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## Research Article

# Quality assessment of stored fresh Cassava Roots and 'fufu' flour produced from stored roots

## Abstract

The aim of this study was to assess the quality characteristics of cassava roots and fermented cassava flour (fufu). Matured cassava was carefully uprooted and stored in high density polyethylene bag for a period ranging from 0 to 10 days. Fermented cassava flour was produced using standard methods. The stored roots were assessed for various quality properties like percentage loss, discoloration, peel to pulp ratio. Also physico-chemical and sensory of 'fufu' flour produced from stored roots were assessed using standard methods. There was found a decrease in the percentage pulp obtained and a corresponding increase in the percentage peel from 22.10% to 35.90% as the period of storage progressed. The moisture and starch contents decreased while the ash, crude-fibre and sugar contents increased during the study. The yield of 'fufu' flour and cyanogenic potential decreased as the storage period progressed. There was no significant difference among 'fufu' samples produced from roots stored for the first seven days with respect to sensory qualities. The study shows that cassava roots can be stored effectively in high density polyethylene bag and result in acceptable product.

## Introduction

Cassava is an important food staple, providing a cheap energy source for more than 800 million people around the world [1,2]. Worldwide production is estimated to be approximately 230 million tonnes per annum, according to recent FAO statistics [3,4]. Due to the high moisture content of cassava roots which is between 65% and 70% on dry weight basis [5], the utilization of cassava has been limited by the extreme perishability of the fresh roots when stored [6].

Normally, fresh cassava roots are transported in bulk or sacks or stored in the soil until needed. Ideal operating conditions demand that the roots be processed on the day of harvesting or one or two days later [7], as primary deterioration normally commenced within two days of harvesting followed by secondary deterioration by the action of micro-organisms on the tissue, causing tissue-rot, which is evident in the root 5-7 days after harvesting [8,9].

Many storage methods to preserve cassava roots have been utilized such as storage in sawdust with an approximately equal weight of water [10]. According to Nabney J [11], roots can be preserved fresh for longer periods if treated with fungicides prior to storage. Moreover [7], reported the storage of cassava roots in the pit for 14 days. Successful as these storage methods may be; it is not without its shortcomings;

some of the methods are labour intensive and space for the storage may pose challenge in most cases, the quality of the stored products has not been fully assessed in food production. This study was however designed to proffer solution to some of the shortcomings of the former methods. The design entails storing fresh cassava roots in high density polyethylene bag, very well closed, as an alternative to earlier methods, to assess the quality parameters of the stored roots and to produce 'fufu' from fresh and stored cassava roots.

## Materials and Methods

### Materials

Matured cassava roots (TMS 30572) were carefully uprooted and transported to the laboratory where the packaging and preservation took place. Five (5 kg) of the roots were packed together to form a sample. There were five samples for the 10 days storage period.

### Methods

**Storage of fresh cassava roots:** The fresh cassava roots were weighed and neatly packaged but not washed in the high density polyethylene bags well closed. The packaged roots were stored for 0, 2 days, 4 days, 7 days and 10 days. The packaged roots were kept in the laboratory at ambient temperature. Meanwhile, samples were taken for assessment of selected quality parameters on the stored roots.

## Physical assessment

### i) Percentage loss of root

The stored cassava roots were examined and weighed at the end of the storage period. The percentage loss of roots was computed using the following expression:

$$\% \text{ Loss of root} = \frac{\text{Weight of spoil roots}}{\text{Weight of whole roots}}$$

### ii) Percentage loss of peel and pulp

The stored roots were peeled and the ratio of the peels to pulp was computed by the following expression.

$$\% \text{ Pulp} = \frac{\text{Weight of Pulp}}{\text{Weight of whole roots}}$$

## Production of 'fufu' flour from stored cassava roots

The stored roots were re-weighed and carefully peeled using hand peeling with a sharp knife. The peeled roots were washed in clean water. It was soaked in clean water for 72 hours during which fermentation set in and the pulp softened. The soft pulp was dissolved in clean water to remove the shaft and wet sieve using the traditional sieve meant for 'fufu' production. The resulting slurry was left to settle. The mash was thereafter packed in a jute bag and presses to remove excess water before drying. The dried 'fufu' was packaged. The process flow chart is presented in [12] (Figure 1).

## Chemical analysis

### i) Moisture Content

The moisture content was determined by hot air oven method as described by [13]. An empty crucible was weighed and 2 g of the sample was transferred into the crucible. This was taken into the hot air oven and dried for 24 hours at 100°C. The crucible and its contents were cooled in the desiccator and their weights taken. The loss in weight was regarded as moisture content and expressed as:

$$\% \text{ Moisture content} = \frac{\text{Weight loss}}{\text{Weight of sample}} \times 100$$

### ii) Ash Content

Ash content was determined using the method of [13]. About 5 g of each sample was weighed into crucibles in duplicate, and then the sample was incinerated in a muffle furnace at 550°C until a light grey ash was observed and a constant weight obtained. The sample was cooled in the desiccator to avoid absorption of moisture and weighed to obtain ash content.

$$\% \text{ Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

### iii) Crude Fibre

Crude fibre was determined using the method of [13]. About 5g ( $W_0$ ) of each sample was weighed into a 500ml Erlenmeyer flask and 100 ml of trichloroacetic acid reagent (TCA) digestion

reagent was added. It was then brought to boiling and refluxed for exactly 40 minutes counting from the start of boiling. The flask was removed from the heater, cooled a little, and then filtered through a 15.0cm number 4 Whatman paper. The residue was washed with hot water stirred once with a spatula and transferred to a porcelain dish. The sample was dried overnight at 105°C. After drying, it was transferred to a desiccator and weighed as  $W_1$ . It was then burnt in a muffle furnace at 500°C for 6 hours, allowed to cool, and reweighed as  $W_2$ .

$$\% \text{ Crude fibre} = \frac{W_1 - W_2}{W_0} \times 100$$

$W_1$  = weight of crucible + fiber + ash

$W_2$  = weight of crucible + ash

$W_0$  = dry weight of food sample

### iv) pH determination

The pH of the flour samples were determined by mixing 10 g of the flour samples with 25ml of distilled water, stirring thoroughly and measured with a pH meter (Corning pH meter model 220) at 20°C [12].

## The total titrable acidity (TTA) and Sugar determinations

The TTA was determined as described by [3]. The total reducing sugar was determined by the phenol sulphuric acid method as described by [14]. Starch was determined after hydrolysis to sugar. The sugar was converted to starch using the factor 0.9. The cyanogenic potential of the roots and 'fufu' were determined by the method of [15].

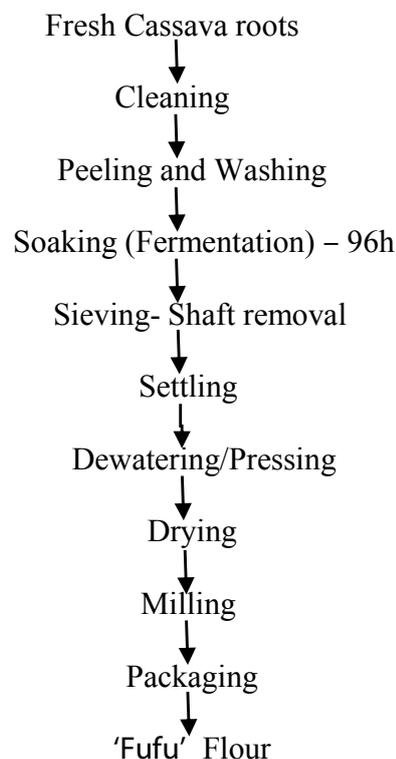


Figure 1: Production of 'Fufu' flour [12].

## Sensory evaluation of reconstituted 'fufu' flour

The various samples of 'fufu' were subjected to sensory evaluation. The products were reconstituted, coded and served warm to the semi trained sensory panellists consisting of people who are used to 'fufu' consumption. The samples were assessed for colour, taste, smoothness/texture, flavour, and overall acceptability. The panellists were made to assess the samples and recorded their observations using a 7-point hedonic scale where, 1- Dislike extremely, 2- Dislike moderately, 3- Dislike slightly, 4- No disliked nor liked, 5- Like slightly, 6- Like moderately, 7- Like extremely.

### Statistical analysis

All the analysis was done in triplicate and the data obtained were subjected to One way Analysis of Variance (ANOVA).

## Results and Discussion

### Physical assessment of stored roots

The stored roots were found to be discolored in the pulp changing from whitish to brownish yellow as the period of storage progressed. This observation may be due to physiological changes resulting from respiration and transpiration processes, microbial activities and pathological changes occurring in the root during storage in high polyethylene bag.

In addition, the percentage peel and pulp of the stored roots ranged between 22.10% - 35.90% and 77.90% - 47.60% respectively (Table 1). The loss of the root increased as the period of storage increases. It was observed that the ease of peeling reduced with the increase in period of storage. The peel tends to adhere more to the pulp this was responsible for losing part of the pulp to peel. This observation agrees with the report of [7], that peeling becomes more difficult during the pre-processing holding of cassava roots.

### Chemical composition of the stored roots

The results of the selected chemical composition are presented in (Table 2). The moisture content of the samples gradually reduced as the period of storage progressed. The moisture was 68.40% in fresh cassava while it was 58.80% on the tenth day of storage. Although the stored roots were kept under ambient temperature in a high density polyethylene bag certain physiological activities still took place which were responsible for the loss in moisture. This observation agrees with the reports of [16-18].

The ash and crude - fibre contents (Table 2) of the roots increased with an increase in the storage period. The increase in ash content (0.60 - 1.30%) may be attributed to loss of nutrient such as starch which might have been mobilized for use during respiration [19]. The sugar content (5.60- 10.80%) increased with a corresponding decrease in starch content over the storage period. This might be due to the hydrolysis of starch to sugar by the endogenous enzymes of the roots leading to quality deterioration [6].

The pH of cassava roots was 6.3 and increased with storage period to 7.3 probably due to the near anaerobic condition of the roots [19]. It was reported that hydrolysis of starch to sugar under anaerobic condition causes alkalinity [20]. However, the total titrable acidity (TTA) (0.02 - 0.05%) of the roots decreased over the storage period. The cyanogenic potential of the roots decreased from 12.7 to 7.4 mg/kg over the storage period, probably due to enzymatic reactions or biochemical changes which detoxify the roots during storage.

### Percentage yield of 'fufu'

The percentage yield of 'fufu' is a function of the pulp that was available for fermentation. From (Table 1) it was discovered that the percentage pulp, reduced as the storage period progressed expectedly the yield of the resulting 'fufu' followed a similar trend. The yield ranged between 14.20% (10th day) and 27.80 (fresh cassava). One of the major reasons for the reduction in yield during storage was the pulp loss to peel during the process of peeling. The reduction in moisture content of the root during storage was responsible for the firm adherence of the pulp to the peel. This made peeling difficult and increase pulp loss to peel.

### Chemical composition of 'fufu'

The selected chemical composition of the fermented cassava product-'fufu' is presented in (Table 3). The moisture content of the 'fufu' flour ranged between 8.10% and 11.30%. The moisture content determines to a large extent the ability of floury product to store well. The moisture content is below 12%, it is expected that the 'fufu' flour will store for a reasonably long period. The ash and crude fibre contents increased in the

**Table 1:** Effect of storage in HDP bag on some physical properties of cassava roots.

Storage period (days)	Loss of roots (%)	Pulp (%)	Peel (%)
0	-	77.90a	22.10c
2	4.70c	70.50a	24.80bc
4	9.30b	63.10ab	27.60ab
7	12.10b	55.80b	32.10a
10	16.50a	47.60c	35.90a

1. Mean of three replicates.

2. Means with the same letters in a column are not significantly different (p > 0.05)

**Table 2:** Mean Chemical composition of roots over the storage period.

Storage periods (days)	Moisture (%)	Ash (%)	Crude fibre (%)	Sugar (%)	Starch (%)	Cyanogenic potential (mg/kg)	pH	TTA (%)
0	68.40a	0.60b	1.20c	5.60c	79.90a	12.70a	6.30b	0.05a
2	65.60a	0.70b	1.30c	6.90c	77.60a	11.20a	6.40b	0.05a
4	62.30a	0.90b	1.50c	8.00bc	75.50a	9.50a	6.70b	0.03a
7	60.50ab	1.10ab	1.60b	9.10bc	69.00ab	8.10ab	7.00ab	0.02a
10	58.80b	1.30a	2.00a	10.80a	60.10b	7.40b	7.30a	0.02a

1. Mean of three replicates.

2. Means with the same letters in a column are not significantly different (P>0.05).

'fufu' flour as storage periods of cassava roots increases. This agrees with the trend in the stored roots, also the observation agrees with the result of [7]. 'Fufu' flour from freshly harvested cassava roots had 1.50 % ash content and 1.40% fibre content, and as the holding period increases, the ash and fibre contents increased to 2.20 % and 1.90 % on the 10th days respectively.

The pH of the 'fufu' flour increased with the increasing storage period of the cassava roots with a corresponding decrease in total titrable acidity. The pH varied from 4.10 to 4.80 while the TTA varied from 0.10% to 0.70% respectively. The cyanogenic potential (Table 3) decreased with the increasing storage period of the roots and ranged from 1.00 (10th day) to 11.10mg/kg (fresh sample). The reduction in the cyanogenic potential of 'fufu' flour was due to a reduction in the cyanogenic potential of cassava roots during storage which was used in 'fufu' production. Also, pressing of the cassava mash aided the cyanogenic potential reduction. It was reported by [21], that pressing and fermentation remove cyanide as glucosides (which are water soluble), or as water soluble free cyanide after hydrolysis of the glucosides. Furthermore, drying process may further reduce the cyanogenic potential of the cakes as free cyanide was volatilized by heat during drying of the flour. It was reported by [22], that the boiling temperature of hydrogen cyanide is 25.70°C. The cyanogenic potential of the 'fufu' flour from cassava roots held in high density polyethylene bag was below a specified standard of 30mg/kg dry weight. It has been observed that traditional processing of cassava roots reduces the cyanogenic potential to an allowable level for human consumption [23–28].

### Sensory evaluation of 'fufu'

The result of the sensory evaluation is as shown in (Table 4) 'Fufu' flours from the stored roots were significantly different ( $p > 0.05$ ) from each other in all the sensory quality attributes

**Table 3:** Mean chemical composition of 'fufu' flour during the storage period.

Storage period (days)	Moisture (%)	Ash (%)	Crude fibre (%)	pH	TTA (%)	Cyanogenic potential (mg/kg)
0	11.30a	1.50c	1.40b	4.10b	0.70ab	11.10a
2	10.40b	1.80bc	1.50b	4.60a	0.60ab	9.20a
4	9.80b	1.90bc	1.50b	4.70a	0.50bc	4.10b
7	8.90c	2.00ab	1.60ab	4.70a	0.30c	2.70bc
10	8.10c	2.20a	1.90a	4.80a	0.10c	1.00c

1. Mean of three replicates.

2. Means with the same letters in a column are not significantly different ( $P > 0.05$ ).

**Table 4:** Mean sensory scores of "fufu" flour in percentage.

Storage period (days)	EColour	Taste	Odour	Texture	Overall Acceptability.
0	94.00a	88.00a	82.00a	88.00a	96.00a
2	92.00a	72.00b	76.00ab	76.00b	82.00b
4	74.00b	60.00bc	70.00ab	62.00c	82.00b
7	64.00c	52.00c	60.00b	58.00c	70.00c
10	54.00c	48.00c	58.00b	40.00d	36.00d

1. Mean of sensory scores in percentages.

2. Means with the same letters in a column are not significantly different ( $P > 0.05$ ).

assessed. 'Fufu' from freshly harvested roots was ranked best in terms of colour, taste, odour, texture and overall acceptability with mean scores of 4.70, 4.40, 4.10, 4.40 and 4.80 respectively. The colour of 'fufu' from roots stored for 10 days had a dark colour and this was as a result of the discoloration of the pulp during storage. Biochemical and physiological reactions coupled with microbial activities are responsible for the deterioration and discoloration which also accounted for the dark colour in 'fufu' from the 10th day storage. There was no significant difference ( $p < 0.05$ ) in the overall - acceptability of 'fufu' obtained from roots stored for the first four days [29], reported that storage of cassava roots for up to 8 weeks does not significantly affect the colour, smell, elasticity and taste of cassava 'fufu'.

### Conclusion

The conclusion from the study was that it was possible to store fresh cassava roots in high density polyethylene bag for about seven days without any pronounced deterioration. Also the quality of the fermented product 'fufu' from the stored roots declined as the days of storage increases. However, "fufu" be produced from stored roots for seven days was considered to be of good quality. Post-harvest losses could be prevented by adopting the process of storage in high density polyethylene bag.

### References

1. FAO (1991) Food and Agriculture Organisation (FAO), Food outlook 15.
2. FAO (2007) Food and Agriculture Organisation (FAO), Food outlook 1.
3. Oyewole OB, SA Odunfa (1992) Effect of processing variables on cassava fermentation for fufu production. Tropical science. 231-240.
4. Rosenthal DM, Ort DR (2012) Examining cassava's potential to enhance food security under climate change. Tropical Plant Biology 5: 30-38. [Link: https://goo.gl/NhrRck](https://goo.gl/NhrRck)
5. Ketiku AO, Oyenuga VA (1992) Preliminary report on the carbohydrate constituents of cassava roots and yam tubers. Nigerian Journal of Science 4: 25-30. [Link: https://goo.gl/mSJU1M](https://goo.gl/mSJU1M)
6. Girma G, Bultosa G, Abera S (2015) Effect of cassava (Manihot esculenta crantz) variety, drying method and blending ratio on the proximate composition and sensory properties of cassava-wheat composite bread, European Journal of Food Science and Technology 3: 41-54. [Link: https://goo.gl/xfruxm](https://goo.gl/xfruxm)
7. Omosuli SV, Olumayede EG (2001) Effect of pre-process holding on some physical and chemical properties of cassava roots. NISEB Journal 1: 255-259.
8. Richard JE, Coursey DG (1981) cassava storage Parts 1: Storage of fresh cassava roots. Tropical Science 23: 1-32. [Link: https://goo.gl/5WvHnf](https://goo.gl/5WvHnf)
9. Obueh HO, Odesiri-Eruteyan E (2016) A Study on the Effects of Cassava Processing Wastes on the Soil Environment of a Local Cassava Mill. Journal of Pollution Effect and Control 4: 177. [Link: https://goo.gl/sD1w7D](https://goo.gl/sD1w7D)
10. Abass AB, Towo E, Mukuka I, Okechukwu R, Ranaivoson R, et al. (2014) Growing cassava: A training manual from production to postharvest. [Link: https://goo.gl/WBQJXB](https://goo.gl/WBQJXB)
11. Nabney J (1995) Transfer of cassava storage technology to Ghana. Newsletter of the Natural Resources Institute. Resources 7:13-14.

12. Shittu TA, Adedokun II (2010) Comparative evaluation of the functional and sensory characteristics of three traditional fermented cassava products. *Journal of Natural Sciences, Engineering and Technology* 9:106-116. [Link: https://goo.gl/ozkeqY](https://goo.gl/ozkeqY)
13. Arlington VA (2012) Official methods of analysis 18th ed. (AOAC) Association of Official Analytical Chemist. [Link: https://goo.gl/YzCrXg](https://goo.gl/YzCrXg)
14. Ibitoye AA (2005) Laboratory manual on Basic methods in Plant Analysis, Concept IT and Educational Consults, Akure, Nigeria 1-25.
15. Ikediobi CO, Onyia GO, Eluwah CE (1980) A rapid and intensive enzymatic assay for total cyanide in cassava (*Manihot esculenta crantz*) and cassava products. *Agriculture and Biology Chemistry* 44: 2803-2809. [Link: https://goo.gl/LcfUWr](https://goo.gl/LcfUWr)
16. Omosuli SV (1997) Effect of pre-process holding of cassava roots on "gari" quality. M.Sc Thesis. Dept. of Food Technology, University of Ibadan, Nigeria.
17. Ikujenlola AV, Lawson SO (2005) Improving the traditional processing techniques of "pupuru" (A fermented cassava product) *Nigerian Journal of Research and Production* 6: 103 -133.
18. Ikujenlola AV, Opawale BO (2007) Effects of processing on the yield and physico - chemical properties of cassava products. *Advanced Material Research* 18: 165 -170. [Link: https://goo.gl/ZW6TQW](https://goo.gl/ZW6TQW)
19. Omosuli SV, Olumayede EG (2000) Effect of pre-process holding on some Physical and Chemical properties of cassava roots. Paper presented at 1st Biennial conference of the Nigerian Society for Experimental Biology, Ilorin, Kwara State, 6-9th September, 2000.
20. Akingbala JO, Osunsanmi AT, Oguntimehin GB (1989) Effects of storage on starch content and modification of cassava. *Starch /Starke*. 41: 54-57. [Link: https://goo.gl/DwziAM](https://goo.gl/DwziAM)
21. Akingbala JO, Falade KO, Ogunjobi MA (2011) The Effect of Root Maturity, Preprocess Holding and Flour Storage on the Quality of Cassava Biscuit. *Food and Bio-process Technology* 4: 451-457. [Link: https://goo.gl/F8v1ga](https://goo.gl/F8v1ga)
22. Karim OR (1995) Effects of Root holding methods on fresh and processed cassava (Garri). M.Sc Thesis. Dept. of Food Technology, University of Ibadan.
23. Bokanga M (1995) Biotechnology and cassava processing in Africa. *Journal of Food Technology* 86-90.
24. Steel RG, Torrie JH (1980) Principles and procedures of Statistics (2nd Edition). New York: McGraw: Hill Books. [Link: https://goo.gl/s8NXZv](https://goo.gl/s8NXZv)
25. Hussein EA, Nwabueze TU, Sanni OL (2012) Nutritional Quality and Preference of Fufu processed from selected Cassava Mosaic Disease (CMD) Resistant Cultivars, *Advances in Applied Science Research* 3: 2687-2692. [Link: https://goo.gl/4GKCPs](https://goo.gl/4GKCPs)
26. Vasconcelos AT, Twiddy DR, Westby A, Reilly PJA (1990) Detoxification of cassava during Gari production. *International Journal of Food Science and Technology* 25: 198-208. [Link: https://goo.gl/sW1pRp](https://goo.gl/sW1pRp)
27. Ajala Lola, Otutu OL, Bamgbose A (2012) Effect of delayed processing on some physico-chemical properties of cassava starch. *American Journal of Food and Nutrition* 2: 31-36. [Link: https://goo.gl/77EKMm](https://goo.gl/77EKMm)
28. Oghenejoboh KM (2012) Effects of Starch Fermentation on the Shelf-life of Cassava Starch Based Adhesive. *British Biotechnology Journal* 2: 257-268. [Link: https://goo.gl/teUV33](https://goo.gl/teUV33)
29. Opare-Obisaw C, Asante IK, Annan EK (2004) Sensory Characteristics of Fufu Prepared with Cassava Roots (*Manihot Esculenta Crantz*) Stored in Polyethylene Sacks *International Journal of Consumer Studies* 28: 14-17. [Link: https://goo.gl/18ZQH8](https://goo.gl/18ZQH8)