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Insect Pests Infestation and Economic Analysis of Insect Damaged Cassava Chips at Storage

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Abstract

A study was conducted in Nasarawa State of Nigeria with a random sample of 70 cassava traders in the year 2004. 100g of sub-sampled dried chips were collected from both old and new stocks of dried cassava chips. Also, a structured questionnaire was used to examine the cost implications of insect pests' infestation on damaged dried cassava chips. Results showed that three primary pests; Lasioderma serricorne, Rhyzopertha dominica *and* Dinoderus minutus *constituted 55 percent while four secondary pests comprising of* Tribolium castaneum, Cryptolestes ferrugineus, Liposcelis bostrychophilus *and* Sitophilus zeamais *constituted the remaining 45 percent of the total number of insects collected. Estimation of the economic loss on dried cassava chips revealed that about 76 percent of loss in value of the stored cassava chips could be attributed to insect pests damage. The loss in value due to insect pests infestation also accounted for 31 percent of the marketing cost for the damaged cassava chips. This is an indication that improved and appropriate processing and storage technologies are required for cassava chips productions and storage in Nigeria.*

Keywords: Economic loss, dried cassava chips, storage, insect infestation.

Introduction

Cassava (*Manihot esculenta* Crantz) is a commonly grown crop in the humid tropics where its storage roots are an important source of high-energy food. In Nigeria, cassava is widely consumed in various forms as fermented and partially gelatinized fried flakes (gari), fermented sun-dried and ground flour (lafun) and as fermented mash (fufu) (Oyenuga 1968). The leaves which are also eaten are very rich in protein, minerals and vitamins and most essential amino acids except methionine and phenylalanine (Ravindran and Ravindran 1988).

In many zones, cassava is gradually replacing more traditional crops due to the ease of its production, drought resistance and ability to thrive in nutrient-poor soil (Aalbersberg and Limalevu 1991). Cassava consists of 60 to 70% water, hence, processing it into a dry form reduces the moisture content and converts it into more durable and stable product with less volume which makes it more transportable (IITA 1990). Processing is also necessary to reduce both the cyanide content and post harvest loss of fresh tubers.

In the recent times, there has been a profound interest by the Federal Government of Nigeria in broadening the awareness of farmers towards increased production of cassava. The increase in production might encounter a setback due to post harvest losses associated with poor processing and storage facilities. Cassava chips are commonly stored as sun-dried chips in the open or by using artificial dryers before storing at about 13% moisture content (Parker and Booth 1979). There are reports indicating that the method of storing cassava has a profound effect on the rapid deterioration of cassava roots as well as influence the rate of insect pest infestation (Ingram and Humphries 1972). About 36 species of microorganisms have been isolated from damaged cassava roots (Plumbley and Rickard 1991) while about 15 insect species have been reported infesting cassava chips in storage (Ingram and Humphries 1972).

In the study area (Nasarawa State of Nigeria), dealers in dried cassava chips procure their merchandise from growers who prepared the chips in their farms some distance away from the point of sales to the dealers. At times, the cassava chips are purchased partially dried and may necessitate further drying before bagging. The chips are generally heaped together in the open irrespective of the source and pre-treatment condition(s) given to the chips by the growers before the dealers purchased them.

This mode of heaping together dried cassava chips in the open before bagging further exacerbated pest infestation in storage and growth of microorganisms as a result of improper drying. This study reports the effects of insect pests infestation and the economic loss that cassava chips dealers suffer as a result of improper handling and processing of the cassava product.

Methodology

A survey of storage insect pests of dried cassava chips and potential economic loss of the chips was conducted in February and March, 2004 in the cassava-producing zone in Nasarawa State of Nigeria. The zone comprises seven Local Government Areas (LGAs) namely; Awe, Doma, Keana, Lafia, Nasarawa-Eggon, Obi and Wamba. Ten dealers in dried cassava chips were randomly sampled in each local government area, giving a total of 70 cassava traders. The number of dealers thus formed the number of replicates of samples in each LGAs.

The study used mainly primary data which where collected by administering structured questionnaire to the sampled cassava traders. The survey data include detailed modules on costs of raw cassava, processing, transportation, storage, insect pest infestation, fungi infection, quantity and value of cassava handled, damaged and sold. Also sub-samples of dried cassava chips were collected from old stocks (unsold dried cassava chips from previous season) and new stocks (recently harvested and dried cassava chips).

In each of the dealer's store five bags each of old stock and new stock of about 110-120kg were selected. In each of these bags, about 1kg of dried chips were sub-sampled, put in Kliner jars, covered with a lid and labelled appropriately. Samples of dried cassava chips was collected in order to determine the type of insects infesting chips. The sub-sampled chips were then kept in a deep freezer (-32^{0}F) for 14 days to render insects immobile. From each sample collected, 100g of dried cassava chips was weighed out, and these were carefully teased and sieved to separate insects that were lodged inside the chips. The species and the number of insects in each 100g sub-samples were observed, counted and recorded. Thereafter each 100g samples collected were mixed together to form a composite mixture of old and new stocks of dried cassava chips. This was later used to determine the total proportion of observable insects in both old and new stock of dried cassava chips.

The proportion of each insect species was determined as the number of individuals of each species divided by the total number of insect pest infesting dried cassava chips and expressed as a percentage. Also, the proportion of each insect species found infesting old and new stocks of dried cassava chips was determined as the number of insect pests recorded in both old and new stocks divided by the total number of individual species and expressed as percentage. t-value was used to test for significant differences between observed insects infesting dried cassava chips in each sampled area.

Economic analysis was done using descriptive statistics such as mean and percentages and by applying budgeting technique. The costs and return analysis was helpful in determining economic loss as a result of the damage caused by insect pests on the cassava chips in storage.

Results and Discussion

Insect pest species identified in stored dried cassava chips

The results of the survey showed that *Lasioderma serricone* (F.) and *Rhyzopertha dominica* (F.) were more predominant in Doma and Lafia (Table 1). In Doma, there was an average of 19 and 14 for *L. serricorne* and *R. dominica*, respectively. While Lafia had an average of 10 and 11 for the same insect type, respectively. Table 2 also showed that there was significant differences ($t_{\alpha 0.05}$ = 2.23) between the number of various insect types recorded in the sampled area. Statistical significant difference was recorded between *L. serricorne* and *Cryptolestes ferrugineus* (Stephens); and between *L. serricorne* and *Liposcelis bostrychophilus* Bad in virtually all the sampled area. Also there was significant difference between *R. dominica* and *L. bostrychophilus* in most of the sampled area.

Table 3 showed that of the seven species of stored product insect pests identified, three, *L. serricorne, R. dominica* and *Dinoderus minutus* (F.) are primary pests while the other four; *Sitophilus zeamais* Mosts., *Tribolium castaneum* (Herbst.), *C. ferrugineus* and *L. bostrychophilus* are secondary pests. *L. serricorne* which constituted 20.39% of the total number of insects collected and identified from dried cassava chips was the most abundant species while *L. bostrychophilus* which constituted 10.39% of the total number of insects was the least abundant species.

Table 3 also showed that there were more stored insect pests infesting old stock of cassava chips than the new stock. Of the total number of individual species of insects collected, *T. castaneum* and *D. minutus*, with 100% infestation was recorded in old stock of dried cassava chips over that of new stock. Generally, insect pests infestation was higher in the old stock of dried cassava chips than that of the new stock.

The study has revealed that dried cassava chips are not totally free from stored insect pests' infestation. The mode of drying cassava chips in the open in the sun has been reported to be a primary source of insect pests as against cassava chips that were oven-dried (Parker and Booth 1979). In the same report by Parker and Booth, (1979) it was shown that there was a preponderance of *L. serricorne* and *R. dominica* in dried cassava chips stored over long period of time than compared to those stored for a short period of time. The present study also showed that old stock of dried cassava chips had a higher insect pests infestation than the new stock.

The high population of *T. castaneum* and *D. minutus* in particular and other secondary pests such as *C. ferrugineus* in the old stock of dried chips might not be unconnected with the large amount of powdery substance produced by the feeding activities of the primary pests over the fairly long period of storage. It has been reported that these pest species develop faster on broken food materials than on whole or intact materials (Haines 1991; Throne 1993). In addition, *T. castaneum* and *C. ferrugineus* are known to have very high intrinsic rate of increase (Smith 1965; Haines 1991). *L. bostrychophilus* is also reported to be a good harvester of stored produce upon which they thrive (Haines 1991).

The survey also showed that virtually all the dealers sampled are engaged in the sale of cereal grains such as maize, sorghum and millet, which are stored close to, or in the same store with cassava chips. Such a practice encourages cross infestation of produce by the pest species. Thus this account for the presence of *S. zeamais,* a major pest of cereal grains on the dried cassava chips in addition to *R. dominica, D. minutus* and *L. serricorne.*

Cost implications of insect pest infestation

Agricultural marketing as a business activity provides satisfaction to consumers of agricultural produce in three dimensions, which are related to the physical functions performed on the produce before reaching the consumers. Satisfaction of 'form' is being obtained through processing, satisfaction of 'place' comes through transportation while the satisfaction of 'time' is being derived from storage. The costs of performing these physical functions are components of the marketing cost. This study also identified value loss due to insect pests and mould infestation on cassava chips in storage as part of the marketing cost.

It was observed as presented in Table 4 that loss in value due to insect pests infestation constituted about 31 percent of the marketing cost for the damaged cassava chips. The marketing costs and the revenue for the damaged cassava chips were ₦677.84 and ₦397.76 per bag respectively. In the end, the loss (negative net income) of ₦280.08 was recorded, out of which ₦67.22 was attributed to mould infection. About 76 percent of the loss in value of cassava chips in the study area was attributed to insect pests. For the undamaged cassava chips, a bag was valued on the average at ₦677.84. The net income recorded was ₦280.08 per bag (equivalent of 120kg).

Magnitude of loss in value of dried cassava chips.

The two major sources of loss in value of cassava chips identified in this study are, insect pests infestation and mould infection. Table 5 compares the value loss due to insect pests with that of mould infection. It was revealed that the maximum value loss due to insect pest was at ₦584.35 per bag while the minimum was ₦38.20 per bag. On the other hand, mould caused maximum loss in value by ₦214.39 per bag, while the minimum was ₦8.14. The estimated average difference in value loss (₦145.64) between the insect pests and mould was found to be statistically significant at 5 percent level.

Variability in the values of dried cassava chips among traders

The maximum value of undamaged cassava chips observed in the study area was ₦1450.00 per bag while the minimum value was ₦560.00. On the other hand, the damaged cassava chips attracted maximum and minimum values of ₦620.00 and ₦50.00 per bag, respectively (Table 6). The value of damaged cassava chips was highly unstable among the traders (coefficient of variation = 0.60). This implies that the probability that a trader who handled damaged cassava chips would get no value for his cassava was 0.6. The average loss in value (₦280.08/bag) was statistically significant at 5 percent level.

The scale of loss in value of dried cassava chips.

The extent of damage and economic loss caused by the insect pests on the dried cassava chips was scaled based on the category of traders. The three categories of traders identified had between 20 to 29 percent of their cassava revenue lost due to insect pests infestation. Specifically, the small-scale traders on the average, had a loss of ₦24,340.56 within a year. The medium-scale traders had a loss of ₦62,685.43 while large-scale traders had a loss of ₦79,224.26 (Table 7).

Conclusion and Recommendations

Efforts towards increasing the production of cassava in Nigeria would hardly give satisfactory results due to high rate of insect pests infestation on dried cassava chips in storage. Cassava producers and traders have for long been experiencing economic loss due to insect pests infestation. The results of this study has revealed that the primary source of insect pests infestation of dried cassava chips is from old stock of dried cassava chips still held in storage. More so, subjecting new stock of dried cassava chips to heaping in the open, makes them to be susceptible to insect pests infestation as some of these insects are active fliers. The study also estimated the economic loss on dried cassava chips as induced by insect pests in cassava producing zone of Nasarawa state. About 76 percent of loss in value of cassava chips was attributed to insect pests damage. The loss in value due to insect pests infestation accounted for 31 percent of the marketing cost of damaged cassava chips. In order to alleviate this problem, the study recommends the following:

(i) Improved processing and storage facilities should be provided to cassava chip producers and traders.
(ii) Further research is required to evolve appropriate methods of cassava chips storage for insect pests control in stores.
(iii) Farmers/processors and cassava marketers should be enlightened and trained through workshops on how to effectively process and store their cassava products.

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Table 1: Insect pests species infesting stored cassava chips in different locations in Nasarawa State of Nigeria.

Sampled area	Storage pest[a]						
	Lasioderma serricorne	*Rhyzopertha dominica*	*Dinoderus minutus*	*Sitophilus zeamais*	*Tribolium castaneum*	*Cryptolestes ferrugineus*	*Liposcelis bostrychophilus*
Awe	7	6	7	5	5	4	3
Doma	19	14	8	15	8	7	9
Keana	4	5	3	4	5	4	2
Lafia	10	11	9	6	4	7	5
Nasarawa-Eggon	3	6	2	2	2	5	3
Obi	4	5	1	3	3	2	3
Wamba	6	5	0	2	2	3	2

[a]The figures for the storage pests are the mean number of insect pests obtained from 10 replicates each of old and new stocks of dried cassava chips, respectively.

Table 2. Significant Difference in the number of insects observed in each LGA

Type of insect	Sampled area (LGA)						
	Awe	Doma	Keana	Lafia	Nasarawa Eggon	Obi	Wamba
Ls & Rd	1.00 (1.22)	5.00* (3.45)	1.00 (1.39)	1.00 (0.98)	3.00* (5.00)	1.00 (1.85)	1.00 (1.92)
Ls & Dm	0.00 (1.05)	11.00* (7.64)	1.00 (1.85)	1.00 (0.65)	1.00 (1.72)	3.00* (6.38)	6.00* (14.29)
Ls & Sz	2.00 (2.20)	4.00* (2.76)	0.00 (0.91)	4.00* (4.30)	1.00* (2.38)	1.00 (1.72)	4.00* (6.90)
Ls & Tc	2.00 (2.20)	11.00* (7.75)	1.00 (1.79)	6.00* (6.98)	1.00* (2.70)	1.00 (1.85)	4.00* (7.41)
Ls & Cf	3.00* (4.00)	12.00* (8.57)	0.00 (0.63)	3.00* (3.61)	2.00* (4.44)	2.00* (2.63)	3.00* (6.12)
Ls & Lb	4.00* (5.56)	10.00* (6.94)	2.00* (3.03)	5.00* (5.38)	0.00 (2.15)	1.00 (2.13)	4.00* (7.14)
Rd & Dm	1.00 (1.20)	6.00* (7.90)	2.00* (2.98)	2.00 (1.91)	4.00* (5.33)	4.00* (8.89)	5.00* (16.67)
Rd & Sz	1.00 (1.30)	1.00 (1.21)	1.00 (1.21)	5.00* (6.10)	4.00* (6.35)	2.00* (3.57)	3.00* (6.00)
Rd & Sc	1.00 (1.30)	6.00* (8.22)	0.00 (0.69)	7.00* (9.59)	4.00* (6.67)	2.00* (3.85)	3.00* (6.67)
Rd & Cf	2.00* (3.45)	7.00* (10.29)	1.00 (1.33)	4.00* (5.71)	1.00 (1.54)	3.00* (5.77)	2.00* (5.13)
Rd & Lb	3.00* (5.55)	5.00* (6.58)	3.00 (3.85)	6.00* (7.32)	3.00 (2.16)	2.00* (4.44)	3.00* (6.38)
Dm & Sz	2.00 (1.96)	7.00* (8.75)	1.00 (1.47)	3.00* (3.13)	0.00 (0.16)	2.00* (4.08)	2.00* (5.00)
Dm & Tc	2.00 (1.96)	0.00 (0.70)	2.00* (4.08)	5.00* (5.62)	0.00 (0.58)	2.00* (4.44)	2.00* (6.06)
Dm & Cf	3.00* (3.41)	1.00 (1.54)	1.00 (1.72)	2.00* (2.30)	3.00* (4.76)	1.00 (2.22)	3.00* (12.50)
Dm & Lb	4.00* (4.65)	1.00 (1.37)	1.00 (1.64)	4.00* (4.17)	1.00 (1.64)	2.00* (5.41)	2.00* (5.56)
Sz & Tc	0.0 (0.87)	7.00* (9.09)	1.00 (1.43)	2.00* (3.33)	0.00 (0.42)	0.00 (0.56)	0.00 (0.52)
Sz & Cf	1.00 (1.43)	8.00* (10.96)	0.00 (0.76)	1.00 (1.79)	3.00* (6.12)	1.00 (1.79)	1.00 (2.13)
Sz & Lb	2.00* (7.69)	6.00* (7.50)	2.00* (2.53)	1.00 (1.43)	1.00 (2.13)	0.00 (0.49)	0.00 (0.36)
Tc & Cf	1.00 (2.04)	1.00 (1.61)	1.00 (1.67)	3.00* (7.14)	3.00* (6.67)	1.00 (0.52)	1.00* (2.38)
Tc & Lb	2.00* (2.98)	1.00 (1.43)	3.00 (0.63)	1.00 (1.67)	1.00* (2.38)	0.00 (0.45)	0.00 (0.49)
Cf & Lb	1.00* (2.38)	2.00 (2.11)	2.00* (2.86)	2.00* (3.57)	2.00* (4.08)	0.00 (0.64)	1.00 (2.22)

Figures in parentheses are t.values; $t_{\alpha 0.05}$ = 2.23 *significant at 5 per cent level of probability
Ls = *Lasioderma serricorne*, Rd = *Rhyzopertha dominica*, Dm = *Dimoderus minutus*,
Sc = *Sitophilus zeamais*, Tc = *Tribolium castaneum*, Cf = *Cryptolestes ferrugineus*
Lp = *Liposcelis bostrychophilus*

Table 3. Species composition of insect pests infesting old and new stocks of dried cassava chips in Nasarawa State of Nigeria

Common name	Species	Family	Group of insect pest	Old Stock		New Stock		Old and New Stock	
				No. of insect species	Proportion over old and new stock (%)	No of insect species	Proportion over old and new stock (%)	No of insect species	Proportion of insect types (%)[a]
Cigarette beetle	*Lasioderma serricorne*	Anobiidae	Primary	47	88.68 (70.36)[b]	6	11.32 (19.64)	53	20.39 (26.85)
Lesser grain borer	*Rhyzopherta dominica*	Bostrychidae	Primary	47	90.39 (71.95)	5	9.61 (18.05)	52	20.00 (26.56)
Powder post beetle	*Dinoderus minutus*	Bostrychidae	Primary	30	100.00 (90.00)	0	0.0 (0.00)	30	11.54 (19.82)
Grain weevil	*Sitophilus zeamais.*	Curculionidae	Secondary	32	86.49 (68.44)	5	13.51 (21.56)	37	14.23 (22.14)
Flour beetle	*Tribolium castaneum*	Tenebrionidae	Secondary	29	100.00 (90.00)	0	0.0 (0.00)	29	11.16 (19.55)
Flat grain beetle	*Cryptolestes ferrugineus*	Cucujidae	Secondary	23	71.88 (57.99)	9	28.13 (31.95)	32	12.31 (20.53)
Book lice	*Liposcelis bostrychophilus*	Liposcelidae	Secondary	23	85.18 (67.37)	4	14.82 (22.63)	27	10.39 (18.81)

[a]Proportion number of insects collected from 10 replicates of both old and new stocks of dried cassava chips

[b]Figures in parentheses are arc sine transformation of mean percentages of insect pests found in both old and new stocks of dried cassava chips.

Table 4. Average marketing costs and returns per bag of damaged and undamaged dried cassava chips in Nasarawa state.

Item	Damaged cassava chips		Undamaged cassava chips	
	Cost (₦)	Percentage of marketing cost	Cost(₦)	Percentage of marketing cost
Raw cassava	211.43	31.19	211.43	53.16
Processing*	73.43	10.82	73.33	18.44
Transportation	28.83	04.25	218.83	07.24
Storage**	84.17	12.42	84.17	21.16
Loss due to insects	212.86	31.40	NA	NA
Loss due to mould	67.22	09.92	NA	NA
Total Marketing cost	677.84	100.00	397.76	100.00
Revenue (₦)	397.76		677.84	
Net Income(₦)	-280.08		280.08	

NA = Not Applicable

*Processing cost includes costs of labour for peeling and drying.

**Storage cost includes costs of labour, bag and rent.

Note = A bag of dried cassava chips in the study area is equivalent to 120 kg.

Table 5. Magnitude of value loss per bag of cassava chips as a result of insect pests infestation and mould infection in Nasarawa state.

Variation parameter	Value Loss (₦ /bag) due to	
	Insect pest	Mould
Maximum	584.34	214.39
Minimum	38.20	08.14
Average	212.86	67.22
Standard deviation	113.24	60.94
Difference	145.64*	
t-value	9.48	

*Significant at 5 percent level.

Table 6. Variation in values of insect damaged and undamaged cassava chips among the traders.

Variation parameter	Value (₦/bag) Undamaged cassava chips	Damaged cassava chips
Maximum	1450.00	620.00
Minimum	560.00	50.00
Average	677.84	397.76
Standard deviation	325.66	237.53
Coefficient of variation	0.48	0.60
Difference	280.08*	
t-value	5.81	

* Significant at 5 percent level.

Table 7. The scale of value loss per trader per year due to insect pest and fungi infestation by category of traders.

Category of traders	Value Loss due to Insect pests (₦)	Mould (₦)
Small-scale (<500 bags)	24,340.56 (20.40)	5,338.26 (4.47)
Medium-scale (500 – 1000 bags)	62,685.43 (23.57)	12,534.19 (4.71)
Large-scale (>1000 bags)	79,224.26 (28.99)	18,663.52 (6.83)

Figures in parentheses are percentages of revenues.