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EFFECT OF PROCESSING METHODS ON NUTRIENT RETENTION AND CONTRIBUTION OF CASSAVA *(Manihot spp)* TO NUTRIENT INTAKE OF NIGERIAN CONSUMERS

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ABSTRACT

There is a global drive for promotion of indigenous foods and feedstuffs as a means of dietary diversification in meeting dietary needs of the people living the traditional lifestyle. Cassava diets constitute a staple source of energy for most Nigerians. However, there is little or no documentation on the nutrient composition, effect of processing methods on nutrient retention and contribution of these diets to nutrient intake of consumers. Nutrition information on contribution of a particular food or diet to nutrient intake of consumers is of paramount importance in food labeling and consumer acceptability. This study, therefore, aimed at providing information on nutrient composition and effect of processing methods on nutrient retention and contribution of some diets prepared from cassava. Fresh cassava roots were obtained from a farm in Alegongo area, Akobo, Ibadan, Oyo State, Nigeria. Proximate and mineral composition of prepared samples was determined alongside the market samples using standard methods of Association of Official Analytical Chemists (AOAC) and atomic absorption spectrophotometry, respectively. The crude protein, lipid, fibre and ash contents of fresh cassava roots were low (0.9, 0.3, 0.5 and 0.4g/100g, respectively). Its mineral profile was: potassium 166.6, sodium 222.1, calcium 25.0, magnesium12.5, phosphorus 57.3, iron 1.7, and zinc 2.1 mg/100g sample. Processing cassava roots into various products improved availability of nutrients such as protein (1.3g in *gari* to 2.6g in *fufu* and *amala*), ash (0.5g in *abacha* to 2.6g in *eba*), potassium (234.5mg in three days fermented *garri* to 473.2mg in two days fermented *lafun*), calcium (22.7mg in *eba* to 67.3mg in two days fermented *lafun*), iron (1.0 – 4.3mg), zinc (2.5 – 6.7mg), as well as their calories ($p<0.05$). A 100g portion of raw and processed cassava into *amala, eba, fufu and abacha* yielded 140.5, 289, 284, 312, and 358 kilocalories of energy, respectively. Soaking fresh cassava for more than two days resulted in significant reduction in mineral content of prepared diets due to leaching. 100g portion of various diets can contribute between 12.3 to 16.1% energy, 6 to 14% iron, and up to 28% zinc to % RDAs of consumers.

Key words: Cassava, Processing, Nutrient, Diets, Contribution

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INTRODUCTION

Cassava (*Manihot esculenta,* Crantz), also called manioc, tapioca or yucca, is one of the most important food crops in the humid tropics, being particularly suited to conditions of low nutrient availability and able to survive drought [1]. It is a widely grown crop in most countries in the tropical regions of Africa, Latin America and Asia; and ranks as one of the main crops in the tropical countries [2].

Among the starchy staples, cassava gives a carbohydrate production which is about 40% higher than rice and 25% more than maize, with the result that cassava is the cheapest source of calories for both human nutrition and animal feeding [3]. More than two-third of the total production of cassava is used as food for humans, with lesser amounts being used for animal feed and industrial purposes [4]. Nigeria alone currently produces over 14 million tonnes annually, representing about 25% of sub-Saharan Africa's output [5].

Although cassava is the third most important food source in the tropical world after rice and maize, and provides calories for over 160 million people of Africa [6], its food value is greatly compromised by the endogenous presence of cyanogenic glucosides. However, processing methods such drying and ensiling have been found to be effective ways of reducing its toxicity in cassava products [7, 8].

Various studies had been carried out on the use of cassava starch for human consumption and animal feed; as well as industrial uses [3, 4, 5]. Nutrient composition of cassava offals and sievates had also been reported [9], but there is a dearth of information on the effect of processing methods on nutrient retention of local diets from cassava. This study, therefore, investigated the effect of processing methods such as soaking, fermenting and boiling on nutrient retention and contribution of diets from cassava to nutrient intake of Nigerian consumers.

MATERIALS AND METHODS

Fresh cassava roots were purchased from a farm in Alegongo, Akobo area in Ibadan, Oyo State of Nigeria. The cassava roots were peeled and cut into small pieces and then randomly divided into fifteen portions. One portion was analysed as fresh (raw) sample, while the other portions were processed into various products as follows:

Preparation of Gari and Eba

Two portions of the cut cassava roots were processed into *gari* by grating using locally made grater and fermented aerobically using local press pump. One sample was fermented for two days and labeled as sample 1, and the other fermented for three days and labeled as sample 2. A sample fermented for three days in the same way was purchased from market for comparison (sample 3). *Eba* was prepared from *gari* sample fermented for three days (sample 2) by adding the *gari* to boiled water (100^0C), stirred very well and labeled as sample 4.

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Preparation of Abacha (Cassava Noodles)

Abacha was prepared by cutting small cassava pieces into 10 cm length, followed by washing in distilled water and then boiling for ten (10) minutes at 100^0C and cooling. The cooled product was shredded using a local shredder. The shredded product was then washed gently four times with distilled water and then soaked in distilled water for 24 hours. It was then rinsed thoroughly, drained and thinly spread on a tray and sun-dried at about 60^0C for five days (sample 5). A sample of *abacha* was purchased from the market for comparison (sample 6). Ready-to-eat *abacha* was prepared by soaking dry *abacha* (sample 5) in water for thirty minutes to rehydrate, sieved, drained and labeled as sample 7.

Preparation of Cassava Flour and Fufu

Two portions of fresh, peeled cassava were soaked in distilled water, one for three days (sample 8) and the other for four days (sample 9). The resultant supernatant liquid was discarded and the left over products mashed, squeezed with hands and packed in jute bags, drained by putting weights on them for 24 hours, and afterwards sun dried. *Fufu* diet was prepared from fermented sample for four days (sample 9) by adding small amount of water and stirred to form a soft paste which was heated and stirred continuously to form gelatinised paste (sample 10). Market sample of *fufu* from four days fermentation was purchased and labeled sample 11.

Preparation of Lafun and Amala

Two portions of peeled cassava roots cut into small pieces were soaked in distilled water to ferment for two (sample 12) and three days (sample 13), respectively. The resultant products were sieved and put in sacks with loads to drain; and then sun-dried on concrete floor for four days. The dried products were then milled and sieved. Market product (*lafun*) fermented for three days was purchased and labelled sample 14. The *lafun* flour of three days fermentation (sample 13) was prepared to *amala* (sample 15) by stirring the flour with boiled water (100^0C) to the desired paste and consistency.

Composite samples of raw cassava, *gari*, *eba*, *abacha*, *cassava flours, fufu*, and *amala* were analysed for moisture, crude protein, lipid, fibre, ash, and minerals using standard methods of AOAC [10] as follows:

Moisture content of the samples was determined by air oven (Gallenkamp) method at 105^0C. The crude protein of the samples was determined using micro-Kjeldahl method by digesting 5g of the sample with conc. H_2SO_4 and Kjeldahl catalyst in Kjeldahl flask for 4 hours. Then 5ml portion of the digest was made up to 100 ml was then pipetted to Kjeldahl apparatus and 5 ml of 40% (w/v) NaOH added. The mixture was steam distilled, and the liberated ammonia collected in 10 ml of 2% boric acid, and titrated against 0.01M HCl solution. The amount of crude protein was then calculated by multiplying percentage nitrogen in the digest by 6.25. Crude lipid was determined by weighing 5g of dried sample into fat free extraction thimble and plugging lightly with cotton wool. The thimble was placed in the Soxhlet extractor fitted up with reflux condenser. The dried sample was then extracted with petroleum

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ether and the crude lipid estimated as g/100g dry weight of sample, and then converted to g/100g fresh sample weight.

The ash content was determined by weighing 5g of sample in triplicate and heated in a muffle furnace at 550°C for 4 hours, cooled to about 100°C in the furnace and then transferred into a dessicator to cool to room temperature; weighed, and ash calculated as g/100g original sample. Crude fibre was determined using the method of Saura-Calixto *et al*.[11].

The carbohydrate content was obtained by difference. Gross energy of the samples was determined using Gallenkamp ballistic bomb calorimeter.

Mineral analysis

Potassium and sodium were determined by digesting the ash of the samples with perchloric acid and nitric acid, and then taking the readings on Jenway digital flame photometer/spectronic20 [12]. Phosphorus was determined by vanado-molybdate colorimetric method. Calcium, magnesium, iron and zinc were determined spectrophotometrically by using Buck 200 atomic absorption spectrophotometer (Buck Scientific, Norwalk) [13] and compared with absorption of standards of these minerals.

Statistical analyses were performed on the results obtained using SPSS version 15.0 analysis of variance (ANOVA) to test the level of significant difference.

RESULTS

Proximate Composition

The result of proximate composition of raw and cassava products are as shown in Table 1.

The raw cassava was very low in crude protein, lipid, fibre and ash; but very high in carbohydrate content. Various methods of processing cassava to end products enhanced the proximate nutrient content of all processed samples (samples 1 to 15). There was no significant difference in moisture, crude protein and carbohydrate content of cassava flour fermented for three and four days (samples 8 and 9), but there was significant increase ($p<0.05$) in crude lipid and ash of sample fermented for four days (sample 9) with a reduction in its crude fibre compared with that of three days (sample 8).

Mineral composition

Grating and fermenting cassava for three days resulted in significant loss ($p<0.05$) of all minerals studied (sample 2) compared with two days fermented sample (sample 1) and raw cassava. Generally, the mineral values of prepared samples were significantly higher ($p<0.05$) than those of raw (fresh cassava) sample. The mineral composition of 'lafun' fermented for two days (sample 12) was significantly higher than that fermented for three days (sample 3) and the prepared 'amala' (sample 15)

DISCUSSION

The moisture, crude protein, lipid, ash, carbohydrate and gross energy content of raw cassava were within the range stated in the literature [14, 15]. The low crude protein value obtained here was in line with the fact that cassava root is a poor source of protein [16], as well as lipids. The low crude fibre value obtained may be due to the age as well as variety of cassava used [17].

'Gari' fermented for two days (sample 1) was slightly higher in nutrient content compared with the one fermented for three days (sample 2). This observation implied that the longer the fermentation period the more the nutrient loss through leaching. Grating exposed the nutrients to easy leaching through draining water. The proximate composition of market sample fermented for three days (sample 3) was significantly higher ($p<0.05$) than that of laboratory sample (sample 2), except for carbohydrate content. This observed difference might be due to varietal difference, which could not be ascertained. Cooking improved the nutrient content of 'eba" (sample 4) with significant reduction in carbohydrate content, and hence, gross energy compared to *gari* (sample 2).

The market dry 'abacha' sample (6) was slightly lower in moisture and higher in crude protein, crude lipid, carbohydrate and gross energy content, while the laboratory sample was slightly higher in crude fibre and ash values. These observed differences might not be unconnected with varietal and species differences, which could not be ascertained from market women. Rehydrated 'abacha' (7) was significantly lower in nutrient content compared with the dry sample (5). This might have been due to leaching of the nutrients into the rehydrating water.

The laboratory-based processed 'fufu' was slightly higher in nutrient content (sample 10) compared with market sample (sample 11), though the difference was not significant. The closeness in nutrient values of laboratory based and market 'fufu' samples supported the similarity in our processing method as well as variety of cassava sample used.

There was slight reduction in nutrient content of sample fermented for three days (sample 13) compared with the two days (sample 12), but the difference was not significant. Both laboratory prepared 'lafun' samples (samples 12 and 13) were significantly higher in nutrient content compared with market sample (sample 14). Cooking cassava flour to 'amala' significantly improved its nutrient content. This observed increase in nutrient content of cooked flour to 'amala' confirmed the fact that cooking improves nutrient availability and digestibility of foods [18, 19].

The result of mineral composition of raw and processed cassava products are as shown in Table 2. The results obtained for the raw sample were slightly different from those obtained in the literature. This difference in value might have resulted from varietal differences as well as the age of the cassava sample [17].

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The observed significant increase in mineral content of processed samples implied that the various processing methods employed here enhanced mineral content in the products. However, there was a significant loss in minerals content of *gari* sample fermented for three days (sample 2) compared with that of two days (sample 1). This pronounced mineral loss was believed to have resulted from grating which exposed the minerals to easy leaching with draining liquid during pressing of the grated roots, as they are water-soluble.

Market gari sample (sample 3) was significantly higher ($p<0.05$) in mineral content than the two laboratory based samples (samples 1 and 2). The observed significant difference might have to do with varietal differences. However, cooking *gari* sample fermented for three days (sample 2) resulted in highly significant increase ($p<0.05$) in mineral content of prepared *eba* (sample 4) compared with the two laboratory-based and market samples. This observation indicated that cooking released more of the minerals from their bonded state, and hence, may be more available to consumers.

Laboratory-based dry *abacha* (sample 5) was higher in potassium, calcium, magnesium, iron and zinc content but lower in sodium and phosphorus than the market sample (sample6). Rehydrated and drained *abacha* sample (sample 7) was significantly lower in mineral content compared with its dry form (sample 5). This was an indication that significant part of the minerals leached into rehydrating water, which was discarded. Processing cassava to cassava noodles (*abacha*) resulted in more mineral retention compared with its *gari* counterparts.

Except for sodium content of sample 9 which was significantly higher than that of sample 8, there was no significant difference in mineral content ($p>0.05$) of *fufu* flour fermented for three (sample 8) and four days (sample 9). Generally, fermentation seemed to significantly increase iron and zinc content of cassava products. Processing *fufu* flour (sample 9) to thick *fufu* paste brought significant reduction in mineral content of the product (sample 10), and laboratory-based *fufu* was higher in mineral content compared to the market sample. This might have been due possibly to the processing method employed.

The mineral composition of *lafun* fermented for two days (sample 12) being higher than that fermented for three days (sample 3) and the prepared *amala* (15) was an indication that the longer the period of soaking, the more the leaching of these minerals into processing water. The laboratory-based *lafun* samples (samples 12 and 13) were significantly higher in mineral content than market sample (sample 14). This may be due to varietal differences, which could not be ascertained, as well as processing method used by marketers.

CONCLUSION

The extent of soaking of cassava had significant effect on nutrient retention and content in the processed samples, with the effect that the longer the extent of soaking the lesser the nutrient retention, especially the minerals. *Lafun* and *fufu* processing methods seemed to retain more of the minerals than other processing methods. *Gari* processing method, which involved grating, predisposes the minerals to easy leaching through draining water. Repeated washings with rehydration and draining of *abacha* led to significant mineral loss in the final products.

Fermentation and cooking enhanced nutrient content in prepared *eba*, *fufu* and *amala*. To improve the nutrient contribution of *gari* and *eba* to intakes of consumers two days fermentation of raw cassava is suggested.

Table 1:Proximate composition of raw and processed cassava products (g/100g fresh sample)

Sample	Moisture	Crude Protein	Crude Lipid	Crude Fibre	Ash	Carbohydrates	Gross Energy (kcal /100g)
Raw	65.3 ± 1.04	0.9 ± 0.07	0.3 ± 0.02	0.5 ± 0.02	0.4 ± 0.02	32.6±0.05	140.5 ± 0.51
1	6.9 ± 0.09	1.5 ± 0.01	0.6 ± 0.01	1.6 ± 0.02	2.1 ± 0.04	87.3±1.52	366.0 ± 1.43
2	6.2 ± 0.07	1.3 ± 0.02	0.6 ± 0.02	1.5 ± 0.01	2.0 ± 0.01	88.4 ± 1.20	370.0 ± 1.45
3	9.0 ± 0.10	1.9 ± 0.02	0.8 ± 0.02	1.6 ± 0.01	2.4 ± 0.02	84.3 ± 1.40	359.0 ± 1.50
4	26.8 ± 0.46	1.4 ± 0.02	0.7 ± 0.00	1.6 ± 0.01	2.7 ± 0.05	66.8 ± 0.23	284.0 ± 1.35
5	9.0 ± 0.82	1.6 ± 0.00	0.5 ± 0.02	1.0 ± 0.02	0.9 ± 0.03	87.0 ± 0.00	362.5 ± 1.45
6	7.8 ± 0.10	1.8 ± 0.02	0.7 ± 0.03	0.8 ± 0.03	0.5 ± 0.02	88.4 ± 0.00	371.9 ± 1.42
7	11.1 ± 0.81	0.8 ± 0.00	0.5 ± 0.01	0.8 ± 0.03	0.7 ± 0.04	86.2 ± 0.06	358.3 ± 1.60
8	12.4 ± 0.25	2.6 ± 0.15	0.9 ± 0.02	2.2 ± 0.02	0.7 ± 0.03	81.2 ± 0.35	359.0 ± 1.15
9	13.3 ± 0.11	2.5 ± 0.15	1.2 ± 0.05	1.7 ± 0.01	1.0 ± 0.02	80.3 ± 0.45	353.0 ± 1.19
10	24.0 ± 0.91	2.1 ± 0.05	0.8 ± 0.01	1.8 ± 0.01	0.5 ± 0.01	70.8 ± 0.16	312.0 ± 1.28
11	24.1 ± 0.47	1.8 ± 0.03	0.7 ± 0.01	1.7 ± 0.01	0.4 ± 0.01	71.3 ± 0.45	310.0 ± 1.16
12	9.0 ± 0.09	1.8 ± 0.02	1.0 ± 0.01	1.0 ± 0.02	2.0 ± 0.02	85.2 ± 0.14	366.0 ± 1.20
13	10.9 ± 0.03	1.6 ± 0.01	0.9 ± 0.01	0.9 ± 0.02	1.9 ± 0.03	83.8 ± 0.30	356.0 ± 1.10
14	11.8 ± 0.02	1.5 ± 0.02	0.6 ± 0.01	0.8 ± 0.02	1.8 ± 0.01	83.5 ± 0.40	351.0 ± 1.00
15	27.2 ± 0.02	2.6 ± 0.02	1.6 ± 0.03	1.4 ± 0.01	2.9 ± 0.04	64.3 ± 0.30	289.0 ± 1.70

Sample 1 = Gari fermented for 2 days; 2 = Gari fermented for 3 days; 3 = Market gari fermented for 3 days; 4 = Eba from 3 days fermented gari; 5 = dry Abacha; 6 = Dry market abacha; 7 = Rehydrated abacha; 8 = Fermented cassava flour for 3 days; 9 = 4 days fermented flour, 10 = Fufu from 4 days fermented flour, 11 = Market fufu fermented for 4 days; 12 = 2 days fermented lafun, 13 = 3 days fermented lafun, 14 = 3 days fermented market lafun; 15 = Amala of 3 days fermented lafun.

Table 2: Mineral composition of raw and processed cassava products (mg/100g)

Sample	Potassium	Sodium	Calcium	Magnesium	Phosphorus	Iron	Zinc
Raw	166.6 ± 5.20	222.1 ± 7.55	25.0 ± 0.40	12.5 ± 0.20	57.3 ± 0.30	1.7 ± 0.04	2.1 ± 0.02
1	279.3 ± 8.50	242.1 ± 5.65	18.6 ± 0.15	13.0 ± 0.11	10.7 ± 0.10	0.9 ± 0.05	2.9 ± 0.05
2	234.5 ± 12.12	206.4 ± 11.15	15.9 ± 0.40	9.4 ± 0.50	10.4 ± 0.30	1.0 ± 0.03	2.5 ± 0.05
3	309.4 ± 12.12	273.0 ± 11.15	21.8 ± 0.35	13.7 ± 0.35	10.0 ± 0.05	1.3 ± 0.03	3.2 ± 0.02
4	322.1 ± 12.12	263.5 ± 11.15	22.7 ± 0.35	15.1 ± 0.35	9.3 ± 0.15	1.3 ± 0.13	3.5 ± 0.15
5	369.0 ± 14.14	486.0 ± 21.21	59.4 ± 0.80	18.9 ± 0.40	129.6 ± 8.15	3.6 ± 0.02	4.9 ± 0.04
6	359.6 ± 14.14	496.1 ± 12.21	55.3 ± 0.40	17.9 ± 0.25	139.9 ± 12.12	2.8 ± 0.03	3.7 ± 0.04
7	249.2 ± 15.50	347.1 ± 14.14	44.5 ± 2.50	8.9 ± 0.50	97.0 ± 6.50	2.0 ± 0.02	3.6 ± 0.02
8	438.0 ± 13.00	543.0 ± 10.00	54.3 ± 0.10	28.9 ± 0.02	143.7 ± 8.10	2.9 ± 0.01	5.8 ± 0.01
9	433.5 ± 10.00	572.2 ± 10.00	52.0 ± 0.20	30.3 ± 0.02	140.9 ± 7.15	3.2 ± 0.01	5.4 ± 0.01
10	342.0 ± 10.00	376.2 ± 15.00	33.1 ± 0.12	19.8 ± 0.01	120.8 ± 0.30	2.1 ± 0.01	4.2 ± 0.02
11	315.0 ± 15.00	303.6 ± 10.00	37.2 ± 0.02	15.6 ± 0.02	112.3 ± 0.11	1.7 ± 0.01	4.2 ± 0.02
12	473.2 ± 21.21	618.8 ± 21.21	63.7 ± 0.35	35.0 ± 0.05	152.0 ± 0.55	4.3 ± 0.05	6.7 ± 0.03
13	427.7 ± 15.55	552.4 ± 18.50	58.8 ± 0.21	27.6 ± 0.05	140.3 ± 5.00	2.9 ± 0.03	6.0 ± 0.05
14	374.9 ± 15.05	511.6 ± 21.12	50.3 ± 0.25	23.8 ± 0.25	134.9 ± 5.50	2.4 ± 0.05	5.3 ± 0.05
15	291.2 ± 12.12	327.6 ± 11.15	36.4 ± 0.35	16.0 ± 0.05	107.7 ± 5.00	1.5 ± 0.02	3.9 ± 0.03

Sample 1 = Gari fermented for 2 days; 2 = Gari fermented for 3 days; 3 = Market gari fermented for 3 days; 4 = Eba from 3 days fermented gari; 5 = dry Abacha; 6 = Dry market abacha; 7 = Rehydrated abacha; 8 = Fermented cassava flour for 3 days; 9 = 4 days fermented flour, 10 = Fufu from 4 days fermented flour, 11 = Market fufu fermented for 4 days; 12 = 2 days fermented lafun, 13 = 3 days fermented lafun, 14 = 3 days fermented market lafun; 15 = Amala of 3 days fermented lafun.

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Table 3: Contribution of diets to % RDAs of consumers

Diet	Sample	Energy			Iron			Zinc		
		Kcal	RDA*	%RDA	mg	RDA*	%RDA	mg	RDA*	%RDA
Gari fermented for 2days	(1)	366	2300	15.9	0.9	15	6.0	2.9	15	19.3
Gari fermented for3 days	(2)	370	2300	16.1	1.0	15	6.7	2.5	15	16.7
Eba from 3 days fermented gari	(4)	284	2300	12.3	1.3	15	8.7	3.5	15	23.3
Rehydrated *abacha*	(7)	358	2300	15.6	2.0	15	13.3	3.6	15	24.0
Fufu from 4 days fermented flour	(10)	312	2300	13.6	2.1	15	14.0	4.2	15	28.0
Amala from 3 days fermented *lafun*	(15)	289	2300	12.6	1.5	15	10.0	3.9	15	26.0

∗Source: [20].

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