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Effect of Nutritional Content of Processed Cassava Chips on Development of *Prostephanus truncatus* (Horn)

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Abstract: Samples of four differently processed cassava chips of two varieties were analysed for their chemical contents. Thereafter, they were infested with adults of *Prostephanus truncatus* at temperature of 25-34°C and relative humidity of 61-92% and studied for their susceptibility to pest in storage. The processed chips differed in their overall chemical contents and their responses to *P. truncatus* attack were significantly different ($P<0.05$). The beetles performance and overall development was high on fermented cassava chips which had highest pest population density (619.9±74.5) and suffered the greatest weight loss (71.7±8.8) than on parboiled chips with population density of (220.6± 48.6) and loss of (20.9±5.0). Correlation analysis between the biology of the pest and the chemical composition of the chips showed that association between the starch and population density of the pest was positive and significantly high ($r = 0.71$, $P<0.05$). Weight loss due to insect feeding also showed significant association with the starch content of the cassava chips ($r = 0.82$, $P<0.05$).

Key words: *Prostephanus truncatus* · nutritional content · processing · cassava chips · parboiling

INTRODUCTION

Cassava, *Manihot esculenta* (Crantz) constitutes the major source of dietary energy for over 500 million people in the world [1]. In Africa, it is mostly used for human consumption and commercially for the production of animal feed and starch-based products [2]. Cassava is primarily a source of carbohydrate and contains very little fat or protein. In fact, its protein content is said to be the lowest among the root crops. On the other hand, it is relatively rich in calcium and ascorbic aid [3].

The extreme perishability of cassava roots stimulated the development of a range of processing techniques even by the earliest Amerindians cultivators of the crop more than 4,000 years ago [4]. Processing is therefore indispensable to facilitate preservation, improve palatability and product quality as well as reduce cyanogenic glucoside toxicity. The production of cassava chips therefore, is the simplest way of obtaining a product which can be stored and reduce losses.

However, processing of chips depends on the cassava type used. Chips obtained from bitter cassava varieties are soaked in water after peeling for one to three days, either before or after the chipping operation during which some fermentation takes place that gives the chips a sour flavour preferred by some consumers [5]. This type fermentation affects the nutrient content of cassava roots [6]. Also, chips may be parboiled to improve their storage ability due to partial gelatinization of starch and to reduce their susceptibility to infestation [7].

Consequently, processed products are essentially inert and storage losses result from the activities of external factors, rather than endogenous process, in contrast to the situation with fresh cassava. The principal cause of postharvest losses during chip storage is infestation by insect pests [4]. *P. truncatus* has been found to among the most damaging insect pests of stored cassava chips in Africa since its accidental introduction in the early 1980's [8, 9].

Activities of these insects during storage are often accompanied by detectable changes in vital nutrients such as starch, sugars, fibers, vitamins and other chemical constituents. For instance, in grains, Pingale *et al.* [10] reported that the reduction in the amount of thiamine in chickpeas and green gram infested with *Callosobruchus maculatus* (F) is roughly proportional to the amount of pest damage. Also, the amount of caffeine in kola-nuts infested by kola weevils, *Balanogastris kolae* and

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Sophrorhinus sp. decreased with increasing level of infestation [11]. This suggests that there exits some relationship between the nutritional composition of food crops and the pest damage. Unlike in fresh cassava roots, where successful relationships have been established between the development of *Phenacoccus manihoti* [12] and biochemical basis for susceptibility, little or no information is available on dry cassava chips. The objective of this study therefore was to determine the influence of major nutrients present in differently processed cassava chips on development of *P. truncatus*.

MATERIALS AND METHODS

The investigations on damage were carried out in the laboratory at the Plant Protection and Regulatory Services, Pokuase, near Accra, Ghana. Proximate analysis was conducted at Ecological laboratory, Nutrition and Food Science laboratory and Department of Biochemistry, University of Ghana, Legon, Accra Ghana.

Processing of cassava chips: Two cassava cultivars, Afisiafi (an improved variety) and Yebesi (a local variety) were collected from one year-old farms near Accra. The tubers were peeled, cut into chips and were subjected to four different processing methods prior to drying. These included fermentation by soaking in water for 48 hours [5] parboiling in water for 2 minutes at 100°C with continuous stirring of the mixture. The ratio of cassava chips (kilogram) to volume of water (litres) used was 1:3 w/v (modification of method by Rajamma *et al.* [13]). The other processing methods were sun-drying of chips for 48 hours and later heating in an oven at 70°C for 3 hours to kill any insects that might have infested the chips during sun-drying. The last batch of the chips was those dried in the oven at 70°C for 48 hours immediately after chipping without any treatment. All the processed chips were used for both chemical analysis and artificial infestation of the chips to determine damage and loss due *P. truncatus*.

Proximate analysis: A representative sample of the processed chips was milled into powder and used for chemical analysis of starch, crude fiber, reducing and non-reducing sugars, ash, fats and moisture content, using the methods for assessing quality characteristics of Non-Grain Starch Staples describe by Bainbridge *et al.,* [14]. Three hundred grammes of the remaining samples were weighed into glass vials and later infested with thirty 1w old adults of *P. truncatus*. Each treatment was replicated four times and then allowed to stand for 69 days on the laboratory bench. Infestation rate was assesses based on the adult numbers and weight loss.

***P. truncatus* development on processed chips:** The developmental period of the insect was also studied at temperature range of 25-34°C and humidity of 61-92%. Twenty adults of *P. truncatus* were placed onto Petri-dishes containing 30g each of the processed chips of the two varieties. The Petri-dishes were covered with Petri-dishes of equal sizes. The insect were allowed to lay eggs for one week after which the adults were removed and the samples kept for emergence of new adults. The minimal time needed for insect development was calculated from the third day after insect release until the first day of emergence [13]. The mean weights of the newly emerged F1 adults were also taken using a sensitive Mettler balance (model KERN 870). The developmental period of the insects and the weights of the F1 adults were used to assess infestation rate on the processed chips of the two varieties.

RESULTS AND DISCUSSION

The infestation level of processed chips pooled across varieties is shown in Table 1. The fermented cassava chips recorded adult population density of 619.9±34.5 and weight loss of 71.7±8.8 compared to parboiled chips with adult density of 220.6±28.6 and weight loss of 20.9±5.0. The chemical and physical factors of the chips combined may explain why parboiled chips experienced the lowest *P. truncatus* number. The relatively lower starch content in parboiled chips of the two cassava varieties (Table 2) and hard texture of the parboiled chips may have played a significant role. Although the starch content in the fermented chips also reduced possibly due to fermentation [6], the texture was soft enough to permit easy boring by the pest. In maize for instance, Howard [15] and Li [16] reported oviposition rate was reduced when *P. truncatus* was maintained on flinty and popcorn maize varieties. Li [16] further explained that this was due to the higher energy cost of tunneling the harder maize since the females had to lay eggs in blind-ending tunnels, thereby leading to reduced fecundity and reduced population size. This suggests that in parboiled chips conditions are less favourable for higher oviposition, larval development and survival of the adults. The lowest number of adults of *P. truncatus* was recorded on parboiled chips confirmed the protective role of the gelatinized chips [17]. Also, *P. truncatus* produced a lot of dust by boring into the cassava chips.

Table 1: Infestation level of *P. truncatus* across four processed chips of the two varieties

Processed form	Population density	Weight loss (%)	Developmental period (Days)	F1 weight (mg)	Frass (g)
Plain	499.6±28.1b	71.5±7.7b	36.3±0.5a	2.69±0.11a	128.0±24.7b
Parboiled	220.6±28.6a	20.9±5.0a	36.3±0.5a	3.45±0.04b	44.3±11.0a
Sundried	533.3±23.43b	71.2±6.7b	36.4±0.9a	2.59±0.19a	155.2±23.4b
Fermented	619.9±34.45c	71.7±8.8b	36.0±0.2a	2.58±0.18a	165.6±22.2b

Means of four replicates (±s.e)

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

Values are pooled across varieties

Table 2: Nutritional composition of four processed cassava chips of two varieties (%)

Processed form	Reducing sugar	Non-reducing sugar	Starch	Crude fiber	Protein	Ash	Moisture content	Fats
Afisiafi								
Plain	3.41	3.97	82.62	1.61	1.49	2.57	9.30	0.50
Parboiled	7.13	0.98	76.28	1.41	1.23	2.62	8.00	0.60
Sundried	2.36	3.40	83.12	1.78	1.64	2.82	8.60	0.60
Fermented	4.69	2.87	76.82	1.68	1.52	2.18	8.75	0.43
Yebesi								
Plain	2.78	3.17	84.66	1.54	1.27	2.30	8.95	0.75
Parboiled	7.13	0.44	79.82	1.56	1.25	2.04	8.65	0.83
Sundried	2.14	3.44	84.53	1.69	1.36	2.46	9.20	0.75
Fermented	3.83	2.48	78.75	1.86	1.08	1.76	9.25	0.45

Table 3: Relationship between insect infestation level and chemical composition of processed cassava chips

	Chemical composition of processed cassava chips							
Infestation level	Reducing sugar	Non-reducing sugar	Starch	Crude Fiber	Protein	Ash	Moisture content	Fats
Density	-0.69*	0.53*	0.71*	0.77*	-0.16ns	0.53*	0.83*	-0.12ns
Dev period	0.31ns	-0.19ns	-0.23ns	-0.56*	-0.18ns	0.20ns	0.67*	0.16ns
Adult wt	0.81*	0.89*	-0.43ns	-0.62*	-0.31ns	-0.06ns	0.70*	0.53*
Wt loss	-0.78*	0.59*	0.82*	0.63*	-0.17ns	-0.38ns	0.80*	0.03ns

Correlation coefficient (r): ns=not significant or * =significant at α level 5%. Means of four replicates

Note: Density = Adults Numbers, Dev period = Developmental period, adult wt =F1 adult weight, Wt loss= Weight loss

Significantly large amount of frass was produced on plain, sundried and fermented chips (P<0.05) compared to the amount produced on parboiled chips. The smooth structure of these processed chips and lack of protective covering both favoured the boring activity of the pest and consequently high frass production.

Also, the developmental period of the insect was longer (37.0±1.0 days) on parboiled chips than other processed cassava chips. Hence, the weight of F1 adults (3.45±0.04) mg that emerged from the parboiled chips was also larger than in the other processed forms (Table 1). However, the longest developmental period of the pest on parboiled chips also suggests that the gelatinized texture of the chips may have prevented the tunneling ability the insect [16]. This may have resulted in the late deposition of eggs in the tunnels and subsequent longer developmental period [15]. Also, the F1 adult weight was significantly higher (P<0.05) on parboiled chips than other processed chips. This could be attributed to high sugar content in the parboiled chips.

Correlation analysis between the population parameters of the pest and the chemical composition of the chips showed that association between the starch and population density of the pest was positive and significantly high (r = 0.71, P<0.05) (Table 3). This supports the assertion by Detmers *et al.* [18], Wright *etal.* [19] and Scholz *et al.* [20] that *P. truncatus* breeds well in products with high starch content. Weight loss due to insect feeding also showed significant association with starch content (r = 0.82, P<0.05). This result suggests that the amount of starch in the chips might influence the survival and damage of the chips by adults of *P. truncatus*. The observation by Detmers *et al.* [18] that possibility of breeding by adults of *P. truncatus* was dependent on the highest starch content in the wood of *Manihot esculenta* verifies this finding. There was also positive and significant association between the crude fiber contents of the cassava chips and insect population density and weight loss (Table 3). The association between starch, developmental period and F1 adult weights was negative and not significant.

The moisture content of the chips within the range of 8.0-9.3 (Table 2) correlated positively and significantly influenced the population density, developmental period, F1 adult weights and weight losses (Table 3). It is, however, obvious that *P. truncatus* is a species that can thrive at both low and high moisture levels. Haines [21] found that maize grains at moisture content of 10.6% and 90% r.h were heavily infested by *P. truncatus*. In addition, Hodges *et al.* [22] observed that *P. truncatus* thrives on maize at low moisture content in a field study. It is therefore possible that the level of moisture content observed in this study were obviously beneficial to the insects and could have affected the susceptibility to damage by the pest. Also, reducing and non-reducing sugars significantly correlated with all the population parameters of the pest (Table 3). Similar trend was also observed in crude fiber and ash content of the processed chips and population parameters of the pest.

This study established that food value of the cassava chips affected, to a large extent, the biological performance of the pest. Efforts should be made to explore the biochemical basis of the susceptibility for effective control of the pest.

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