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Effect of Processing Methods on Proximate Composition of Cassava Varieties *Manihot esculenta* (Crantz) Before and After Infestation by *Prostephanus truncatus* (Horn)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In Africa, *Prostephanus truncatus* is a destructive pest of economic importance which has assumed a serious pest status on stored maize and dry cassava chips. This study investigates the effect of processing methods of cassava varieties *Manihot esculenta* on the proximate composition before and after exposure to *P. truncatus*. The four cassava varieties used for this study were; TMS 0505, TME 419, NR 8082 and TMS 0581 subjected to two processing method parboiling and plain sun-drying at temperature 28-34°C and relative humidity of 65-75%. The experiment was carried out in a Complete Randomized Design. Proximate composition was carried out to determine the Moisture, Ash, Crude fibre, Fat, Crude Protein and Carbohydrate of the different samples. Analysis of Variance was used for the statistical analysis of the data obtained. The result reveals that the proximate composition of the sundried chips are significant at P<0.05%. All the proximate contents of the sample were significant at P<0.05% before the introduction of *P.*

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trucatus. After the introduction of *P. truncatus* and the storage period of 30days, the sundried sample had a higher reduction in the moisture contents of TMS 0505 with 13.05±0.00[a] and carbohydrate contents of NR 8082 with 50.0±0.00[a]. The activity of *P. truncatus* also has a negative impact on some of the nutritional components of cassava chips.

Keywords: Cassava; proximate composition; protesphanus; manihot; parboiled; sundried.

1. INTRODUCTION

Nutritional composition of cassava depends on the specific tissue (tuber or leaf) and on several factors, such factors includes geographic location, variety, age of the plant, and environmental conditions. The roots and leaves, which constitute 50% and 6% of the mature cassava plant, respectively, are the nutritionally valuable parts of cassava [1]. The nutritional value of cassava roots are important because they are the main part of the plant consumed in developing countries. Cassava root is an energy-dense food. In this regard, cassava shows very efficient carbohydrate production per hectare. It produces about 250,000 calories/hectare/day which rank it before maize, rice, sorghum, and wheat [2]. The root is a physiological energy reserve with high carbohydrate content, which ranges from 32-35% on a fresh weight (FW) basis, and from 80-90% on a dry matter (DM) basis [2]. Eighty percent of the carbohydrates produced are starch 83% is in the form of amyl pectin and 17% is amylose [3].

Cassava roots contain low amounts of the B vitamins, that is, thiamine, riboflavin, and niacin and part of these nutrients are lost during processing. Usually the mineral and vitamin contents are lower in cassava roots than in sorghum and maize [3]. The protein, fat, fibre, and minerals are found in larger quantities in the root peel than in the peeled root.

However, the carbohydrates, determined by the nitrogen free extract, are more concentrated in the peeled root (central cylinder or pulp) [3]. Thus, cassava roots are rich in calories but low in protein, fat, and some minerals and vitamins.

Processing methods use in processing cassava affects the nutritional value of cassava roots through modification and losses in nutrients of high value. Analysis of the nutrient retention for each cassava edible product shows that raw and boiled cassava root keep the majority of high-value nutrients except riboflavin and iron [4]. *Garri* is a common root product that involves grating, fermenting and roasting. *Garri* and products obtained after retting of cassava root with peel are less efficient than boiled root in keeping nutrients of high value but are better than products obtained after retting of cassava roots.

However, the latter is richer in riboflavin than sun-dried flour or chips. *Fufu,* an important staple in Africa, is a mashed cassava root product that is allowed to ferment with *Lactobacillus* bacteria [5]. *Medua-me-mbong* is a root product that requires only boiling and prolonged washing. However, *medua-me-mbong* has the poorest nutritional value compared to other cassava products with the exception of calcium content [2]. In contrast to boiled cassava, processed cassava loose a major part of dry matter, carbohydrates, protein, significant vitamin C, it is very sensitive to heat and easily leaches into water. Almost all of the processing techniques seriously affect its content [2]. Boiled cassava, *garri* and products resulting from retting of cassava root with peel, retain thiamin and niacin better than products obtained after retting of shucked cassava roots and smoked-dried flour. Riboflavin is well retained in boiled cassava, *garri*, and smoked-dried cassava flour obtained after retting of cassava root with peel in contrast, the losses vitamin B2 (riboflavin) [2]. Thus, the aim of this study is to investigate the effect of processing methods of plain sundried and parboiled cassava root varieties on the proximate composition before and after infestation of *P. truncatus*.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in the laboratory of the Department of Parasitology and Entomology, situated in Science Village Faculty of Biosciences, Nnamdi Azikiwe University Awka, Anambra State, Nigeria.

2.2 Experimental Design

The experiment was laid out in a completely randomized design (CRD) with each treatment replicated three times.

2.3 Data Collection

2.3.1 Collection and culture of the experimental insect

The adult larger grain borer, *Protephanus truncatus* used for the study was obtained from commercial produce stores in Enugu main market in Enugu state. One kilogram of the dried cassava chips containing both adults and larvae of the insect was measured and divided into two, one litre transparent plastic buckets each and subsequently cultured for two months under ambient laboratory temperature and humidity conditions [6].

2.3.2 Collection of experimental crop

Four genetically improved cassava varieties namely NR 8082, TMS 0505, TME 419 and TMS 98/0581 were used for the study. They were collected from the National Root Crop Research Institute Substation, Igbariam Anambra State, Federal Ministry of Agriculture and Rural Development Nigeria.

2.4 Processing of cassava varieties

Fifty kilogram each of the four cassava varieties was peeled, washed and cut separately into sizes of approximately 2x5cm and subjected into two processing methods: parboiling and sun drying for plain chips. In these methods, twenty-five kilogram of the samples was parboiled for 10 minutes while the remaining twenty-five kilograms was only washed and this was done for each variety. Both were sundried for two months [7].

2.5 Determination of the proximate composition

Samples of the differently processed chips were taken and milled for determination of the following proximate composition of cassava flour; Moisture, Ash, Crude fibre, Fat, Crude protein and Carbohydrate content. Infested samples were analysed for their proximate composition at the end of storage.

2.5.1 Moisture contents

The moisture content of the samples was determined by gravimetric method as described by Bradley [8]. A measured weight of the fresh sample (5g) was added in a previously weighed crucible and dried in the oven at 95-100^{0}C under pressure not exceeding 100mgHg for 30 minutes in the first instance. It was cooled on the desiccator and reweighed. The weight was recorded and the sample returned to the oven for further drying. The drying, cooling and weighing was done at intervals repeatedly for each samples until a constant weight was obtained. By weight difference, the weight of moisture lost was determined and expressed as a percentage of the sampled weight analyzed. Moisture content was then calculated using the formula:

$$\text{Moisture (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

W_1= initial weight of empty crucible
W_2= weight of empty crucible + sample
W_3= final weight of empty crucible + sample after drying to constant weight

2.5.2 Ash contents

The furnace incineration gravimetric method by AOAC [9] was used. A measured weight **(**5g) of each sample was added in a previously weighed porcelain crucible. The sample in the crucible was introduced into a muffle furnace at 550^{0}C for 2 hours, the sample was allowed to burn until it became white ash. The crucible was carefully removed from the furnace (taking care not to allow air blow the ash away), cooled in the desiccator and reweighed. The difference in weight of ash obtained was expressed as percentage of the sample weight analysed. The ash content of the sample was calculated using the formula:

$$\text{Ash (\%)} = \frac{W_2 - W_1}{W} \times \frac{100}{1}$$

Where:

W = weight of sample
W_1 = weight of empty crucible
W_2 = weight of crucible + ash

2.5.3 Crude fibre contents

This was determined by the method described by James [10]. Exactly 5g of each sample was defatted (fat determination) using petroleum ether. The defatted samples were boiled in 200mls of 1.25g of H_2S0_4 solution under reflux for 30 minutes. After that, the samples were washed with several portions of hot water using a two-fold muslin cloth to trap the particles. The washed samples were carefully transferred back to the flask and 200ml of 1.25% NaOH solution was added to it. Again the samples were allowed to boil for 30 minutes and washed with hot water. It was then carefully transferred to a weighed porcelain crucible and dried in the oven at 105°C for an hour, cooled in desiccator and reweighed. The loss in weight after incineration was used to determine the crude fibre content and expressed as a percentage of the weight of the samples. Crude fibre will be calculated as follows:

$$\text{Crude fibre (\%)} = \frac{W_2 - W_3}{W_1} \times \frac{100}{1}$$

Where:

W_1 = weight of sample
W_2 = weight of crucible + sample after drying
W_3 = weight of crucible + sample ash.

2.5.4 Fat contents

The Bligh dyer technique as described by Bligh [11] was used. Exactly 2g of each sample were mixed with 15ml ethanol and 15ml chloroform or petroleum either in 1:1 in such way to give single phase miscible with water. 5ml of additional chloroform was added to give a separation of the phases. The solution was centrifuge for 3mins for effective solve phase separation. The chloroform or petroleum ether layer contained was removed leaving the fat which was collected. The experiment was repeated two more times to get an average. The fat content was determined by weight difference of each sample and expressed as a percentage of each weight of sample as shown below:

$$\text{Fat (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

Where:

W_1 = weight of empty filter paper
W_2 = weight of paper + sample before defatting
W_3 = weight of paper + sample after defatting and drying.

2.5.5 Crude protein contents

The protein content of the samples was determined by the kjeldahl method as described by James [10]. The total nitrogen was determined and multiplied by the factor 6.25 to obtain the protein content; 5g of each sample will be mixed with 10ml of concentrated sulphuric acid (H_2SO_4) in a kjeldahl digestion flask. A tablet of a selenium catalyst was added to it and the mixture digested by heating in a fume cupboard until a clear solution was obtained. Each of the digest was carefully transferred into a 100ml volumetric flask and made up to the mark by distilled water. 10ml portion of each digest were mixed in an equal volume of 45% NaOH solution in a kjeldahl distilling unit. The mixture was distilled and the distillate collected into 10ml of 4% boric acid solution containing three drops of mixed indicator-bromocressol green and methyl red. A total of 50mls distillate was collected and titrated against 0.02N H_2SO_4 solution from green to a deep red point. A reagent blank was also digested, distilled and then titrated, just as the sample. The nitrogen and protein content was calculated thus:

$$\text{Nitrogen (\%)} = \frac{\text{Va} - \text{Vb x Nacid x } 0.01401}{\text{W}} \text{ x } 100$$

Where:

Va = vol(ml) of acid required to titrate sample
Vb = vol(ml) of acid required to titrate the blank
N = Normality of titrant (0.01N)
W= Weight of sample in grams

The percentage of protein was then calculated as % protein = %nitrogen × 6.25 (conversion factor).

2.5.6 Carbohydrate contents

The carbohydrate content of the test samples was determined by estimation using the arithmetic difference method described by Bemiller and James [12]. The carbohydrate was calculated and expressed as the nitrogen free extract (NFE) as shown below:

% CHO = 100 - % [fat + protein + crude fiber + moisture+ ash].
Where:

CHO = Carbohydrate

3. RESULTS

3.1 Proximate Composition

3.1.1 Proximate composition of four varieties of parboiled and sundried Cassava chips before infestation

The result of the moisture contents of the parboiled cassava chips before infestation with

P. truncatus showed that TMS 0505, TME 419, NR 8082, and TMS 0581 had moisture contents values of 10.30±0.00, 12.150±0.77, 12.35±0.21, and 10.60±0.14 respectively. Also the sundried Cassava Chips had moisture contents of 15.550±0.07, 14.850±1.20, 15.500±0.00 and 15.500±0.00 for TMS 0505, TME 419, NR 8082, and TMS 0581 respectively. The result also showed that the mean values of all the sundried samples are higher and significant at P > 0.05% level as compared to that of the parboiled samples.

Table 2 showed the results of the ash contents of parboiled cassava chip before infestation with *P. trucatus.* TMS 0505, TME 419, NR 8082, and TMS 0581 had ash contents values of 12.500±3.53, 27.500±3.53, 26.000±5.65 and 23.500±2.12 respectively. Also, the sundried Cassava Chips had ash contents of 0.500±0.00**,** 26.000±5.65, 19.000±1.41 and 27.500±3.53 for the varieties TMS 0505, TME 419, NR 8082 and TMS 0581 respectively. However, irrespective of the differences in mean value, the ash content of the samples is all significant at P<0.05.

In table 3 the result showed that the crude fiber contents values of the parboiled chips of TMS 0505, TME 419, NR 8082 and TMS 0581 are 0.160**±**0.07, 0.255±0.08, 0.155**±**0.007 and 0.180**±**0.028 respectively. Furthermore the sundried Cassava Chips had the Crude fibre values of 0.195±0.007, 0.360±0.014, 0.470**±**0.014 and 0.235**±**0.049 for the varieties TMS 0505, TME 419, NR 8082AND TMS 0581 respectively. The crude fiber for both parboiled and sundried of TMS 0505, TME 419, NR 8082 and TMS 0581 are all significant except for TMS 0581 sundried that is not significant at P > 0.05%.

In table 4, the result of the fat contents of the parboiled cassava chips before infestation with *P. truncatus* showed that TMS 0505, TME 419, NR 8082, and TMS 0581 had fat contents values of 0.30±0.14, 0.20±0.14, 0.25±0.07 and 0.255±0.06 respectively. Also the sundried Cassava Chips had moisture contents of 0.105±0.01, 0.21±0.14, 0.355±0.08 and 0.42±0.01 for TMS 0505, TME 419, NR 8082, and TMS 0581 respectively. The fat content is not significant at P > 0.05%, however, the fat contents in the samples are significant for TMS 0505 sundried, TME 419 sundried and TMS 0581 sundried.

Table 1. Moisture contents of parboiled and sundried cassava chips before infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Moisture Contents (± S.E)
1	TMS 0505	Parboiled	$10.30±0.00^b$
2	TMS 0505	Sundried	$15.55±0.07^a$
3	TME 419	Parboiled	$12.15±0.77^b$
4	TME 419	Sundried	$14.85±1.20^a$
5	NR 8082	Parboiled	$12.35±0.21^b$
6	NR 8082	Sundried	$15.50±0.00^a$
7	TMS 0581	Parboiled	$10.60±0.14^b$
8	TMS 0581	Sundried	$15.50±0.00^a$

Mean value with subscript ^{a} is significant at P < 0.05, Mean value with subscript ^{b} is not significant at P > 0.05

Table 2. Ash contents of parboiled and sundried cassava chips before infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Ash Contents (±S.E)
1	TMS 0505	Parboiled	$12.50±3.53^a$
2	TMS 0505	Sundried	$0.50±0.00^a$
3	TME 419	Parboiled	$27.50±3.53^a$
4	TME 419	Sundried	$26.00±5.65^a$
5	NR 8082	Parboiled	$19.00±1.41^a$
6	NR 8082	Sundried	$27.50±3.53^a$
7	TMS 0581	Parboiled	$23.50±2.12^a$
8	TMS 0581	Sundried	$27.50±3.53^a$

Mean value with subscript ^{a} is significant at P < 0.05, Mean value with subscript ^{b} is not significant at P > 0.05

Table 3. Crude fibre contents of parboil and sundried cassava chips before infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Crude Fibre Contents (± S.E)
1	TMS 0505	Parboiled	0.160±0.07^{a}
2	TMS 0505	Sundried	0.195±0.007^{a}
3	TME 419	Parboiled	0.255±0.08^{a}
4	TME 419	Sundried	0.360±0.014^{a}
5	NR 8082	Parboiled	0.155±0.007^{a}
6	NR 8082	Sundried	0.470±0.014^{a}
7	TMS 0581	Parboiled	0.180±0.028^{a}
8	TMS 0581	Sundried	0.235±0.049^{b}

Mean value with subscript ^{a} is significant at P < 0.05, Mean value with subscript ^{b} is not significant at P > 0.05

Table 4. Fat contents of parboil and sundried cassava chips before infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Fat Contents (±S.E)
1	TMS 0505	Parboiled	0.30±0.14^{b}
2	TMS 0505	Sundried	0.105±0.01^{a}
3	TME 419	Parboiled	0.20±0.14^{b}
4	TME 419	Sundried	0.21±0.14^{a}
5	NR 8082	Parboiled	0.25±0.07^{b}
6	NR 8082	Sundried	0.355±0.08^{b}
7	TMS 0581	Parboiled	0.255±0.06^{b}
8	TMS 0581	Sundried	0.42±0.01^{a}

Mean value with subscript ^{a} is significant at P < 0.05, Mean value with subscript ^{b} is not significant at P > 0.05

Table 5. Protein contents of parboil and sundried cassava chips before infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Protein Contents (±S.E)
1	TMS 0505	Parboiled	0.0390±0.01^{b}
2	TMS 0505	Sundried	0.0422±0.06^{b}
3	TME 419	Parboiled	0.0570±0.02^{b}
4	TME 419	Sundried	0.0675±0.03^{b}
5	NR 8082	Parboiled	0.0410±0.02^{b}
6	NR 8082	Sundried	0.168±0.13^{b}
7	TMS 0581	Parboiled	0.0450±0.03^{b}
8	TMS 0581	Sundried	0.156±0.026^{b}

Mean value with subscript ^{a} is significant at P < 0.05, Mean value with subscript ^{b} is not significant at P > 0.05

Table 6. Carbohydrate contents of parboil and sundried cassava chips before infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Carbohydrates Contents (±S.E)
1	TMS 0505	Parboiled	76.7±0.00^{a}
2	TMS 0505	Sundried	83.6±0.00^{a}
3	TME 419	Parboiled	59.8±0.00^{a}
4	TME 419	Sundried	56.0±0.00^{a}
5	NR 8082	Parboiled	68.20±0.00^{a}
6	NR 8082	Sundried	56.0±0.00^{a}
7	TMS 0581	Parboiled	65.4±0.00^{a}
8	TMS 0581	Sundried	56.2±0.00^{a}

Mean value with subscript ^{a} is significant at P < 0.05, Mean value with subscript ^{b} is not significant at P > 0.05

Table 5 results of the protein contents of the parboiled cassava chips before infestation with *P. truncatus* had the values 0.0390**±**0.01, 0.0570**±**0.02, 0.0410**±**0.02 and 0.0450**±**0.03 respectively for the varieties TMS 0505, TME 419, NR 8082 and TMS 0581. Also the sundried Cassava Chips had protein contents of 0.0422**±**0.06, .0675**±**0.03, 0.168**±**0.13 and 0.156**±**0.026 respectively. These results also show that the protein content of the samples are not significant at P>0.05%.

Table 6 results of the carbohydrate contents of the parboiled cassava chips before infestation with *P. truncatus* had the values 76.7±0.00, 59.8±0.00, 68.20±0.00 and 65.4±0.00 respectively for the varieties TMS 0505, TME 419, NR 8082 and TMS 0581. Also the sundried Cassava Chips had carbohydrate contents values of 83.6±0.00, 56.0±0.00, 56.0±0.00 and 56.2±0.00 respectively for the different varieties. Carbohydrate content of the samples was also noted to be very highly significant as indicated in the result**.**

3.1.2 Proximate Composition of Four Varieties of Cassava Parboiled and Sundried Cassava Chips after Infestation

The results in Table 7 showed that TMS 0505, TME 419, NR 8082 and TMS 0581 parboiled chips had moisture contents values of 7.10±0.03, 10.12±0.07, 9.10±0.21 and 9.30±0.13 respectively. However the sundried Cassava chips had the value of 13.05±0.00, 11.153±1.20, 11.50±0.00, and 13.20±0.00 for their respective varieties. The results of the moisture content showed that the mean values of all the sundried samples are higher and significant at P < 0.05% level as compared to that of the parboiled samples.

The results in Table 8 showed that mean ash contents of parboiled cassava chips before infestation with *P. truncatus* had the values 10.30±1.53, 23.50±3.53, 16.00±0.21 and 15.50±1.12 respectively for the varieties TMS 0505, TME 419, NR 8082 and TMS 0581. Also the sundried Cassava Chips had protein contents of 0.20±0.00, 19.00±1.25, 23.20±1.53 and 0.20±0.00 respectively for the varieties TMS 0505, TME 419, NR 8082 and TMS 0581. Their differences in mean value, the ash content of the samples are all significant at P < 0.05%.

Table 9 shows that the Crude fibre content of the parboiled chips after infestation with *P. truncatus* for TMS 0505, TME 419, NR 8082 and TMS 0581 had the values of 0.030**±**0.05, 0.051±0.05, 0.050**±**0.007 and 0.060**±**0.028 respectively. Furthermore the sundried varieties of TMS 0505, TME 419, NR 8082 and TMS 0581 had values of 0.065±0.007, 0.140±0.012, 0.070**±**0.013 and 0.134**±**0.045 respectively. From the result, the crude fiber of all the parboiled samples are significant at p<0.05% while that of the sundried is not significant at P>0.05%.

Table 10 results of the fat contents of parboiled cassava chips after infestation with *P. truncatus* had the values 100±0.04, 0.100±0.04, 0.130±0.02 and 0.015±0.03 respectively for the varieties TMS 0505, TME 419, NR 8082 and TMS 0581. Also the sundried Cassava Chips had fat contents values of 0.002±0.01, 0.100±0.04, 0.035±0.03 and 0.100±0.01 respectively. However, the fat contents in the samples are not significant at 0.05% level.

The result of the protein contents of the parboiled cassava chips before infestation with *P. truncatus* showed that TMS 0505, TME 419, NR 8082, and TMS 0581 had moisture contents values of 0.012**±**0.01, 0.013**±**0.02, 0.02**±**0.01 and 0.013**±**0.03 respectively. Also the sundried

Table 7. Moisture contents of parboil and sundried cassava chips after infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Moisture Contents (±S.E)
1	TMS 0505	Parboiled	7.10±0.03[b]
2	TMS 0505	Sundried	13.05±0.00[a]
3	TME 419	Parboiled	10.12±0.07[b]
4	TME 419	Sundried	11.153±1.20[a]
5	NR 8082	Parboiled	9.10±0.21[b]
6	NR 8082	Sundried	11.50±0.00[a]
7	TMS 0581	Parboiled	9.30±0.13[b]
8	TMS 0581	Sundried	13.20±0.00[a]

Mean value with subscript [a] is significant at P < 0.05, Mean value with subscript [b] is not significant at P > 0.05

Table 8. Ash contents of parboil and sundried cassava chips after infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Ash Contents (±S.E)
1	TMS 0505	Parboiled	10.30±1.53[a]
2	TMS 0505	Sundried	0.20±0.00[a]
3	TME 419	Parboiled	23.50±3.53[a]
4	TME 419	Sundried	19.00±1.25[a]
5	NR 8082	Parboiled	16.00±0.21[a]
6	NR 8082	Sundried	23.20±1.53[a]
7	TMS 0581	Parboiled	15.50±1.12[a]
8	TMS 0581	Sundried	23.40±2.53[a]

Mean value with subscript [a] is significant at P < 0.05, Mean value with subscript [b] is not significant at P > 0.05

Table 9. Crude fibre contents of parboil and sundried cassava chips after infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Crude Fibre Contents (±S.E)
1	TMS 0505	Parboiled	0.030±0.05[a]
2	TMS 0505	Sundried	0.065±0.007[b]
3	TME 419	Parboiled	0.051±0.05[a]
4	TME 419	Sundried	0.140±0.012[b]
5	NR 8082	Parboiled	0.050±0.007[a]
6	NR 8082	Sundried	0.070±0.013[b]
7	TMS 0581	Parboiled	0.060±0.028[a]
8	TMS 0581	Sundried	0.134±0.045[b]

Mean value with subscript [a] is significant at P < 0.05, Mean value with subscript [b] is not significant at P > 0.05

Table 10. Fat contents of parboil and sundried cassava chips after infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Fat Contents (±S.E)
1	TMS 0505	Parboiled	0.100±0.04[b]
2	TMS 0505	Sundried	0.002±0.01[b]
3	TME 419	Parboiled	0.100±0.04[b]
4	TME 419	Sundried	0.100±0.04[b]
5	NR 8082	Parboiled	0.130±0.02[b]
6	NR8082	Sundried	0.035±0.03[b]
7	TMS 0581	Parboiled	0.015±0.03[b]
8	TMS 0581	Sundried	0.100±0.01[b]

Mean value with subscript [a] is significant at P < 0.05, Mean value with subscript [b] is not significant at P > 0.05

Cassava Chips had protein contents of 0.010±0.06, 0.0002±0.02, 0.021±0.13 and 0.016±0.026 for TMS 0505, TME 419, NR 8082, and TMS 0581 respectively. These results also indicate that the protein content of the samples are not significant at P > 0.05%.

Table 12 results of the carbohydrates contents of the parboiled cassava chips before infestation with *P. truncatus* had the values 70.3±0.00, 53.6±0.00, 63.10±0.00 and 62.3±0.00 respectively for the varieties TMS 0505, TME 419, NR 8082 and TMS 0581. Also the sundried Cassava Chips had carbohydrates contents of 81.2±0.00, 55.0±0.00, 50.0±0.00 and 53.1±0.00 respectively. Carbohydrate content of the samples was also noted to be highly significant as indicated in the result.

Table 11. Proteins contents of parboil and sundried cassava chips after infestation after *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Protein Contents (±S.E)
1	TMS 0505	Parboiled	0.012±0.01[b]
2	TMS 0505	Sundried	0.010±0.06[b]
3	TME 419	Parboiled	0.013±0.02[b]
4	TME 419	Sundried	0.0002±0.02[b]
5	NR 8082	Parboiled	0.020±0.01[b]
6	NR 8082	Sundried	0.021±0.13[b]
7	TMS 0581	Parboiled	0.013±0.03[b]
8	TMS 0581	Sundried	0.016±0.026[b]

Mean value with subscript [a] is significant at P < 0.05, Mean value with subscript [b] is not significant at P > 0.05

Table 12. Carbohydrate contents of parboiled and sundried cassava chips after infestation of *P. trucatus*

S/N	Sample Name/code	Method Of Processing	Carbohydrates Contents (±S.E)
1	TMS 0505	Parboiled	70.3±0.00[a]
2	TMS 0505	Sundried	81.2±0.00[a]
3	TME 419	Parboiled	53.6±0.00[a]
4	TME 419	Sundried	55.0±0.00[a]
5	NR 8082	Parboiled	63.10±0.00[a]
6	NR 8082	Sundried	50.0±0.00[a]
7	TMS 0581	Parboiled	62.3±0.00[a]
8	TMS 0581	Sundried	53.1±0.00[a]

Mean value with subscript [a] is significant at P < 0.05, Mean value with subscript [b] is not significant at P > 0.05

4. DISCUSSION

The finding of the study showed that moisture content of the samples varies from parboiled samples to that of the sundried. The variation was due to the processing methods that were used in processing the samples as well as the varieties of the sample. All the varieties that were sundried were found to have higher moisture content as compared to the parboiled samples.

The difference in the mean moisture contents of the sundried samples could be due to the fact that the samples were not subjected to boiling which may have drained moisture from it when compared to the parboiled samples and also the fact that the sample was kept in air-tight container during infestation which do not allow the sample to absorb moisture from the environment.

Ash contents of the samples in different treatments were also noted to vary but significant among the varieties irrespective of the type of treatment. From the result, it could be seen that the mean ash value for sundried samples are more than that of the parboiled samples except for that of TMS 0505 sundried which is 0.200±0.00. This variation could be due to the fact that boiling reduced some of the ash content of the samples.

The fat content of the samples was also observed to be dependent on the type of treatment that was given but independent of the varieties. The findings indicated that the fat contents of the sundried samples were more than that of the parboiled and as well significant when compared to the parboiled samples. This invariably indicated that parboiling the cassava varieties denatured them and affected their fat contents. This finding corroborate with the findings of Onyenwoke and Simonyan [4] who reported that processing methods use in processing cassava affect the nutritional value of cassava through modification and losses in nutrients of high value.

The crude fiber of the sample was observed to be independent of the varieties of cassava and method of processing. This implies that the varieties of cassava coupled with the method that is employed in processing them had no significant adverse effect on the sample. The crude fiber content of the samples was noted to be significant as well in all the varieties with different processing method that was employed. This finding disagrees with the findings of Gil and

Buitrago [13], who said that fiber contents in cassava roots depend on the variety and the age.

The finding of the study further showed that the carbohydrate content of all the samples is highly significant. This finding means that high percentage of carbohydrate content of all the varieties are still much intact irrespective of the variety and the processing method used.

After the introduction of *P truncatus,* it was further observed that the moisture content of the sundried samples among the varieties were significant while that of the parboiled was not significant. Therefore, it's a clear indication that the activities of *P.trucatus* do not have any effect on the moisture content of cassava chips. This finding as well is in consonance to that of Terry [14], who reported that several pathogens and pest like *P.truncatus* are endemic in major cassava-growing areas. Ash contents of all the samples were also noted to be highly significant after introduction of *P. truncatus*, which means that *P.truncatus* does not really reduce the ash content of the cassava chip. On the contrary, the fat and protein content of the samples after infestation of the sample with *P. truncatus*, the fat content was degraded while there was a minute amount of protein present was deteriorated by *P truncates* after infestation.That is to say that the activities of *P. truncatus* made the cassava chips loose it fat and protein content. The carbohydrate content of the samples was noted to be less after infestation with *P. truncatus* when compared to the value before infestation. But the availability of carbohydrate left in the samples after infestation is still significant as indicated in the result.

Raw cassava root has more carbohydrate than potatoes and less carbohydrate than wheat, rice, yellow corn, and sorghum on a 100g basis. The fibre content in cassava roots depends on the variety and the age of the root. Usually its content does not exceed 1.5% in fresh root and 4% in root flour [13]. The lipid content in cassava roots ranges from 0.1 to 0.3% on a FW basis. This content is relatively low compared to maize and sorghum, but higher than potato and comparable to rice.

5. CONCLUSION

Evidence from the finding on the study has shown that the parboiling of cassava chips reduces some of the nutritional content (protein, carbohydrate, fat, moisture, fibre and ash) of the cassava while having no effect on some of it nutrient composition. The activity of *P. truncatus* as well has a negative impact on some of the nutritional components of cassava chips. Their nutritional value is, consequently, lower than those of cereals, legumes, and some other root and tuber crops such as potato and yam.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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