the weight loss in *D. cayenensis* (28.63) and *D. rotundata* (46.27). The weight loss in the DYC of *D. cayenensis* was significantly ($p < 0.05$) lower than the weight loss in DYC *D. alata* (70.61) and *D. rotundata* (46.27) (Table 1).

Table 1: Mean percentage damage and weight loss in dried yam chips infested with *P. truncatus* for 90 days

Yam Chips	Weight loss (%)	Damage chips (%)
<i>Dioscorea alata</i>	70.61 ± 2.31a	100.00 ± 0.00a
<i>Dioscorea cayenensis</i>	28.63 ± 2.31c	80.98 ± 2.61b
<i>Dioscorea rotundata</i>	46.27 ± 1.20b	96.43 ± 0.20a

Means followed by the same letter along the same column are not significantly different at a 5% level of probability

Adult mortality, number of larvae and number of adult *P. truncatus* emergence in dried yam chips infested with the insect.

The number of adult LGB (539.80) in the DYC of *D. alata* was significantly ($p < 0.05$) higher than the number of insects in *D. cayenensis* (117.8) and *D. rotundata* (216.80). The numbers of the insect in the DYC of *D. cayenensis* and *D. rotundata* are not comparable ($p > 0.05$). The number of adult mortality of LGB in the DYC of *D. alata* (38.50) and *D. cayenensis* (21.12) are comparable and significantly lower than the number of dead LGB in the DYC of *D. rotundata*

(41.50). The number of larvae in the DYC of *D. alata* infested with LGB was 38.50 and comparable ($p > 0.05$) with the numbers in the DYC of *D. rotundata*. The number of larvae in DYC of *D. cayenensis* (4.25) was significantly ($p < 0.05$) lower than the numbers of larvae of LGB in DYC of *D. alata* (30.00) and *D. rotundata* (21.00) (Table 2)

Table 2: Number of adult mortality, larvae and adults of *P. truncatus* in dried yam chips after 90 days of infestation

Yam Chips	Emerged adults	Adult mortality	Emerged Larvae
<i>Dioscorea alata</i>	539.8±0.91a	8.50±0.21c	30.00±1.50a
<i>Dioscorea cayenensis</i>	117.8±1.02c	21.12±2.01c	4.25±0.26b
<i>Dioscorea rotundata</i>	216.8±1.12b	41.50±0.71a	21.00±2.12a

Means followed by the same letter along the same column are not significantly different at 5% level of probability

Rating Scale and resistance rating of dried yam chips cultivar to damage by *Prostephanus truncatus*

A rating scale with a score of 1-5 based on four damage indices (% weight loss, number of adults, % damage, and number of adult mortality) according to Osipitan and Odebiyi (2007) was used to score and rate the DYC for resistance to damage by *P. truncatus* (Table 3).

The weighted average score was used to rate the dried yam chips as resistant, moderately resistant or susceptible (Table 4) (Osipitan and Odebiyi, 2007; Adebowale *et al.*, 2019).

Table 3: Damage Rating of Dried Yam Chips infested by *Prostephanus truncatus*

Range of % weight loss	Rating
0-15	1
15.1-30	2
30.1-45	3
45.1-60	4
60.1-75	5
Range of number of adults	
0 - 110	1
111 - 220	2
221 - 330	3
331 - 440	4
441 - 550	5
Range of % damage	Rating
0 - 20	1
20.1 - 40	2
40.1 - 60	3
60.1- 80	4
80.1 -100	5

Rang of number of adult mortality	Rating
0 - 9	5
9.1 - 18	4
18.1 - 27	3
27.1 - 36	2
36.1 - 45	1

The least range for % weight loss, number of adult insects, and range of % damage have the lowest rating and highest level of resistance. The highest range of mortality has the lowest rating and highest level of resistance.

Resistance rating of dried chips of three yam cultivars to damage by *Prostephanus truncatus*

The dried chips of *Dioscorea alata* were susceptible to infestation by *Prostephanus truncatus*, while those of *D. cayenensis* and *D. rotundata* were moderately resistant to infestation by the insect (Table 4).

Table 4: Resistance rating of dried chips of three yam cultivars to damage by *Prostephanus truncatus*

Yam cultivars	% weight loss	Number of adult	Number of adult mortality	% damage	Weighted average	Resistance level
<i>Dioscorea alata</i>	5	5	1	5	4	Susceptible
<i>Dioscorea cayenensis</i>	2	2	3	5	3	Moderate resistance
<i>Dioscorea rotundata</i>	4	2	1	5	3	Moderate resistance

DISCUSSION

High damage of DYC of *D. alata* by *Prostephanis truncatus* suggests preference of the yam specie for infestation, breeding and damage among others yam species; *D. alata*, *D. cayenensis*, and *D. rotudanta*. Espinal *et al.* (1996) reported the ability of the adult of *P. truncatus* and its larval stages to damage several commodities such as certain roots and tubers, cereals, pulses, cocoa, coffee, groundnuts and wood. Nyakunga (1982) and Osipitan *et al.* (2011) reported the ability of *P. truncatus* to proliferate dried root and tuber crops and cause damage to them. Okeke *et al.* (1989) and Akunne (2008) reported variations in developmental periods of *P. truncatus* in cassava cultivars and linked the variations to variations in the nutritional qualities of the cassava cultivars. The percentage damage of the dried yam chips infested with *P. truncatus*

was total. Giles and Leon (1975) and Hodges *et al.* (1985) reported *P. truncatus* as a very voracious insect pest that can reduce yield in stored maize grains by up to 40% in 6 months and fermented cassava roots by up to 75% in 4 months.

The difference in the damage to the chips of the three yam species by LGB in this study could be attributed to the physicochemical characteristics of the yam species, such as color, smell or texture, physical properties, and yam genetic composition, which can influence the build-up of insect and their mortality.

The dried chips of *Dioscorea alata* were susceptible to infestation by *Prostephanus truncatus*, while those of *D. cayenensis* and *D. rotundata* were moderately resistant to infestation by the insect. In a similar study on the resistance of maize to infestation and damage by *P. truncatus*, Osipitan *et al.* (2015)

screened nine maize varieties to infestation and damage by *P. truncatus* and reported four as susceptible and five as resistant. Painter (1958) defined resistance as the relative amount of heritable quality possessed by a plant and on the basis of which the is able to influence the ultimate degree of damage by insect. In 1965, Beck defined HPR as the collective heritable characteristics possessed by a plant species, race, clone to reduce the probability of successful utilization of plant as a host by an insect spp, race or biotype.

In this study, the number of adult progenies from DYC of *D. cayenensis* and *D. rotundata* was relatively lower, which suggests resistance. Onzo *et al.* (2015) reported that a resistant yam landrace is expected to have a relatively lower number of adult progenies than a susceptible landrace. The relative resistance of *D. cayenensis* and *D. rotundata* in this study suggests possible presence of toxic substances that caused the yam species to be resistant. This may be due to the effects of the toxic substances that caused adverse effect on the survival, growth and ultimately cause the death of the LGB as a result of feeding on the yam. Antibiosis involves presence of toxic or other antibiotic agents in a resistant variety. Nutritionally, the varieties may also lack important nutrients such as essential amino acid, potassium, vitamin B6, manganese, thiamin and dietary fiber or specific sterols required for the survival, growth and development of the insect. The genetic diversity in the yam varieties could be explored to develop yam cultivars that are resistant to infestation and damage by insect pests of dried yam chips.

Dried yam chips from *D. rotundata* and *D. cayenensis* yam species are moderately resistant to infestation by the LGB. They can be used to process DYC to reduce pest damage and preserve DYC in storage.

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