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Production and Evaluation of Selected Chemical Properties of Some Fermented Chemically Peeled Yellow-Fleshed Cassava Products

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Abstract

Cassava (*Manihot esculenta* Crantz) has varying sizes and shapes leading to difficulty in peeling mechanization. This study was carried out to investigate the effect of chemical peeling on some chemical properties of some fermented yellow- fleshed cassava roots products. Cassava roots (IITA-TMS-IBA070593) were dipped in 15% NaOH solution (96°C, 5 minutes), softened peels were removed by brushing under running water and neutralized with 3% citric acid solution or with sharp stainless-steel knife. Batches of peeled roots were fermented into *gari* or *fufu*. Some quality characteristics of the peeled roots and products were determined. *Gari* produced had sodium content of 40.91 or 41.47mg/100g respectively for knife or chemically peeled cassava. Ca and P contents increased in *gari* but were lower in *fufu*. Percentage carotenoid retention were 62.62% and 70.21% for *gari* and 47.89% and 58.53% for *fufu*. Chemical peeling had no adverse effects on quality characteristics of *gari* and *fufu* produced.

Keywords: Yellow-Fleshed-Cassava; Peeling Treatment; Fermentation; Characteristics; Production

Introduction

Cassava (*Manihot esculenta* Crantz) is a dicotyledonous plant belonging to the family Euphorbiaceae [1]. Cassava is the most perishable of roots and tubers crops and can deteriorate within two or three days after harvesting. It is an important source of carbohydrate for humans and animals, having higher energy than other root crops, 610KJ/100g fresh weight and roots have energy similar to cereals [2,3]. It is composed of moisture 62-65%, total carbohydrate 32-35%, protein 0.7-2.6%, fat 0.2-0.5%, fibre 0.8-1.3% and ash 0.3-1.3% [4]. Cassava has high contents of magnesium, sodium, riboflavin thiamine, nicotinic acid and citrate [2]. The major constraint on cassava roots as human food is the presence of toxic cyanogenic glucoside compounds (hydrogen cyanide (HCN) in the tissues but they are soluble in water and evaporate when heated.

Traditionally, cassava is processed for 4 to 6 days in order to effect sufficient detoxification of the roots [5]. Processing cassava for foods involve combination of peeling, grating, fermentation, drying and cooking.

In Africa, about 93% of the produce is used as food [6]. Pro-Vitamin A cassava is a new, yellow-fleshed breed of one of the most popular root crops in the tropics. It can provide up to 25% of daily recommended Vitamin A intake [7]. Three yellow root cassava varieties, UMUCASS 36, UMUCASS 37, and UMUCASS 38, which are the second in the series of pro-vitamin A cassava released in the country, and are commonly known as NR07/0220, IITA-TMS-IBA070593, and IITA-TMS-IBA070539 are being grown under the Harvest Plus Project in Nigeria for their high concentrations of β-carotene, which is a precursor to Vitamin A [7]. Just like other cultivars of cassava the yellow fleshed cassava has varying shapes and sizes and this constitutes a major problem in the design and use of mechanical peeling machine for the peeling process.

Cyanogenesis results due to hydrolysis of linamarin by linamarase to form an acetone cyanydrin, which is

either spontaneously or enzymatically transformed by α-hydroxynitrile lyase to release hydrogen cyanide (HCN). Even though linamarin and linamarase are present in most of the plant tissues, no HCN is detected under physiological conditions, suggesting that the enzymes and their substrate exist in two different compartments [8]. Hydrolysis of the glucoside by the enzyme can be accelerated by soaking the roots in water, by crushing or cutting them or by heating. Hydrogen cyanide content of cassava roots vary with planting location, time of harvest and variety [9]. During fermentation, microorganisms break down cells of the root thereby opening up the cell compartments in which the HCN are held so that they are leached into the steep water or drain out of the broken-down cells. Therefore, the longer the period of fermentation, the lesser the cyanide content and the safer it becomes to consume the products. A period of 3-5 days has been recommended as the appropriate duration for fermentation of cassava pulp so as to achieve safe level of 1mg HCN/100g of *gari* [10,11]. However, in some areas in Southeastern Nigeria, keeping cassava pulps some days for fermentation to occur is no longer in practice among processors. Rather, fermentation duration is only limited to the period cassava pulp is placed under dewatering machine for expression of water [12].

Cassava fermentation involves various microorganisms, lactic acid bacteria, yeasts and moulds, depending on different fermentation techniques and preferences [13]. The microbes are involved in the degradation of cassava carbohydrates and produce different products with different flavours and tastes improving the preservation of cassava product [14]. Microbial growth enables softening of tissues of soaked cassava roots and has combined effect of allowing linamarin to come into contact with linamarase and also enable leaching of the cyanogens [13].

Gari is a fermented gelatinous granular product made from Cassava. It is one of Nigeria's most popular staple foods and contributes up to 60% total calorie intake of the population. It comes in various granular sizes classified into high, medium and smooth, It may be consumed soaked in water with addition sugar or salt accompanied with groundnuts or dried smoked fish or coconuts. It may be made into dough meal and eaten with soups. Since *gari* is a ready-to-eat, easy-to-prepare food item, its acceptability cuts across all economic and social strata [15].

Fufu is one of widely consumed fermented cassava products in regions where cassava is cultivated. It is made by steeping whole or cut peeled cassava roots in water to ferment for some days (4-6 days) depending on ambient temperatures. During steeping, fermentation decrease the pH, softens the roots and helps to reduce potentially toxic cyanogenic glucosides. When sufficiently soft, the roots are taken out, broken by hand and sieved to remove fibrous materials. *Fufu* production may employ two types of fermentation system; submerged roots and submerged/solid state technology [16]. The study evaluated the effects of peeling methods on the chemical characteristics of *gari* and *fufu* produced from chemically peeled yellow-fleshed cassava roots.

Materials and Methods

Peeling Processes

Modified peeling method described by Arisa, et al. [17] was adopted in peeling the roots. Fresh pro-vitamin A cassava roots (yellow cassava) IITA-TMS-IBA070593 were sorted and washed with portable water, drained and kept for subsequent use. The cassava roots (40 kg) was weighed and divided into two parts, one part (20 kg) was peeled manually using sharp stainless steel knife, while the other part (20 kg) was peeled by dipping the roots in 15% NaOH solution (lye) at 96°C for a period of 5 minutes to loosen the periderm and cortex. The softened peels were removed by scrubbing the roots with a hard brush under running water. Peeled roots were treated with 3% citric acid solution at ambient temperature for 5 minutes, thoroughly washed, drained and stored for subsequent processes.

Gari Processing

The peeled cassava roots (manually or chemically peeled) were processed into *gari* using the method described by Arisa, et al. [18]. The peeled roots (8.55kg) respectively for manually or chemically peeled roots were milled using a Sahara engineering cassava grating machine. The grated cassava mash was scooped into a porous bag, tightly tied and placed in a hydraulic press to dewater gradually and ferment for 72 hours. Fermented cassava mash was sieved to remove fibrous materials and to loosen the particles. *Garification* was carried out in a large shallow cast iron frying pan for 30 minutes. *Gari* produced were cooled and packed in Ziplock polythene bags and stored at room temperature for analysis.

Fufu Processing

Fufu was processed using the method described by Etudaiye, et al. [16]. The peeled and washed cassava roots (7.40kg respectively) were cut into cubes of 8 to 10cm long and completely submerged in water at room temperature in stainless steel buckets. They were scooped out and grated using a Sahara Engineering grating machine after 48hrs. The grated mash was soaked again in water for another 48 hours, after which it was sieved through a 150µm mesh sized sieve. The slurry was allowed to sediment, poured into a muslin bag to further dewater. The wet fufu cake was dried

in Uniscope SM 9053 Laboratory oven (Surgifriend Medicals, England) at 45°C for 24 hrs. After drying, it was milled using Imex 100901231disc attrition mill (Europe), sieved to obtain fine *fufu* flour, which was packed in Ziplock polythene bags and stored at room temperature for subsequent analyses.

Analyses

The moisture content was determined using the method described by AOAC [19]. The ash, crude fibre, crude protein and fat contents of the samples were determined using the method described by AOAC [20].

Calcium, phosphorus and sodium contents were determined on the fresh cassava, *Gari* and *Fufu* flour using the method described by IITA [21]. Vitamin A content was determined using the method of AOAC [19] Residual cyanide content was determined using the method described by Bradbury, et al. [2]. Sample (0.1g) was weighed into a flat-bottomed flask with a screw cap lid. 0.5ml of 0.1M phosphate buffer at pH 6 was added with a pipette. A yellow picrate paper attached to a plastic strip was placed in the flat-bottomed flask containing the sample and buffer. The bottle was immediately closed with the screw capped lid. A blank was also prepared as above into another screw capped bottle.

Linamarin standard stock solutions were also prepared using 10mg linamarin in 10ml 0.1M phosphate buffer at pH 6, diluted to 25, 50 75 and 100ppm used to standardize and were used to calibrate the spectrophotometer. Linamarin paper of 50ppm concentration was treated as sample above and put in a separate screw capped flask containing phosphate buffer and linamarase enzyme. All the bottles containing samples, blank and linamarin standard paper were allowed to stand for 24 hours at room temperature. At the end of 24 hours, the bottles were opened, plastic backing sheet of the picrate papers were removed and placed in a test tube. Distilled water 6ml was pipetted into the test tube containing the picrate paper with occasional gentle stirring. The absorbances of all solutions in the test tubes including linamarin standard solution were measured against a blank in a spectronic21D spectrophotometer at a wavelength of 510nm.

Calculation

Total cyanide content (ppm or mg/kg) = 396 x Absorbance

$$Total\ cyanide(\%) = \frac{ppm\ cyanide}{10,0000}$$

Results obtained were analyzed using SAS (Statistical Analytical System) version 9.3 package. One-way analysis of variance (ANOVA) was carried out.

Results and Discussions

The moisture (Table 1) contents of the peeled cassava roots were 59.24% and 60.31% respectively for the manually and chemically peeled cassava roots. The slightly lower percentage moisture content when compared to 62% reported Bencini MC [22] may have been as a result of difference in the period of harvest since moisture content of cassava roots tend to be higher during rainy season. The peeled roots also contained; Fat (1.86% and 2.23%), protein (1.06% and 1.26%), ash (1.60 and 1.61%), carbohydrates (33.31 and 36.15%) and Crude fibre (1.73% and 1.79%) respectively for manual and chemical peeling and these results are in line with Hillocks RJ, et al. [4], Arisa NU, et al. [23], Buitrago JA [24].

Sample	Moisture (%)	Ash (%)	Crude fat (%)	Crude protein (%)	Crude fibre (%)	Carbohydrate (%)
KNCA	59.24±0.11	1.61±0.12	2.23±0.29	1.06±0.01	1.74±0.01	36.15±0.00
NACA	60.31±0.20	1.60±0.05	1.86±0.16	1.26±0.03	1.79±0.25	33.31±2.28

Table 1: Effect of peeling treatments on the proximate composition of the Cassava roots.
Legends:
KNCA: Cassava roots peeled with knife
NACA: Cassava roots peeled with NaOH

Results of the proximate composition of the peeled cassava roots products are as presented on Table 2. The moisture content (9.80 and 10.17%) of *gari* produced from the manually peeled and chemically peeled cassava roots are in agreement with the moisture content of 8.5-10.6% reported Ikujenlola AV, et al. [25] and is below 12% which is the maximum permissible moisture content for *gari* [26]. The ash content of the gari samples were 1.24% and 1.26% and fat content of 1.98%. Protein content ranged between 1.59% and 1.69%, with *gari* made from cassava peeled with NaOH having higher value. Carbohydrate (85.90% and 86.67%) and crude fibre (1.79% and 1.80%). Protein contents of the *gari* samples were higher than that of cassava from which they were made. This supports the point made [26] that the activities of micro-organisms increase the protein content of cassava and cassava residues during solid-state fermentation. In general, the proximate compositions of the *gari* produced compare well with those reported by Bamidele PA [27].

Sample	Fibre (%)	Moisture Carbohydrate (%)	Ash (%)	Crude fat (%)	Crude protein (%)	Crude (%)
KNGA	1.79±0.02	9.80±0.09	86.67±0.32	1.24±0.01	1.98±0.33	1.59±0.00
NAGA	1.80±0.01	10.17±0.11	85.90±0.00	1.26±0.11	1.98±0.70	1.69±0.01
KNFU	0.92±0.47	5.87±0.04	91.05±0.00	0.59±0.12	1.93±0.03	0.82±003
NAFU	0.86±0.37	6.00±0.06	91.21±0.00	0.49±0.11	1.52±0.53	0.94±0.00

Table 2: Effect of peeling treatments on the proximate composition of the fermented cassava products.
Mean values ± standard deviation.
Legends:
KNGA: *Gari* made from cassava peeled with knife; NAGA: *Gari* made from cassava peeled with NaOH
KNFU: *Fufu* made from cassava peeled with knife; NAFU: *Fufu* made from cassava peeled with NaOH

Moisture content of *fufu* processed from cassava peeled using the two methods ranged from 5.86% to 6.00%. Ash content ranged from 0.49% to 0.59%. During processing, the grated cassava mash was dewatered Ikujenlola AV [25] by pressing with a screw press. This may have resulted in loss of some of the minerals in the expressed water thereby reducing ash content. *Fufu* from cassava peeled with knife has higher fat content of 1.93% and lower in *fufu* from cassava peeled with NaOH (1.52%). Higher protein content of 0.94% was obtained from *fufu* made from cassava peeled with NaOH compared with 0.82% recorded on *fufu* from cassava peeled with knife. Both *fufu* samples had high carbohydrate content of 91.05% and 91.21%. Crude fibre ranged between 0.86% and 0.92%. The values obtained were in line with those obtained in the study of Etudaiye AH, et al. [16], Achi OK, et al. [28].

The results of mineral content of cassava peeled with knife and NaOH is shown in Table 3. It revealed that the cassava peeled with NaOH (30.05mg/100g) had higher sodium content compared with that peeled with knife (26.01mg/100g). This higher Na content may have been due to residual Na left from NaOH solution used in the peeling process. The calcium content of the peeled cassava roots was 15.76mg/100g and 16.16mg/100g respectively for the cassava roots peeled with NaOH and knife. The phosphorous content of the cassava root peeled with NaOH was 2.31mg/100g while that peeled with knife was 2.49mg/100g. Values obtained on the mineral contents compared well with the values reported by Arisa NU, et al. [9], Ajai AI, et al. [29].

Sample	Sodium (mg/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)
KNCA	26.01±12.72	15.76±2.83	2.31±4.86
NACA	30.05±38.89	16.16±27.58	2.49±5.06

Table 3: Effect of peeling treatments on mineral content of the cassava roots.
Mean values± standard deviation
Legends: KNCA: Cassava peeled with knife;
NACA: Cassava peeled with NaOH

Sample	Sodium (mg/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)
KNGA	40.91±1556	21.20±5.66	1.81±4.86
NAGA	41.47±40.31	21.53±2.12	0.63±0.80
KNFU	18.10±20.51	25.02±7.07	1.15±2.51
NAFU	21.08±4.95	25.15±67.18	1.37±2.02

Table 4: Effect of peeling treatments on mineral content of the fermented cassava products.
Mean values± standard deviation
Legends:
KNGA: Gari made from cassava peeled with knife; NAGA: Gari made from cassava peeled with NaOH
KNFU: Fufu made from cassava peeled with knife; NAFU: Fufu made from cassava peeled with NaOH

Higher sodium content was obtained in *gari* made from cassava peeled with NaOH solution (41.48mg/100g) while that made from cassava manually peeled was 40.91mg/100g (Table 4). The higher value of sodium content in the former could be due to the residual sodium from the chemical peeling agent. Calcium content of the *gari* samples varied between 21.20 mg/100g (*gari* made from cassava peeled with knife) and 21.53mg/100g (*gari* made from cassava peeled with NaOH solution). The *gari* samples had low phosphorus content of 1.81mg/100g and 0.63mg/100g respectively for

gari made from cassava peeled with knife and cassava peeled with NaOH.

Sodium content of *fufu* made from cassava from both peeling treatments varied from 18.10mg/100g to 21.09mg/100g and was lower in sodium when compared with *gari* samples. This could be due to leaching of sodium from the cassava roots during steeping and decanting of supernatant after settling and sedimentation. Calcium content of the *fufu* was 25.02mg/100g and 25.15mg/100g respectively while the while the phosphorous contents (1.15mg/100g and 1.37mg/100g) were the lowest on all samples among all the mineral contents analyzed. This may be because of the fact that phosphorus contents of flours vary with botanical source, maturity as well as growing environment of the plant [30].

Results Table 5 showed that peeling with NaOH solution resulted in cassava with lower carotenoid content (230 I.U/kg) as against 319.5IU/Kg obtained from cassava peeled manually with stainless steel knife. This may have been because of the reaction between the carotenoids and the sodium hydroxide. The predominant carotenoid in these yellow cassava varieties is β-carotene, which makes up about 90% of total carotenoid in cassava [31]. Processing of the peeled cassava roots into *gari* and *fufu* led to further reduction in the carotenoid content as reflected by the result with fufu made from manually peeled cassava (153,00 IU/Kg) and *gari* made from NaOH peeled cassava (161.50 IU/Kg) having the least concentration of carotenoids representing 47.89 and 50.54% retention of carotenoid after processing.

Sample	carotenoid (I.U/kg)	Carotenoid Retention (%)
KNCA	319.50±0.71	90
NACA	230.00±1.41	71.99
KNGA	200.00±0.00	62.6
NAGA	161.50±2.12	50. 54
KNFU	153.00±1.41	47.89
NAFU	187.00±0.00	58.53

Table 5: Effect of peeling treatments on carotenoid content of the fermented cassava products.
Mean values±standard deviation
Legends:
KNCA: Cassava peeled with knife; NACA: Cassava peeled with NaOH
KNGA: Gari made from cassava peeled with knife; NAGA: Gari made from cassava peeled with NaOH
KNFU: Fufu made from cassava peeled with knife; NACA: Fufu made from cassava peeled with NaOH

Sample	Hydrogen cyanide (mg/kg)
KNCA	2.31±0.08
NACA	2.44.±0.04
KNGA	1.19±0.03
NAGA	1.35±0.05
KNFU	0.47±0.01
NAFU	0.63±0.06

Table 6: Effect of peeling treatments on hydrogen cyanide content of the fermented cassava products.
Mean values±standard deviation
Legends:
KNCA: cassava peeled with knife; NACA: cassava peeled with NaOH; KNGA: Gari made from cassava peeled with knife; NAGA: Gari made from cassava peeled with NaOH; KNFU: Fufu made from cassava peeled with knife; NAFU: Fufu made from cassava peeled with NaOH

Peeling with stainless steel knife resulted in cassava roots with 2.31mg/Kg hydrogen cyanide which is slightly lower than 2.44mg/Kg hydrogen cyanide contained in the cassava peeled with NaOH solution. The use of the peeled cassava in the production of *gari* and *fufu* led to reduction in the hydrogen cyanide content of the products (1.19 mg/Kg and 1.35 mg/Kg respectively for *gari* made from knife peeled and NaOH cassava peeled *gari*). However, the production of *fufu* from the peeled cassava samples resulted in products with further reduced hydrogen cyanide content (0.47) and 0.63mg/Kg hydrogen cyanide respectively for knife and NaOH peeled fufu samples. This reduction in hydrogen cyanide content of the products is in agreement with Arisa NU, et al. [9], Bradbury JH [32] and meets standard of not more than 50mg/Kg for edible starch.

Conclusion

The use of chemical (NaOH solution) in the peeling of yellow fleshed cassava roots resulted in cassava products that compared favourably in terms of proximate, mineral, carotenoid and antinutritional characteristics with manually peeled onesIt led to production of fermented cassava

products with slightly higher minerals (Na, Ca and P) contents and acceptable hydrogen cyanide level.

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