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Effect of storage of cassava roots on the chemical composition and sensory qualities of gari and fufu

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The effect of storage of cassava roots (TMS 30572), at ambient temperature for 0–4 days, on percentage yield, chemical composition and sensory qualities of gari and fufu was investigated. Acidity of cassava roots did not change appreciably during storage, but moisture and cyanide contents decreased by 3·2 and 7·7%, respectively. Storage of cassava roots led to a reduction in cyanide content of gari and fufu. It also reduced the percentage yield of gari and fufu by 49·9 and 60·3, respectively. Moisture content, pH and acidity of gari and fufu, however, remained fairly constant irrespective of the length of storage of cassava roots. Also, acidity increased while cyanide content decreased during fermentation of gari and fufu mash. Storage of cassava roots was found to have no significant effect on the organoleptic qualities of gari and fufu.

INTRODUCTION

Cassava (*Manihot esculenta*) is one of the most important staple food crops in Nigeria. As the world's biggest producer of cassava in 1992, Nigeria contributed an estimated 22·4 million tonnes of cassava out of a total world production of 153·3 million tonnes (AAU, 1992). Most of the cassava produced in Nigeria is processed into various food forms for consumption rather than for industrial use. Such food forms include popular fermented products like gari and fufu. Gari in particular has been described as a major food resource for many people, not only in Nigeria, but also in other parts of Africa and in Latin America (Ukhun & Nkwocha, 1989). Fufu, on the other hand, is widely eaten in Nigeria and many parts of West Africa (Okechukwu & Okaka, 1984).

Investigations into the toxicity, post-harvest deterioration and processing of the cassava roots into gari and fufu, including the role of fermentation in the development of desired flavour and reduction of cyanide content during processing, are well documented (Montgomery, 1980; Maduagwu & Oben, 1981; Odunfa, 1985; Almazan & Han, 1987; Akingbala *et al.*, 1991; Plumbley & Rickard, 1991). However, most research investigations on gari and fufu are centred on their production from freshly harvested cassava roots whereas, at the village farm level and in many urban centres where most of the gari and fufu brought to the market is prepared, cassava roots, inadvertently, are often stored at ambient temperature for two to three days prior to processing either due to transportation problems between the farm sites and the processing centres, or delay in processing caused by the slow manual peeling process that is often employed. Hence information is scanty on gari and fufu produced from stored cassava roots. This paper reports the effect of storage of cassava roots on the percentage yield, chemical composition and sensory qualities of gari and fufu. It also provides data on changes in acidity and cyanide content of gari and fufu mash during fermentation.

MATERIALS AND METHODS

Freshly harvested cassava roots (TMS 30572) obtained from the farm of the University of Agriculture, Abeokuta, were stored at ambient temperature (25–30°C) for a period of zero to four days before processing into gari or fufu.

Preparation and determination of percentage yield of gari and fufu

Gari was prepared from either fresh or stored cassava roots as described by Ukhun and Nkwocha (1989), while fufu was prepared using a traditional method (Akingbala *et al.*, 1991).

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For gari preparation, 10 kg cassava roots were peeled, washed and grated using a Lister Diesel grating machine (2·7 kw, 3·5 hp). The grated pulp was packed into a jute bag and pressed to remove unwanted liquid. The pulp was fermented for 96 h, sifted to remove coarse fibre and roasted at about 80°C to obtain gari. For preparation of fufu, 10 kg cassava roots were peeled, washed, cut into pieces and steeped in water for 96 h to soften and ferment the pulp. The fermented mash was washed over a fine sieve to remove fibre while the starch extract was dewatered by pressing inside a cotton bag to obtain fufu.

The yield was determined from the weight of product (gari or fufu) per unit weight of peeled cassava.

Chemical analysis

The acidity (as lactic acid) was determined by the method of Oyewole and Odunfa (1985); pH was determined using a Kenteil 7020 pH meter and moisture content by the method of SON (1988). For the determination of hydrogen cyanide content, 10 g sample was diluted with 20 ml distilled water and an Ogawasaki cyanide ion-selective electrode was used after the instrument had been calibrated with 0·1 and 10 ppm standard solutions of potassium cyanide.

Sensory evaluation

A taste panel evaluation of gari was conducted using a panel of 10 judges who were regular gari eaters. The judges were asked to score for colour, odour, taste and overall acceptability using a 9-point hedonic scale, where 1 and 9 represent dislike extremely and like extremely, respectively. Gelatinised pastes of gari ('eba') and fufu were also prepared with boiling water at a ratio of 2 : 3 (flour : water). For 'eba', a descriptive sensory evaluation was used to assess the mouldability and stickiness. Similar procedures as described for gari were used for fufu paste except that the panellists were asked to score for texture in addition to other attributes assessed. Responses of the panellists were subjected to statistical analysis of variance and means were separated by Duncan's Multiple Range test to establish if there were significant differences between the samples (Larmond, 1977).

Table 1. Chemical properties of cassava roots during storage

Storage period (days)	Chemical property			
	Moisture content (%)	pH	Titratable acidity (%)	Cyanide content (mg/100 g)
0	61·2	6·6	0·02	13·0
1	61·0	6·6	0·02	12·7
2	60·0	6·5	0·02	12·4
3	59·0	6·4	0·02	12·0
4	58·0	6·3	0·02	12·0

RESULTS AND DISCUSSION

Chemical properties of cassava roots during storage

Moisture and cyanide contents of cassava roots decreased from 61·2% and 13·0 mg/100 g to 58·0% and 12·0 mg/100 g, representing a 3·2 and 7·7% decrease, respectively, in the original moisture and cyanide contents of the cassava roots within the four days of storage at ambient temperature (Table 1).

Although the pH decreased slightly from 6·6 to 6·3 on the fourth day of storage, the drop in pH did not lead to a detectable difference in the acidity of cassava roots as reflected by a fairly constant 0·02% titratable acidity recorded throughout the four days of storage. The slight reduction in moisture content of the cassava roots is a reflection of the relative humidity and the ambient temperature at the time of the experiment (May/June). Greater dryness of the roots may occur during harmattan (Nov./Dec.). The decrease in cyanide content could be due to production of free cyanide as a result of contact of linamarin with linamarase at the bruised spot on the cassava roots as reported earlier by Aalbersberg and Limalevu (1991).

Chemical properties and percentage yield of gari and fufu

Moisture content, pH and titratable acidity values range from 9·9 to 10·5%, 4·0 to 4·2 and 0·20 to 0·23%, respectively for gari, while the range is from 51·1 to 53·0%, 4·1 to 4·2 and 0·20 to 0·23%, respectively for fufu (Table 2). The fairly close values of moisture content, pH and titratable acidity, irrespective of the

Table 2. Effect of storage of cassava roots on the chemical properties and percentage yield of gari and fufu

Storage period (days)	Gari					Fufu				
	Moisture content (%)	pH	Titratable acidity (%)	Cyanide content (mg/100 g)	Yield (%)	Moisture content (%)	pH	Titratable acidity (%)	Cyanide content (mg/100 g)	Yield (%)
0	10·4	4·1	0·22	1·40	67·1	52·0	4·2	0·20	0·97	36·0
1	10·5	4·1	0·22	1·15	66·5	51·5	4·2	0·20	0·80	17·4
2	9·9	4·0	0·23	1·05	62·7	53·0	4·1	0·21	0·70	16·4
3	10·2	4·2	0·20	0·96	44·8	52·0	4·2	0·20	0·55	15·3
4	10·3	4·1	0·22	0·87	33·6	51·0	4·2	0·20	0·50	14·3

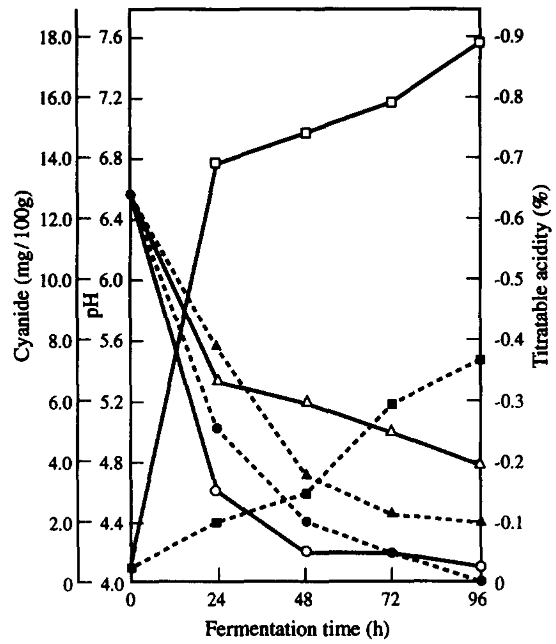

Fig. 1. Changes in chemical composition during fermentation. Gari: ○, pH; □, acidity; △, cyanide. Fufu: ●, pH; ■, acidity; ▲, cyanide.

length of storage of cassava roots, suggest that the above chemical properties of gari and fufu may be processing-technology-dependent since the same processing technique was employed for the production of all the gari and fufu samples, respectively.

Percentage yield and cyanide content, however, decreased from 67·1% and 1·40 mg/100 g to 33·6% and 0·87 mg/100 g for gari and from 36·0% and 0·97 mg/100 g to 14·3% and 0·5 mg/100 g for fufu, respectively, after four days of storage of cassava roots. Processing was found to result in a great reduction of cyanide content of cassava products (gari and fufu) compared with a fairly stable cyanide content of stored cassava roots (Tables 1 and 2). Although the decrease in percentage yield is slight for gari within the first two days of storage, it is drastic for fufu production throughout the storage period as reflected by about 52 and 60·3% decrease in yield of fufu, respectively, for the second and fourth days of storage of cassava roots.

Table 3. Mean scores for sensory evaluation of gari processed from cassava stored for 0–4 days

Gari sample[a]	Mean score[b]			
	Colour	Taste	Odour	Overall acceptability
G0	6·89a	6·33a	5·11b	6·33b
G1	6·22b	6·11a	6·22a	6·44b
G2	6·11b	5·66b	6·77a	7·55a
G3	5·89b	6·00a	6·44a	6·55b
G4	5·89b	5·00c	6·00a	6·00b

[a]G0, G1, G2, G3, and G4 are gari samples from cassava stored for 0, 1, 2, 3, and 4 days, respectively.
[b]Mean scores with the same letters in a column are not significantly different ($P < 0{\cdot}05$).

The decrease in yield of gari could be due to deterioration of the cassava roots which was observed to appear in the form of blue–black discoloration after the second day of storage (Plumbley & Rickard, 1991). During fufu production, retting of cassava is probably affected by storage, due to loss of activity of retting enzymes such as amylases and pectin-methyl esterases which have been established to be present in cassava roots during submerged fermentation (Oyewole, 1991). Furthermore, storage appears to contribute to detoxification of not only the cassava roots but also the products (i.e. gari and fufu). The different cyanide contents recorded for gari and fufu samples over the four days of cassava storage are a reflection of the initial cyanide contents of cassava roots used as raw material.

Changes in the chemical composition of fermenting mash of gari and fufu

Analysis of the fermenting mash of gari and fufu showed an increase in acidity and a decrease in pH and cyanide content as the period of fermentation increases (Fig. 1). This result is similar to the findings of Akingbala *et al.* (1991) during fufu fermentation of low-cyanide cassava. The increase in acidity which is more pronounced in gari than fufu mash was due to production of organic acids during fermentation (Collard & Levi, 1959). The decrease in cyanide content during fermentation also agrees with the findings of Aalbersberg and Limalevu (1991). Detoxification of cyanide within the fermenting mash of gari after 24 h was more rapid than in fufu mash because of the expression of cyanide through the waste water. However, fufu attained a lower cyanide content than gari after 96 h fermentation and this agrees with the view that soaking coupled with fermentation is more effective than fermentation alone (Almazan, 1992).

The fermenting gari mash almost attained a terminal pH after 48 h and only a slight drop in pH was observed after 96 h fermentation. Hence 48 h fermentation may be enough for the development of the desired flavour during gari production.

Sensory evaluation of gari and fufu

The results of sensory evaluation are presented in Table 3. Although the gari sample processed from cassava stored for two days (G2) was better rated than other gari samples in terms of odour and overall acceptability, analysis of variance showed that none of the gari samples was significantly different in terms of colour, taste, odour, and overall acceptability ($P < 0{\cdot}05$). However, 'eba' made from gari processed after two days of cassava storage (G2) was described as most acceptable by the panellists while 'eba' made from gari processed after the third and fourth days of cassava storage (G3 and G4) was described as unacceptable because of poor stickiness and mouldability. This result may be due to a decrease in starch content of cassava during storage (Osunami *et al.*, 1989). Sensory evaluation results ob-

Table 4. Mean scores for sensory evaluation of fufu processed from cassava stored for 0–4 days

Fufu sample[a]	Mean score[b]				
	Colour	Taste	Odour	Texture	Overall acceptability
F0	7·78a	6·22a	6·22a	7·20a	7·00a
F1	7·56a	6·89a	7·11a	7·11a	7·00a
F2	6·78b	6·44a	6·67a	6·11b	6·56a
F3	6·00b	6·22a	6·44a	6·56a	6·78a
F4	6·56b	5·78a	6·44a	6·56a	6·56a

[a]F0, F1, F2, F3 and F4 are fufu samples processed from cassava stored for 0, 1, 2, 3 and 4 days, respectively.
[b]Mean scores with the same letters in a column are not significantly different ($P < 0{\cdot}05$).

tained for fufu were similar to those of gari (Table 4). All the fufu samples had close scores and are not significantly different in terms of colour, taste, odour, texture or overall acceptability ($P < 0{\cdot}05$). However, fufu processed from zero (fresh cassava) and one-day-storage cassava (i.e. F0 and F1) were better rated than all other samples in terms of colour, texture and overall acceptability.

CONCLUSION

Although storage at ambient temperature for 0–4 days may help to detoxify cassava roots and their products (gari and fufu), it could also lead to drastic reduction in percentage yield of fufu. However, storage for 0–2 days did not affect the yield of gari substantially and organoleptic properties of gari and fufu are not significantly affected by storage of cassava roots.

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