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Full Length Research Paper

The effect of processing method of cassava chips on the development of *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae)

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Susceptibility of processed cassava chips to infestation by the Larger Grain Borer, *Prostephanus truncatus* (Horn) was investigated in the laboratory (25 - 34°C, 61 - 92% r. h and 12 h: 12 h light: dark regime). Chips of two varieties were variously processed by fermentation, parboiling and sun-drying and stored for different periods. About 150, 200 and 300 g of processed cassava chips in Kilner jars were artificially infested with 15 pairs of *P. truncatus* adults and stored for 49, 59 and 69 days respectively. Significant differences (P < 0.05) were observed in the mean numbers of adults recorded on the processed chips after 49 days of storage. Across varieties, fermented chips recorded the highest number of adults (407.0 ± 53.9), followed by 395.9 ± 34.5 and 351.0 ± 42.1 adults found on plain and sun-dried chips, respectively. Parboiled chips however supported the lowest number of adults (89.0 ± 16.4). The number of *P. truncatus* adults increased with increasing storage period on all chips. The overall mean weight loss recorded on plain, sun -dried and fermented chips were 71.5 ± 7.7%, 71.2, 6.7% and 71.7± 8.8% respectively after 69 days of storage by which time most of the chips had disintegrated completely. The lowest amount of loss, 20.9 ± 5.0%, was recorded on parboiled chips. The study showed that the practice of parboiling confers greater protection to cassava chips against infestation and losses due to *P. truncatus* than the other traditional fermentation and sun-drying methods.

Key words: *Prostephanus truncatus*, cassava chips, processing, susceptibility, Ghana.

INTRODUCTION

Cassava, *Manihot esculenta* (Crantz), is an important root crop in several parts of Africa but has a few major limitations as a food crop including the presence of toxic cyanoglucosides and the rapid perishability of the root tubers. The roots deteriorate quickly from the internal heat generated from high respiration rate of the tissues (Ikujenlola and Opawale, 2007) and subsequent infection and rotting by microbes. Processing the roots by chipping and drying has become one of the ways of adding value, reducing the cyanogenic glucoside content (Jakubczyk, 1982) and improving its storage (Westby, 2002). A range of traditional processing techniques has been developed for the tubers in cassava producing countries around the world. For instance, in Nigeria and Tanzania, cassava chips are usually fermented prior to sun-drying (Hodges et al., 1985; Oyewole, 1992), while in Ghana, the chips are usually sun-dried without prior submerged fermentation (Nicol, 1991; Stumpf, 1998). However, in parts of India, the chipped cassava is parboiled to gelatinize the texture before drying (Rajamma et al., 1994). These methods of processing the chips from root and tuber crops have been found to influence the amount of losses experienced in storage and other indices of susceptibilityto insect attack. Nwana and Azodeh (1984) showed that the intensity of damage by the coffee bean weevil, *Araecerus fasciculatus* (Degeer) to yam chips blanched before drying were low. Similarly, parboiled

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cassava chips have been reported to suffer lower damage by *A. fasciculatus* than plain sun-dried chips (Rajamma and Premkumar, 1993, Rajamma et al., 1994). In Tanzania, Hodges et al. (1985) observed that *Prostephanus truncates (Horn) (Coleoptera: Bostrichidae)* caused greater weight losses to fermented cassava chips than the unfermented chips. In similar studies in India, Rajamma et al. (1996) found that not fermenting cassava chips reduced infestation by *A. fasciculatus*.

However, susceptibility of cassava chips to insect attack varies not only with the postharvest processing method but also with the varietal characteristics of the produce. A number of parameters have been used to evaluate susceptibility of crops to insect infestation in several stored products. These include percentage of damaged produce, weight loss, total progeny production and weight of the F1 progeny. Widstrom et al. (1972) evaluated these parameters for their efficiency and adaptability, and found that total progeny rated comparably to any of the other parameters while weight loss was the best economic indicator for susceptibility.

Since its introduction into West Africa, dried cassava alongside maize has been most attacked by *P. truncatus* (Borgemeister et al., 1997). In Ghana for instance, Stumpf (1998) reported weight loss of between 39 and 50% in cassava chips stored for 8 weeks due to *P. truncatus* infestation. In another survey carried out in the Northern Ghana, Entsie and Ofosu (2001) reported a loss of about 25% of stored “Kokonte” (sundried cassava chips) due to *P. truncatus* attack. Helbig and Schulz (1996) also recorded a 75% loss of chips after 8 – 12 weeks of storage in Togo as a result of infestation by this insect.

There is a dearth of information on the effectiveness of the different traditional processing methods in protecting cassava chips during storage in many cassava producing countries in Africa. Against this background, the present study was aimed at evaluating the effectiveness of different traditional processing methods in conferring protection to cassava chips against storage pests.

MATERIALS AND METHODS

The investigations were carried out in the laboratories at the Plant Protection and Regulatory Services, Pokuase, near Accra, Ghana.

Culture of experimental insect

P. truncatus used in the study was a strain collected from Agricultural Research Station, Kpeve in the Volta Region, Ghana. They were subsequently cultured on dried cassava chips for 3 months. The newly emerged adults of the pest were used for the study.

Processing of cassava chips

Two cassava cultivars, Afisiafi (an improved variety) and Yebesi (a local variety) were collected from one year- old farms at Pokuase. The tubers were peeled, cut into chips of approximately 3 x 3 x 1 cm and were subjected to four different processing methods prior to drying. These were; fermentation by soaking chips in water for 48 h (Diop, 1998); parboiling for two minutes at the boiling point of water (100^{o} C) with continuous stirring of the mixture. The ratio of cassava chips (kilogram) to volume of water (liters) used was 1:3 w/v (modification of method by Rajamma et al., 1994). The other methods included sun drying chips for 48 h then heating them in an oven at 70^{o} C, and the last batch of the chips were dried immediately after peeling in the oven at 70^{o}C without any pre-treatment. The dried samples were later conditioned for 2 weeks in a room before they were used. This was done to equilibrate the chips with the experimental room conditions (Helbig and Schulz, 1996).

Laboratory trials

Fifteen pairs of newly emerged, unsexed adult *P. truncatus* were used to artificially infest 150 g of cassava chips in glass jars for 49 days trial, 200 g for 59 days and 300 g for 69 days. The glass jars were covered with heavy duty wire gauze to ensure ventilation. Each treatment was replicated four times and the climatic room conditions recorded during the trials was 25 - 34^{o}C and 61 - 92% relative humidity. At the end of each experimental period, susceptibility of cassava chips to *P. truncatus* attack was assessed based on the total adult population count, percent weight loss and weight of frass produced. The weight loss was determined by sieving the contents of the jars with sieve of 3.2 mm mesh. The pieces which remained on the sieve were weighed and the weight difference from the original weight classified as loss. The fractions passing through the sieve classified as insect frass, and were also weighed. The numbers of both dead and newly emerged adults were counted.

Insect development

Twenty newly emerged, unsexed adults of *P. truncatus* were placed inside each of Petri- dishes containing 30 g of each processed chips of the two cultivars. They were allowed to lay eggs for one week after which they were removed. The samples were kept on a laboratory bench at room temperature of 25 - 34^{o}C and 61 - 92% RH for emergence of F1 adults. The newly emerged adults were counted daily and removed. The minimal time needed for insect development was calculated from the third day after insects were added until the first day of emergence (Rajamma et al., 1994). The weights of three newly emerged F1 adults were also taken using a sensitive Mettler balance (Model: Kern 870).

Data analysis

Data collected on insect numbers were log transformed using $\log_{10}(x+1)$. Dry weight loss was calculated with the formula: *dry weight loss = (wtloss *(100 – mc)/100*), where *mc* is the percentage moisture content of the chips, *wtloss* is weight loss calculated on wet basis. The percentage dry weight loss was then transformed using arcsine. Data were analyzed with analysis of variance (ANOVA) model in StatView for Windows v5.01 (SAS Institute Inc. Cary, NC, USA) statistical package at 0.05 -level. Means were separated using Fisher’s protected LSD.

RESULTS

The development of *P. truncatus* was strongly influenced by the method of processing and the variety of cassava (Table 1). Significant differences ($P < 0.05$) were observed in the mean numbers of adult of *P. truncatus*

Table 1. Mean (± s.e) number of *P. truncatus* adults recorded on processed chips of two cassava varieties at three storage periods.

Processed chips	Length of storage (days)		
	49	59	69
Plain	395.9 (± 34.5) b	463.0 (± 46.4) b	499.6 (± 48.1) b
Parboiled	89.0 (±16.4) a	166.0 (± 36.0) a	220.6 (±48.6) a
Sundried	351.0(±42.1) b	415.4(±48.7) b	533.3(±43.4) b
Fermented	407.0(± 53.9) b	435.8(± 65.8) b	619.9(± 74.5) c
Variety			
Afisiafi	119.2(± 62.0) a	214.8(± 57.5) a	259.0(±89.0) a
Yebesi	183.4(± 89.8) b	326.7(±80.5) b	390.7(± 85.1) b

Means followed by the same letter in a column are not significantly different from each other (P > 0.05) by LSD.

Table 2. Mean (± s.e) dry weight loss (%) of processed cassava chips of two varieties due to *P. truncatus* infestation at three storage intervals.

Processed chips	Length of storage (days)		
	49	59	69
Plain	63.4 (± 10.3) b	68.2 (± 8.8) b	71.5 (± 7.7) b
Parboiled	13.0 (± 3.2) a	19.3 (± 9.5) a	20.9 (±5.0) a
Sundried	56.0(±7.7) b	59.9(±7.4) b	71.2(±6.7) b
Fermented	59.4(± 9.2) b	64.5(± 10.2) b	71.7(± 8.8) b
Variety			
Afisiafi	31.4(± 4.6) a	33.2(±4.6) a	40.8(±4.1) a
Yebesi	69.6(±3.8) b	73.3(±3.3) b	75.5(± 2.3) b

Means followed by the same letter in a column are not significantly different from each other (P > 0.05) by LSD.

recorded among the processed forms. Across varieties, fermented chips recorded the highest number of adults, (407.0 ± 53.9) while parboiled chips supported the lowest number of adults (89.0 ± 16.4). The population of the borer gradually increased with storage duration on all types of chips. At 69 days of storage, fermented chips had the highest number of adults (619.9 ± 74.5) . More adults were found on the local Yebesi variety than on the improved Afisisafi variety. Significant interaction (P<0.05) of variety and processing methods was observed.

The increase in number of adult *P. truncatus* had influenced the extent of losses on the chips (Table 2). Highest amount of loss, (71.7 ± 8.8%) was recorded on fermented chips while the parboiled chips had the lowest loss of (20.9 ± 5.0%) at the end of the 59 days. The interaction between variety and processed forms was also significant (P<0.05) with fermented Yebesi sustaining the highest weight loss of 75.5 ± 2.3% at which time most of the chips had already disintegrated.

The insects produced a lot of frass by boring into the cassava chips (Table 3). The amount of frass produced from plain chips after 59 and 69 days of storage were 116.8 ± 15.0 g and 128.0 ± 24.7 g, respectively. This was significantly (P < 0.05) lower on parboiled chips where only 27.5 ± 6.0g and 44.3 ± 11.0g of dust were produced respectively.

The mean developmental period of *P. truncatus* and the weight of the newly emerged adults are shown in Table 4. The developmental period of the *P. truncatus* on ranged between 36 - 37 days with no significant diffe-rences (P > 0.05) among the differently processed forms. The mean weight of F1 progeny was significantly higher (P< 0.05) on parboiled chips (3.45 ± 0.04 g) than on the rest.

DISCUSSION

Processing fresh cassava roots into dry chips does not usually aim at reducing their susceptibility to storage insects but rather to increase the shelf life of the roots, improve palatability and reduce their cynogenic potential (Coursey, 1982; Knoth, 1993). However, the quality of food material produced after the processing, plus the length of time the chips are stored allow stored product insect pests to infest, consume and damage them. So

Table 3. Mean (± s.e) weight (g) of frass (g) produced by *P. truncatus* adults from processed chips of two cassava varieties at three storage periods.

Processed chips	Length of storage (days)		
	49	59	69
Plain	93.0 (± 9.9) b	116.8 (± 15.0) b	128.0 (± 24.7) b
Parboiled	15.2 (±3.4) a	27.5 (± 6.0) a	44.3 (±11.0) a
Sundried	79.3 (±12.9) b	102.6 (± 15.9) b	155.2 (±23.4) b
Fermented	86.5 (±13.6) b	96.1 (± 18.4) b	165.6 (±22.2) b

Means followed by the same letter in a column are not significantly different from each other (P > 0.05) by LSD.

Table 4. Developmental period and weight of F1 adults of *P. truncatus* on processed cassava chips.

Processed chips	Mean (± s.e) Developmental period (days)	Mean (± s.e) Weight of F1 adults(mg)
Plain	36.3 (± 0.5) a	2.69 (±0.11) a
Parboiled	37.0 (± 1.0) a	3.45 (± 0.04) b
Sundried	36.4 (± 0.9) a	2.59 (±0.19) a
Fermented	36.0 (± 0.2) a	2.58 (± 0.18) a

Means followed by the same letter in a column are not significantly different from each other (P > 0.05) by LSD.

that if the processing methods could in themselves serve to prevent or reduce insect damage of the chips in storage, then those methods should be evaluated and adopted.

Among the differently processed chips evaluated in this study only those produced from parboiling were found to offer some amount of protection to the cassava chips from *P. truncatus* damage. The general performance of parboiling in conferring protection to the cassava chips against *P. truncatus* was observed in relation to the low numbers of adults recorded, low weight loss and low weight of dust produced. Generally, when chips are parboiled the starch granules in the cassava mass exposed to heat gelatinize (Tran et al., 2007) and later harden up after drying (Knoth, 1993). This substrate hardness, according to Li (1988), affects adults of *P. truncatus* in their selection of host commodities for breeding. However, the relatively soft, smooth and less dense texture of fermented, plain and sun-dried chips enhanced the boring and oviposition activities of the insect and subsequently increased weight losses. But, the effect was not varietal. Although the improved variety performed better than the local variety in terms of percent weight loss sustained and F1 progenies developed from the chips, the significant interaction between processed form and variety observed indicates that the varietal characteristics of cassava may have influenced the quality and performance of the processed chips differently.

In Ghana, common method of processing cassava chips is sun drying (Nicol, 1991; Westby and Gallat, 1999) and the destructive potential of *P. truncatus* to sundried cassava chips was very high, confirming earlier works by Compton et al. (1993), and Entsie and Ofosu (2001) in Ghana and Wright et al. (1993) in Togo. Indeed weight losses in excess of 70% were recorded in the fermented, sundried and plain processed chips after just 69 days. .The damaging activities of *P. truncatus* could also be seen from enormous amount of frass produced from other processed chips compared to the significantly lower frass quantity generated from parboiled chips.

The effectiveness of parboiling in suppressing the population of *P. truncatus* when breeding on dried cassava chips was similar to that observed by Rajamma et al. (1994) and Helbig and Schulz (1996). Traditionally, small-scale farmers in India have successfully stored the cassava chips after parboiling with relatively low amount of losses to insects even without the use of chemical protectants (Rajamma et al., 1994).

The developmental period of 36 - 37 days recorded in this study was shorter than the 43.1 days found by Nyakunga (1982) on blocks of dried cassava under similar environmental conditions. The similarity of developmental periods of *P. truncatus* progenies from the different processed forms suggests small nutritious differences among the chips (Li, 1988). However, offspring body weight at emergence from parboiled chips were higher than those from other processed forms contrasting with observations in maize by Li (1988) that offspring from softer varieties were significantly heavier than those from harder varieties. In softer substrates, developing larvae could mobilize more feeding resources leading to heavier body weight. But according to Smith and Leselles, (1985) substrate hardness increases tunneling cost and subsequently reduces egg production by female insects. Thus, reduced clutch size (that is, number of eggs per unit weight of substrate) would reduce larval competition and increase offspring body weight at emergence (Gutierrez, 1992).

The study showed that parboiling of cassava chips before drying could be an important way of reducing damage caused by *P. truncatus* to dried cassava chips. If this method of processing chips before drying is acceptable to African farmers it could greatly reduce the insect infestation and concomitant damage to cassava chips in several cassava processing areas.

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