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Residual β-carotene and Cyanide Levels in Gari Produced from Unfermented Yellow Cassava (*Manihot esculenta* Crantz) Using Local Processing Method

V. E. Osagie[1*], I. A. Onimawo[1] and O. E. Alamu[2]

[1]Department of Biochemistry, Faculty of Life Sciences, Ambrose Alli University, Ekpoma, Edo State, Nigeria.
[2]International Institute for Tropical Agriculture, Ibadan, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author VEO in collaboration with author IAO designed the study. He in addition processed the cassava into gari, analysed the results and wrote up the manuscript and managed the literature searches. Author IAO conceptualized the study and gave the general direction of the study. Author OEA did the practical analyses in his laboratory. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This study was carried out to determine the level of the retained β-carotene in processing yellow cassava (variety IITA TMS 01/1371 or UMUCASS 38) into gari using local processing method, in addition, it was also carried out to determine the residual cyanide after processing (fermented and unfermented) the yellow-fleshed cassava into gari.
Place of Study: Department of Biochemistry, Ambrose Alli University Ekpoma and International Institute for Tropical Agriculture Ibadan.
Methodology: High performance liquid Chromatography (HPLC) was used to determine the level

**Corresponding author: E-mail: vicehiosa@aauekpoma.edu.ng;*

of β-carotene in gari produced from fermented and unfermented yellow cassava while the cyanide level was determined by an automated Enzymic method.

Results and Discussion: It showed that the gari produced from fermented yellow cassava had a higher level of β-carotene depending on the number of days of fermentation compared with the gari from unfermented yellow cassava. The gari produced from unfermented cassava had the least content of β-carotene (8.076±0.311 ug/g) during the first week of storage compared with those produced from fermented cassava (10.600±0.470 - 20.610±0.098 ug/g). There was a reduction in the β-carotene contents in all groups during the 5week storage period. The rate of loss of β-carotene over a five week period showed that the gari from unfermented cassava had the least rate of loss (0.885 ug/week) compared with the gari from fermented cassava over the same period (0.955-2.447 ug/week). However the level of Hydrogen cyanide (HCN) retained was more in the gari from unfermented yellow cassava (3.160±0.006 mg/100 g) compared with the gari from fermented cassava (0.470±0.046-1.423±0.006 mg/100 g).

Conclusion: On the basis of the result, it is suggested that yellow cassava should be fermented before being roasted into gari and adequate method of storage be adopted to reduce loss of β-carotene while in storage.

Keywords: β-carotene; cyanide; unfermented; gari; yellow cassava.

1. INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is a tropical root crop which is normally propagated by vegetative stem cuttings. It is a major staple food for millions of people in the tropics and sub-tropical regions [1]. It is well known for its wide adaptability to different environmental conditions due to its ability to grow under conditions considered suboptimal for the majority of other food crops. Because cassava tubers contain very low level of protein (0.7-2%) it has often been regarded as the poorest in nutritional quality of the staple foods in these regions. In addition, it also contains some vitamins (ascorbic acid and carotenoids). Most white varieties lack carotenoids but the yellow cassava exists in Brazil and has been found to contain β-carotene (a pro-vitamin A substance) [2]. The carotenoids are a group of over 700 naturally occurring plant pigments. Selecting cassava varieties with high β-carotene content may contribute significantly to solving the problem of vitamin A deficiency in poor countries [3]. It has been evaluated and found that some varieties of cassava rich in β-carotene can sufficiently meet the vitamin A daily requirement in adults [4]. However, one of the major fears regarding the consumption of cassava is the presence of cyanide in the form of cyanogenic glycosides. Two glycosides linamarin and lotaustralin are synthesized and stored inside the cells while the enzyme responsible for the hydrolysis, linamarase is stored in the cell wall. There is no free Hydrogen cyanide (HCN) in plant. Only when the plant cells are ruptured does the enzyme come in contact with linamarin. This is then hydrolysed to acetone cyanohydrins which may spontaneously or upon the action of a second enzyme be decomposed into acetone and HCN [5]. Processing of the raw cassava into various edible products reduces the level of cyanide [6,7]. Various varieties are usually differentiated from one another by their morphological characteristics such as colour of stem, petioles, leaves and tubers [8]. The presence of carotenoids and the absence of cyanide are the two major factors when considering the nutritional and safety qualities of processed cassava for human consumption. Luckily, the selection of cassava high in carotenoid resulting in yellow-fleshed cassava has been achieved. Carotenoids from foods often have low bioavailability because of a variety of food matrix effects [9] therefore applying different food-processing techniques such as fermentation will definitely improve the carotenoid bioavailability. Reports exist of the retention of β-carotene after processing, using different processing methods on this improved cassava [10,11]. The aim of the present study is to determine the level of carotenoid present, represented by the level of β-carotene, in processing a variety (IITA TMS01/1371 or UMUCASS 38) of yellow cassava into gari which is a major staple food in Nigeria. The study is also to determine the residual cyanide after processing the fermented and unfermented yellow-fleshed cassava into gari. Finally, this study is to find out the implication of processing yellow cassava into gari without the fermentation process with reference to the residual β-carotene and cyanide as practiced in our local environment. The effect of long term storage of the gari as it affects the β-carotene level will also be determined.

2. MATERIALS AMD METHODS

2.1 Samples

Freshly harvested samples of yellow cassava variety IITA TMS 01/1371 were obtained from the International Institute of Tropical Agriculture Ibadan Nigeria (IITA).

2.2 Gari Production

The local method of gari production was adopted. The cassava samples were washed in distilled water, peeled with a knife and grated in a machine. The grated cassava had a portion removed immediately and processed into gari by roasting over firewood heat to obtain a granulated product, gari. The rest portion was allowed to ferment for about three days in water. Samples were taken after each day and pressed thoroughly to expel water and roasted into gari. These samples were then stored in screened containers to eliminate light for a 5 week period during which analyses were carried out.

2.3 β-carotene Analysis

The level of retained β-carotene was extracted and determined in gari produced from fermented and unfermented yellow cassava using High performance liquid chromatography (HPLC), based on a standard HarvestPlus procedure [12, 13]. The level of residual HCN was also determined in the gari so produced using the procedure as described by Rao and Hahn [14].

3. RESULTS

3.1 Statistics

Data collected from this study were subjected to analysis of variance using computer SPSS software. The differences between means were separated by Turkey-Kramer multiple comparison test.

Table 1 shows the result of residual β-carotene content of gari in unfermented and fermented gari which were stored over a period of time. The result showed that the unfermented yellow cassava recorded the least level of β-carotene while the sample subjected to 3 days of fermentation recorded the highest amount. As the storage period increased, there was loss of the β-carotene present. Table 2 represents the rate of loss of β-carotene over a 5 week period. The unfermented sample had the least rate of loss of β-carotene and the sample fermented for 2 days recorded the highest rate of loss. Table 3 represents the cyanide content of the gari so produced. The unfermented cassava recorded the highest residual cyanide level and the cassava that was fermented for 3 days recorded the least amount of residual cyanide.

4. DISCUSSION

It was observed that the gari produced from fermented yellow cassava had a relatively higher level of β-carotene (10.600±0.271 - 20.610±0.056 µg/g) depending on the number of days of fermentation compared with the gari from unfermented yellow cassava (8.076±0.179 µg/g) and this is also dependent on the period of storage. This result may indicate that β-carotene molecules may be located in cassava cells that may require the process of fermentation to expose. This is in agreement with earlier reports that in higher plants, carotenoids compounds are synthesized and localised in cellular plastids and present as semi-crystalline structures derived from the plastids [15,16]. Cell wall and chromoplast substructure have been identified as the main barrier for the release of β-carotene in carrot during digestion; this may also be true during fermentation [17]. However, there was a reduction in the β-carotene contents in all the groups during the 5-week storage period. The rate of loss of β-carotene over a five week storage period showed that the gari from unfermented cassava had the least rate of loss (0.885 µg/week) compared with the gari from

Table 1. β-carotene content of gari prepared from yellow cassava

Treatment	Storage period		
	Week 1 (µg/g)	Week 3 (µg/g)	Week 5 (µg/g)
Unfermented	8.076^{a} ±0.311	5.940^{a} ±0.062	4.546^{a} ±0.012
Fermented day 1	10.600^{b} ±0.470	7.883^{b} ±0.133	6.906^{b} ±0.140
Fermented day 2	19.320^{c} ±0.395	13.257^{c} ±0.035	9.570^{c} ±0.035
Fermented day 3	20.610^{d} ±0.098	14.510^{d} ±0.080	11.497^{d} ±0.132

Results represent mean ± standard deviation (SD) of three replications. Values with same superscript that are in a column are not significantly different (P>0.05)

fermented cassava over the same period (0.955-2.440 µg/week). This observation may result from the effect of the cassava microstructure on the release of the β-carotene. It had earlier been reported that food microstructure do affect several nutrients bioavailability [18]. Therefore unfermented cassava may still have its microstructure more intact compared with fermented cassava. So fermentation may have softened the tissue, hence less ability to retain the β-carotene over a long period of time while in storage.

Table 2. Rate of loss of β-carotene per week

Unfermented (ug/week)	Fermented (ug/week)		
	Day 1	Day 2	Day 3
0.885	0.955	2.447	2.290

Results represent the rate of loss of β-carotene per week in the produced gari stored over a 5 week period

Table 3. Cyanide content of gari from yellow cassava

Treatment	mg/100 g
Fermented day 1	1.423^{a} ±0.006
Fermented day 2	1.150^{b} ±0.000
Fermented day 3	0.470^{c} ±0.050
Unfermented	3.160^{d} ±0.006

Results represent mean ± standard deviation (SD) of three replications. Values with the same superscript in a column are not significantly different (P>0.05)

The level of HCN retained was more in the gari from unfermented yellow cassava (3.16±0.006 mg/100 g) compared with the gari from fermented cassava (0.47±0.005-1.42±0.006 mg/100 g). Though this value is well below the lethal dose for a man (30-120 mg) or 0.5-3.5 mg/kg body weight [19,20] it is important to observe that the unfermented gari recorded the highest residual cyanide content.

5. CONCLUSION

Based on the results obtained in this study, it is suggested that yellow cassava should be fermented for 3 days for the maximum level of β-carotene to be obtained in the gari, which will in addition, also contain the least amount of residual cyanide before being roasted into gari. Adequate method of storage should also be adopted to reduce loss of the β-carotene while in storage. This may be achieved by storing gari in darkened containers since β-carotene is light sensitive.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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