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Comparative Assessment of Two Methods in the Production of Fermented Cassava Flour (Láfún) on Manual Energy Expended, Retting Time and the Product Quality

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Abstract
In this study, two methods (pre peeled and post pealed) of processing fermented cassava flour "*Lafun*" are compared on the bases of production cost (time and manual energy), and product quality. To establish the bases, some anthropometry parameters of the processor were measured, alongside with workstation parameters, which includes environmental factors. An experiment was set up and carried out using 66kg of cassava tubers; 33kg each for respective methods, black plastic drums of equal volumes (50liters) containing 30liters of water in each. The results showed that pre peeled method has longer production time, which is associated with retting period (12 days), while post peeled took only 5 days to ret. Also, manual energy expended on dissimilar operations showed that more energy is consumed in pre peeled method of production compared to post peeled methods. The quality test of the fermented flour showed that, the pre peeled method gives better nutritional values, while the post peeled method presented high level of microorganisms when compared. It is concluded on the fact that, the end products seem to counterbalance the processing methods.
Keywords: Comparative Assessment, Fermented Cassava Flour (Láfún), Manual Energy Expended, Production Methods, Product Quality, Retting Time

1. Introduction

Cassava [*Manihot esculenta* Crantz] is an important staple food crop for millions of people in the tropics (Rao and Hahn, 1984). This statement later was substantiated by FAO (2002) that cassava is grown widely in Nigeria and in many regions of the tropics, where it serves as one of the basic food sources for about 200- 300 million people. Komolafe, et al. (2004) revealed that its rapid spread in the continent of Africa was attributed to its adaptability to the social frame work of the farming community, Nigeria not been an exception. They further stressed that cassava has the advantage of growing in relatively poor soils and in low rainfall areas, but gives highest yield on rich well drained loamy soil with a light or medium rainfall.

Cassava is well known not only for its high carbohydrate content but also for the poor quality and concentration (<1%) of its protein (Sanni and Sobamiwa, 1994). Traditionally, cassava roots are processed into different products according to local customs and preferences (Hahn, 1987). In Nigeria, cassava is processed into various products that are consumed in various ways. Among the fermented cassava products of cassava roots are 'garri', 'fufu', 'tapioka', and 'lafun' (FAO, 2002; Oyewole, 1991). Cassava root is normally processed before consumption as a means of detoxification, preservation and modification of various fermented cassava products such as: garri, fufu and lafun (Oyewole, 2011).

Lafun is a processed cassava product very popular in Nigeria and Benin. In the production of lafun, peeled or unpeeled fresh cassava tubers are immersed in a slow flowing stream, in stationary water (near a stream) or in an earthenware vessel/plastic drums, and fermented until the roots become soft, it is then dewatered and sun dried on mats, racks, cement/concreate floor or roof of the house. Fermentation imparts on acidic taste to the final product. The drying process helps to increase the shelf life and reduces the bulkiness of the product. Milled dried fermented cassava root materials give the lafun (cassava flour). Lafun is fermented cassava flour, popularly consumed in south west Nigeria, owing to its high carbohydrate content which serves as a source of energy. It is usually prepared as a stiff porridge using boiled water, prior to being consumed (Oyewole and Afolami, 2001)

The moisture content of 'Lafun' for safe storage is below 12.7%, when temperature and relative humidity are above 27^0C and 70% respectively. The type of bags used for storing also affects the shelf life depending on the ability of the material to maintain safe product moisture level. Jute and Hessian bags are

recommended in dry cool environment because they allow good ventilation (Igbeka 2005). As reported by Segla et al. (2009) Lafun has been extensively studied in Nigeria for the analysis of chemical composition, alongside with this is evaluation of different drying methods (solar, oven and sun-drying) on the quality. Oyenusa (2008) showed that the crude protein values of the peeled cassava to be 2.58% of that unpeeled bitter variety, 2.71% and the peels roots of 5.29% both the protein and non-protein fractions contains the amino acids tyrosine, tryptophan and cysteine in fair amount and the high arginine content. A study conducted by Oyewole and Odunfa (1988), showed that Bacillus spp., Lactobacillus spp., Geotrichum spp. and Aspergillus spp. were present in cassava during fermentation of "lafun".

Processing of cassava tuber to" lafun" involves manual material handling and operations through all the stages, which subject human body to some physiological changes. The body's physiological responses to physical workload involve the musculoskeletal and cardiovascular systems. Muscular forces are required to perform the physical work, that is, to hold and move the load from one point to another. Muscular activities (muscle contraction and extension) during physical work require energy. Supplying the demanded energy creates loads on the cardiovascular system (heart and blood vessels) and respiratory system. The heart must pump faster to deliver the increased oxygen demand through blood vessels to the involved muscles (Health Uottawa, 2003). Tayyari and Smith (2003) submitted that volume of oxygen intakes (VO_2) and aerobic power (VO_2max) vary significantly among individuals, and are affected by many factors, such as:

- Somatic factors: body size, age, sex
- Psychic factors: attitude, motivation
- Environment: altitude, temperature, humidity, e.t.c.
- Nature of work: workload (or intensity), duration, rhythm, technique.
- Physiological characteristics of the individual which are genetically determined (inherited at birth).
- Posture).

Hedge (2008) defined energy expenditure (EE) as the amount of work done by a body in kilocalories per minute. The EE of a man or woman over a whole day is often divided into different components, which can be individually determined. Kroemer et al., (2000) stated that to match a person's work capacity with the requirements of a job, one needs to know the individual's energy capacity and how much the job demands from this capacity. Two methods of lafun production are put forward in this study; pre-peeled and post-peeled, with the aim of determining the cost input in terms of manual energy expended (MEE), production time in terms of retting period (RP) and product quality (PQ) in order to ascertain the method with optimal utilization of available resources, which ensures safety of the finished product for human consumption.

2. Materials and Methods

In order to actualize the objectives of the study, some workstation related ergonomics parameters [anthropometry parameters of subject (hand length, hand width, and standing height), physiological parameters (heart rate, blood pressure, and energy expenditure) before and after the operations were measured, and determined, alongside with these are measurement of knife handle-size and weight of the knife, and seat height]. Others, like drum height, water volume, cassava quantity and cassava type are held constant for the two specified processing methods. Environmental factors (relative humidity and temperature) as well as time taken for each operation are also considered across the methods. Measuring tape are used for all linear measurements, electric weigh balance (Mettler H75 AR Balance), sphygmomanometer (andon BPM KD-795) and WS-HT12Pocket Temperature and Humidity Pen. The flow chart for the two methods clearly shows all the processing stages through to the finished product (Fig. 1).

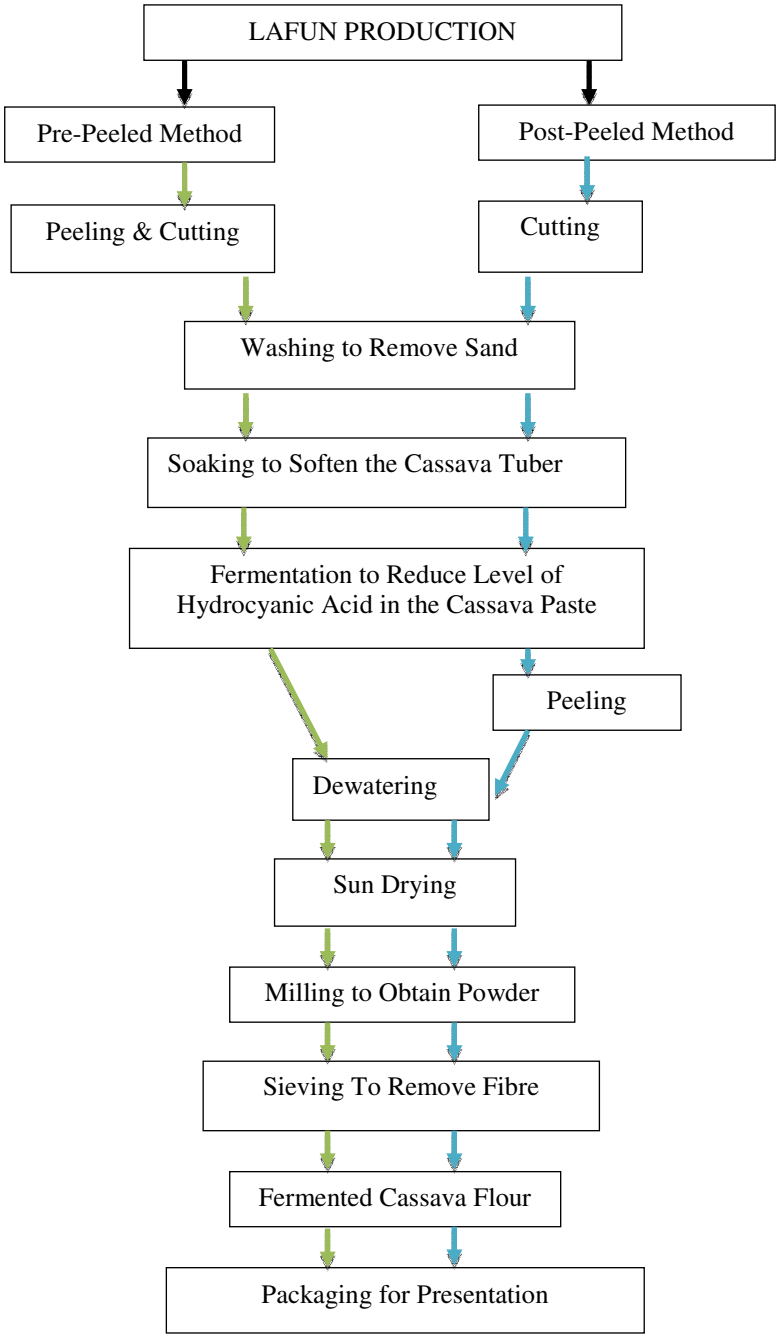

Fig. 1: Flow Chart of Two Methods in the Production of Fermented Cassava Flour

2.1 Determination of Energy Expenditure (EE)

The maximum heart rate of the subject was determined according to formula 220 – age (Rodahl. 1989; Afolabi and Akanbi, 2013). Oxygen consumption is calculated, while the energy expenditure is determined by the relationship between oxygen consumption and energy expenditure as specified in the equations:

$$Y = 0.259X - 6.422 \quad \text{(Oxygen Consumption Rate)} \quad 1$$

Where: Y = predicted oxygen consumption

X = measured heart rate (Scott and Christie, 2004; Afolabi et al., 2013)

$$1\ KJmin^{-1} \equiv 20.88 \times \text{Oxygen Consumption} \quad \text{(Energy Expenditure)} \quad 2$$

(Singh et al., 2008; Afolabi et al., 2013; Afolabi and Akanbi, 2013)

2.2 Processing of Cassava roots to "Lafun"

66kg of cassava tubers was used for the research work. It was divided into two equal halves of 33kg for pre

peeled and post peeled methods which are carried out simultaneously.

2.2.1Pre Peeled Method and Post Peeled Method

The cassava tuber of quantity 33kg was peeled, and cut by knife into smaller sizes to support the level of softening. The pieces were later washed to remove dirt, after which the entire quantity was soaked in the black drum of 50liters containing 30liters of water. Changes in water surface were observed on 3rd and 5th day respectively and cassava was allowed to stay in water until total retting is achieved. After the softening is achieved, the pieces were taking out of the water and the cassava pulp was put into a hessian sack and a relatively big stone and plank was placed on the sack to drain out the excess water from the cassava pulp.

In the case of post peeled, the cassava tuber of quantity 33kg was only cut into smaller sizes and washed to remove dirt, after which the entire quantity was soaked in the black drum of 50liters containing 30liters of water. Also, changes in water surface were observed on 3rd and 5th day respectively and cassava was allowed to stay in water until total retting is achieved.

After the softening is achieved, the pieces were taking out of the water and the outer layer of the cassava pulp was removed with ease by hands and cassava pulp was put into a hessian sack and same big stone and plank was placed on the sack to drain out the excess water from the cassava pulp.

2.3 Proximate Analysis

Samples of the cassava pastes and cassava waters (pre peeled and post peeled) were taken to the laboratory for proximate and microbial test. Lastly the dewatered cassava pulps were broken down by hands into smaller pieces and spread on separate polythene sheet for sun drying. Finally, before the granulation of the dry cassava, samples of the dry cassava chip from the two methods were also taken to the laboratory for proximate and microbial analysis.

2.4 Determination of Microbiological Contaminants

2.4.1 Determination of Moisture and Dry Matter

2g of the sample was weighed into a previously weighed crucible. The crucible plus sample taken was then transferred into the oven set at 10^0C to dry to a constant weight for a period of 24 hours overnight. At the end of the 24 hours, the crucible plus sample was removed from the oven and transferred to desicator, cooled for ten minutes and weighed. The percentage dry matter (%DM) was determined using:

$$(\%\ DM)\ \text{dry matter} = (W_3 - W_0 / W_1 - W_0) * 100 \quad (3)$$

$$\%\ \text{moisture} = 100 - \%\ DM \quad (4)$$

Where; W_0 = weight of empty crucible
W_1 = weight of the crucible plus sample
W_3 = weight of the crucible plus oven-dried sample

2.4.2 Determination of Ash

2.0gm of the sample were weighed into a porcelain crucible. This was transferred into the muffle furnace set at 550^0C and left for about 4 hours, at this time it had turned to white ash. The crucible and its content were cooled to about 100^0C in air, at room temperature in a desiccator and weighed. This was done in duplicate. The percentage ash was calculated from the formula;

$$\text{Ash content} = (W_a / W_s) * 100 \quad (5)$$

Where; W_a = weight of ash
W_S = original weight of sample

2.4.3 Determination of Crude Fibre

2.0gm of the sample was accurately weighed into the fibre flask and 100ml of 0.255N H_2SO_4 added. The mixture was heated under the reflux for 1 hour with the heating mantle. The hot mixture was filtered through a fibre sieve cloth. The filtrate obtained was discarded and the residue was returned to the fibre flask to which 100ml of (0.313N NaOH) was added and heated under reflux for another 1 hour. The mixture was filtered through a fiber sieve cloth and 10ml of acetone added to dissolve any organic constituent. The residue was washed with 50ml hot water on the sieve cloth before it was finally transferred into the crucible. The crucible and the residue were oven- dried at 105^0C overnight to drive off moisture. The oven-dried crucible containing the residue was cooled in a desicator and later weighed to obtain the weight W_1. The crucible with weight W_1 was transferred to the muffle furnace for ashing at 550^0C for 4 hours. The crucible containing white or grey ash (free of carbonaceous material) was cooled in the desicator and weighed to obtain W_2. The percentage fibre was obtained by the formula;

$$\%\ \text{fibre} = (W_1 - W_2 / W_S) * 100/1 \quad (6)$$

2.4.4 Determination of Crude Fat

1gm of each dried sample was weighed into fat free extraction thimble and plug lightly with cotton wool. The thimble was placed in the extractor and fitted up with reflux condenser and a previously weigh oven dried and

desiccator cooled 250 ml soxhlet flask. The flask is then filled to $\frac{1}{2}$ of its volume with petroleum ether (b.pt. $40^0C - 60^0C$), and the extractor plus condenser set was placed on the heater. The heater was put on for six hours with constant running water from the tap for condensation of ether vapour. The set is constantly watched for ether leaks and the heat source is adjusted appropriately for the ether to boil gently. The ether is left to siphon over several times (12 times) until it is short of siphoning. It is after this is noticed that any ether content of the extractor is carefully drained into the ether stock bottle. The thimble containing sample is then removed and dried on a clock glass on the bench top. The extractor, flask and condenser is replaced and the fat or oil is detached, its exterior cleaned and dried to a constant weight in the oven. The percentage fat/oil is obtained by the formula;

$$\%fat = (W_f - W_l / W_S) * 100/1 \quad 7$$

where: W_l = initial weight of prepared soxhlet flask

W_f = weight of flask + extracted oil

2.4.5 Determination of Crude Protein

0.5g of each finely ground dried sample was weighed carefully into the Kjeldahl digestion tubes to ensure that all sample materials got to the bottom of the tubes. To this were added 1 Kjeldahl catalyst tablet and 10ml of conc. H_2SO_4. These were set in the appropriate hole of the digestion block heaters in a fume cupboard.

The digestion was left on for 4 hours, after which a clear colourless solution was left in the tube. The digest was cooled and carefully transferred into 100ml volumetric flask, thoroughly rinsing the digestion tube with distilled water and the flask was made up to mark with distilled water. The distillation was done with Markham distillation apparatus which allows volatile substances such as ammonia to be steam distilled with complete collection of the distillate. The apparatus was steamed out for about ten minutes. The steam generator is then removed from the heat source to the entire developing vacuum to remove condensed water

5ml portion of the digest above was pipette into the body of the apparatus via the small funnel aperture. To this was added 5ml of 40% (W/V) NaOH through the same opening with the 5ml pipette. The mixture was steam-distilled for 2 minutes into a 50ml conical flask containing 10ml of 20% Boric Acid plus mixed indicator solution placed at the receiving tip of the condenser. The Boric Acid plus indicator solution changes colour from red to green showing that all the ammonia liberated have been trapped. The green colour solution obtained was then titrated against 0.01N HCL contained in a 50ml Burette. At the end point or equivalent point, the green colour turns to wine colour which indicates that all the Nitrogen trapped as Ammonium Borate $\{(NH_4)\ BO_3\}$ have been removed as ammonium chloride (NH_4CL)The crude protein content is determined by multiplying percentage Nitrogen by a constant factor of 6.25

2.5Statistical Analysis

Samples of the cassava pastes and cassava waters (pre peeled and post peeled) were taken to the laboratory for proximate and microbial test. Lastly the dewatered cassava pulps were broken down by hands into smaller pieces and spread

3. Results and Discussion

The results on energy expended during the peeling, loading and off-loading operations of the cassava tuber and pulp for both the pre peeled and the post peeled methods along with respective time taken are presented. All observations during the experiment are noted and presented in this chapter. Also, the results on microbial analysis carried out to know the numbers of E.coli, staph, Bacci, Pseudo and fungi present in both the pre peeled and the post peeled methods samples in the cassava paste, retting waters and the chips are presented. In the same vein the results on proximate analysis are presented on the level of available nutrients (dry matter, moisture, ash, crude fibre, fat and protein content) across the methods samples in the cassava pastes and chips.

3.1 Measurement of Some Anthropometry Parameters and Relevant Workstation Parameters

Anthropometry parameters measured are; height (1750mm), hand length (192mm), Hand Breath (85mm), weight(52kg), the immediate environment at work station; height of the stool = 290mm, knife handle circumference (71mm), and knife weight (0.5kg)

Table 1. Physiological Parameters[1] and Other Factors Relative to Two Methods of *Lafun* Production

parameters	pre peeled	post peeled
heart rate after peeling (beat/min)	95	80
heart rate after loading (beat/min)	68	65
heart rate after off-loading (beat/min)	72	70
EE for peeling (kj/min)	379.661	298.542
EE for loading (kj/min)	233.647	217.423
EE for off-loading (kj/min)	255.279	244.463
weight after peeling & dewatering (kg)	23	25
total time for peeling and soaking (min)	149.2	140.05

Processor Age = 25 years

[1]The physiological parameters may not be sustainable over time or representative of processor's performance rating.

Some physiological parameters for both the pre peeled and post peeled methods used in the production of the fermented cassava flour are as shown in Table 1, alongside with differences in weights after dewatering as well as time utilized for pealing and soaking for each method. The measured and calculated results revealed that all parameters relative to the pre-peeled method are on the higher side compared to post-peeled method, except on the quantity remained after dewatering which are 23kg for pre-peeled and 25kg for the post-peeled (Table 1). This implied that, the post peeled method minimized waste of the cassava tuber, the processing time and energy expenditure than the pre peeled method.

3.2 Observed Variations during Retting Operation for the two Methods

The appearance of water surface for post peeled method on the 3rd and 5th day is as presented in Plates 1 and 2 respectively, while the one for pre peeled method for the same time interval is presented in Plates 3 and 4 respectively. It was observed that cassava used for post peeled method softened on the sixth day, this may be as a result of osmotic pressure which enhances the absorption of water through the outer layer thereby speeding up the softening process whereas, that of the pre peeled method softened on the twelfth day. The immediate environment of the retting area was noted to be characterized with foul smell.

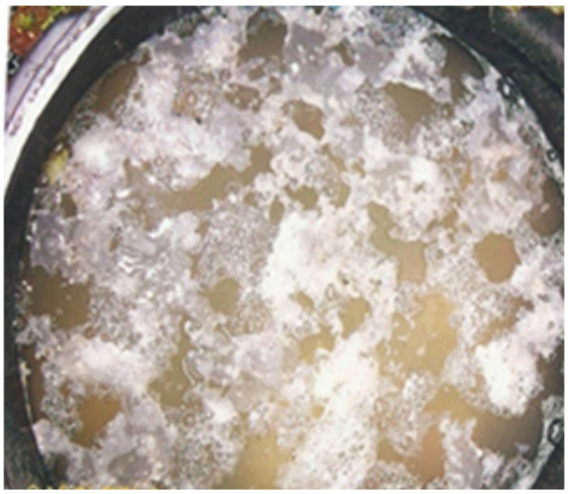

Plate 1: Water Surface on the 3rd Day for Post-Peeled Method

Plate 2: Water Surface on the 3rd Day for Post-Peeled Method

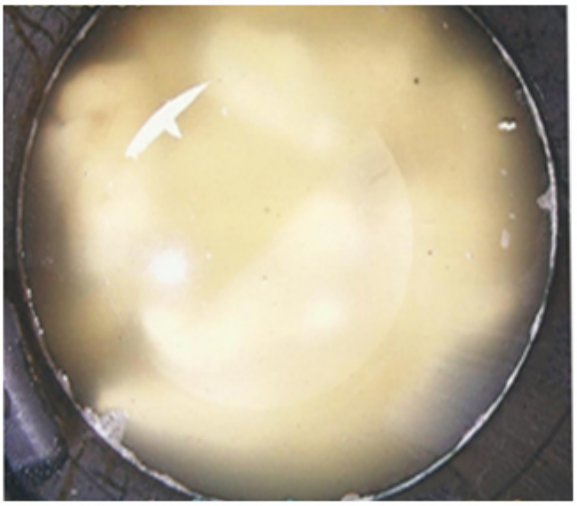

Plate 3: Water Surface on the 3rd Day for Pre-Peeled Method

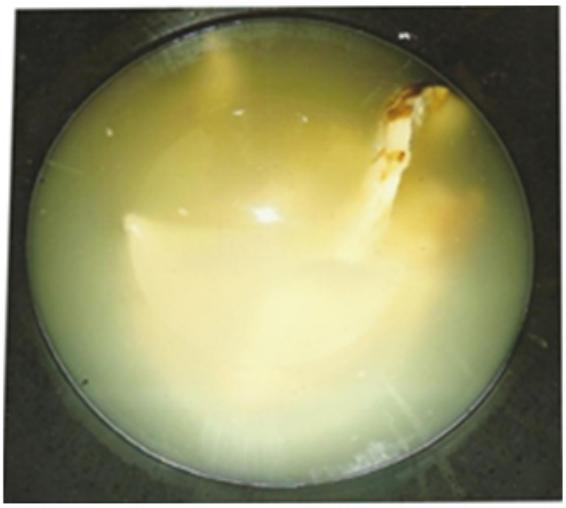

Plate 4: Water Surface on the 5th Day for Pre-Peeled Method

Table 2. Proximate Analysis of the Pre peeled and Post peeled Cassava Paste and Chip.

Sample		Dry matter (%)	Moisture (%)	Ash (%)	Crude fibre (%)	Fat (%)	Protein (%)
Pre-peeled	Paste	38.66	61.34	1.15	2.00	0.30	0.31
	Chip	91.80	8.20	1.25	2.50	0.10	0.38
Post-peeled	Paste	36.48	61.52	1.00	4.40	0.20	0.31
	Chip	76.26	23.74	0.90	0.40	0.20	0.30

Table 2 shows the proximate analysis carried out on the samples, as this analysis seeks to determine all the various components of the food material. The percentage dry matter of the pre peeled cassava paste / chip which are 38.66 / 91.80 are higher than the percentage dry matter of the post peeled cassava paste / chip which are 36.48 / 76.26. In line with this are percentages of ash content which follow the same trend for both pastes and chips. On the other hand, the percentage moisture content of the pre peeled cassava paste / chip which are 61.34 / 8.20 are lower than the post peeled cassava paste / chip which are 61.52 / 23.74.

The percentage of the crude fibre of the pre peeled cassava paste is lower than that of the post peeled cassava paste with their respective values 2.00 and 4.40 while the chip sample of the pre peeled cassava has a higher percentage of crude fiber than the post peeled chip sample with their respective values of 2.50 and 0.40. The percentage of fat content in pre peeled cassava paste is higher than that in the post peeled cassava paste while fat content in chip sample of the pre peeled cassava is lower than that of the chip sample of the unpeeled cassava. The percentage protein content in the pre peeled cassava paste sample and the post peeled cassava sample are of the same amount, while the dry chip of the pre peeled cassava chip sample has more protein content than the post peeled cassava dry chip (Table 2).

Table 3. Analysis of Variance for Proximate Analysis (Methods versus Properties)

Source	DF	SS	MS	F	P
Property	5	0.000	0.000	0.00	1.000
Error	18	6.000	0.333		
Total	23	6.000			

S = 0.5774 R-Sq = 0.00% R-Sq(adj) = 0.00%

The ANOVA test showed that effects of samples; cassava paste and chip and interaction between the two methods, pre peeled and post peeled, had significant effects at the 5% level on the properties; moisture level, ash content, dry matter, crude fibre, fat and protein. This is shown in Table 3.

Table 4. Microbial Analysis of the Pre peeled and Post peeled Cassava Paste and Chip.

Treatment		Total viable count (cfug1)	Total coliform (cfug1)	Total fungi count (cfug1)	Staphylococcus aureus	Escherichia coli count
Pre peeled	Liquid	25.55 x 10^5b	0.75 x 10^5c	0.45 x 10^5	0.50 x 10^5b	0.40 x 10^5c
	Paste	6.30 x 10^5 c	0.70 x 10^5c	0.30 x 10^5	0.25 x 10^5b	0.40 x 10^5c
	Chip	3.10 x 10^5d	0.40 x 10^5c	0.50 x 10^5	0.25 x 10^5b	0.20 x 10^5c
Post peeled	Liquid	4.30 x 10^5 cd	0.50 x 10^5 c	0.25 x 10^5	0.85 x 10^5c	0.30 x 10^5c
	Paste	37.80 x 10^5 a	10.80 x 10^5a	5.05 x 10^5	1.70 x 10^5b	1.70 x 10^5a
	Chip	35.65 x 10^5 a	5.75 x 10^5b	0.45 x 10^5	2.30 x 10^5a	1.10 x 10^5b

Table 4 shows the number of microorganisms that are present in the collected samples in respect to the two methods.

For the pre peeled method sample the total viable count cfug in the liquid is $25.55*10^5$, paste is $6.3*10^5$ and the chip is $3.1*10^5$ while the unpeeled method has $4.3*10^5$ in the liquid, $37.80*10^5$ in the paste and $35.65*10^5$ in the chip. It could be inferred that in the liquid, the number of total viable count cfug present in the pre peeled sample is more than the post peeled sample while in the paste and chip, the post peeled sample has more total viable count cfug than pre peeled sample.

According Table 4 the pre peeled method sample, the total coliform cfug present in the liquid is $0.75*10^5$, paste is $0.7*10^5$ and the chip is $0.4*10^5$ while the post peeled method has $0.5*10^5$ in the liquid, $10.8*10^5$ in the paste and $5.75*10^5$ in the dry chip. This shows that in the liquid, the number of total coliform cfug present in the pre peeled method sample is more than the post peeled method sample, while in the paste and chip the post peeled samples have more total coliform cfug than the pre peeled samples. The total coliform cfug has to do with specie of E.coli found in the sample. E.coli is regarded as normal flora of the intestine but we have some strains e.g. enteroheamorrhagic (EHEC) that causes bloody diarrhea in humans when foods contaminated with the organisms are consumed according to Ojo (2008).

The total fungi count cfug present in the retting liquid, paste and chip for pre peeled method and post peeled method are $0.45*10^5$, $0.3*10^5$, $0.5*10^5$ and $0.25*10^5$, $5.05*10^5$, $0.45*10^5$ respectively. The results reveal that more of fungi activities are embraced in the retting liquid and chip under pre peeled method compared to the paste sample (Table 4).

Staphylococcus is a group of bacteria that can cause a number of diseases as a result of infection of various tissues of the body. Staph related illness can range from mild and requiring no treatment to severe and potentially fatal. The pre peeled method samples have number of total staphylococcus aureus count present in the liquid as $0.5*10^5$, in the paste as $0.25*10^5$ and the chip as $0.3*10^5$, while the post peeled method samples have $0.85*10^5$ in the liquid, $1.7*10^5$ in the paste and $2.3*10^5$ in the chip. This shows that the post peeled method has more staphylococcus count in the samples compared to the pre peeled samples, with wide range of differences for paste and chip (Table 4).

Escherichia coli (E.coli) have many beneficial functions out of which are production of vitamin K2 and prevention of harmful bacteria known as pathogenic bacteria from establishing themselves in the intestine. Most E.coli poses no harm to human health, except for serotype 0157:H7 which can cause food poisoning in humans and can become life threatening. The consumable samples for the two methods have total number of Escherichia coli of $0.2*10^5$ and $1.1*10^5$ for pre peeled and post peeled respectively. This shows grater E.coli count in post peeled chip sample (Table 4).

Conclusion

From the study carried out and the laboratory test results, the following conclusions were drawn;

i. The post peeled cassava tuber softens faster than the pre peeled cassava tuber which may be as a result of osmotic pressure.
ii. The pre peeled fermented cassava flour is whiter than the post peeled fermented cassava flour after granulation which may be as a result of the induced colour through outer layer that have already being fermented with the cassava pulp before the peeling in the post peeled method.
iii. The post peeled method of processing presents higher level of microorganisms than the pre peeled method based on the laboratory result.
iv. End product from the pre pealed method of production has a higher level of nutrients compared to the post peeled method.
v. Total energy expended and production time on pre peeled method is discovered to be higher than that of post peeled method

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