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Effect of Cooking Time on Starch and Cyanide Contents of Freshly Harvested Cassava Tubers Used for Tapioca Production

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Authors' contributions

This work was carried out in collaboration between all authors. Author ORE designed the study, managed the literature searches and wrote the first draft of the manuscript. Author MUE managed the analyses of the study while author ZOI performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

This study investigated the effect of cooking time on starch and cyanide contents of freshly harvested cassava tubers used for tapioca production. Tapioca is a cassava meal commonly consumed in most part of the world and prepared from freshly harvested cassava tubers. The cassava tubers used for tapioca production are first boiled and sliced, before soaking in water overnight. The cassava tubers used for this study were harvested from the eastern farm of National Root Crops Research Institute, Umudike in Abia State, Nigeria. Some freshly harvested cassava tubers were subjected to 90 minutes cooking in clean water and at intervals of 15 minutes, samples were collected for starch and cyanide analyses. The result showed that increase in cooking time decreased the starch and cyanide contents of the cassava samples. Starch was reduced from 13.37% to 4.65% for every 2 g of starch tuber given 65.22% reduction after 90 minutes. The cyanide content was reduced from 36.65±0.16 to 2.49±0.08 mg/kg after 90 minutes of boiling, given a 93.2%

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reduction. The statistical analysis on the effect of cooking time on starch and cyanide contents showed significant mean difference ($P < 0.0001$) at both 5% and 1% levels of the various cooking time of the cassava. It is recommended that cassava used for tapioca production should be adequately cooked to reduce the cyanide content which could result in food poisoning.

Keywords: Freshly harvested cassava tubers; starch content; cyanide content; cooking time.

1. INTRODUCTION

Cassava (*Manihot escilanta,* crantz) is a root tuber crop that is widely cultivated in the tropical regions of the world [1]. Cassava is grown primarily for its starchy tuberous roots, which are important staple food for more than 800 million people in parts of Africa, Asia and South America [2]. According to Food and Agriculture Organization (FAO) of the United Nations Global Cassava Development Strategy [3], cassava is the third most important source of calories in the tropics, after rice and corn. Millions of people depend on cassava in Africa, Asia and Latin America. It is grown by poor farmers, many of them women, often on marginal land. This crop is vital for both food security and income generation. Cassava tubers are processed in Nigeria into various products like garri, cassava meal, fufu, flour, chips, alibo, tapioca etc. Tapioca is a traditionally prepared meal from cassava tuber consumed in different parts of the world. There are various methods of tapioca preparation, however, in the eastern part of Nigeria where locally prepared tapioca (abacha) is consumed, the cassava tuber is peeled, boiled, sliced into tiny bits or shredded before soaking in fresh water overnight.

Of the global production of cassava, approximately 140.9 million metric tones are produced in Africa. Nigeria accounted for 38.3 million metric tones per annum [4]. Currently, Nigeria is the highest producer of cassava in the world [4]. Recently, the Nigerian Government encouraged her citizens to grow and process more cassava for domestic and international needs, resulting to increase in production and processing. A food safety problem with cassava is that cassava root contains considerable quantities of cyanide which occurs in the form of cyanogenic glycosides [5]. Roots and leaves contain the highest amount of cyanogenic glycosides [6]. These cyanogenic glycosides break down to release toxic hydrogen cyanide gas during digestion [7,8]. The amount of these toxic compounds varies according to cultivars and growing conditions [9]. The toxic effect of cyanogenic glycosides ranges from diarrhea to severe gastroenteritis, often leading to death.

Despite the presence of these naturally occurring toxins, millions of people all over the world have been safely consuming cassava for hundreds of years. The on-going challenge is to ensure that the presence of these cyanogenic glycosides is minimized through proper processing. Today, various methods are employed in different parts of the world where cassava is consumed [10]. These methods consist of different combinations of peeling, chopping, grating, slicing, soaking, drying, frying, boiling and fermenting. While all these methods reduce the cyanide level, the reported loss in cyanide content differs considerably due to analytical methods, the combinations of methods and the extent of which the process is carried out. In Africa, where cassava flour is a major food product, wetting is an effective method of removing cyanide [11,12]. In the Pacific where cassava is a dietary staple, boiling freshly harvested cassava root is the norm. Cooke and Maduagwu [13] reported a 55% reduction of bound cyanide by cooking of cassava. Fifty to sixty percent (50-60%) reduction was reported by Aalbersberg and Limalevu [14] while Nambisan and Sundaresan [15] obtained 25-75% reduction of cyanide. The figures by Nambisan and Sundaresan [15] were dependent on cooking time and chip size, with smaller chip size recording highest cyanide losses.

Many methods of processing cassava roots commence with the peeling of the tubers. Generally, the cassava peel contains higher cyanide content than the pulp. Removal of the peels therefore reduces the cyanogenic glycoside content considerably [16]. Although boiling has been reported to be one of the major ways of cyanide removal from cassava, FAO [17] reported that nutrients may be lost during cooking by leaching into the cooking medium. Boiling therefore resulted in a 20-30% loss of vitamins C from unpeeled roots and tubers [17]. This study aimed at investigating the effect of cooking time on starch and cyanide contents of cassava, will be of great benefit to people processing cassava for tapioca and other uses.

2. MATERIALS AND METHODS

2.1 Sample Collection

Fresh cassava tubers were obtained from the eastern farm of the National Root Crops Research Institute, Umudike, Abia State and transported to the National Research Laboratory for analysis.

2.2 Preparation of Sample

Fresh samples of harvested cassava tubers were peeled and washed with clean water before analysis. Some quantities of cassava tubers were boiled for 90 minutes in fresh water, following the traditional process of tapioca production and allowed to cool. The samples were analyzed for starch and cyanide contents at every 15 minutes interval.

2.3 Determination of Hydrogen Cyanide

The hydrogen cyanide content of the boiled cassava samples were determined every 15 minutes, using the method described by Onwuka [18]. 5 g of each sample was blended into a paste and dissolved in 50 mL of distilled water in a conical flask and allowed to stay overnight before filtering. 2 mL of the filtrate was poured into another conical flask and 4mL alkaline picrate solution was added and the content incubated in a water bath for 5 minutes for colour change (reddish-brown) and absorbance taken at 450 nm. The blank and standard test (which serves as control) was prepared using 1 mL distilled water and 4mL alkaline picrate solution.

Calculation: 100/W × An/As × C × Vf/Va × 1/106 (mg/kg)

Where Vf= total volume of extract
Va= volume of extract used
An= Absorbance of sample
As= Absorbance of standard
C= concentration of standard

2.4 Determination of Starch Content

The percentage starch content was determined every 15 minutes of boiling, using the spectrophotometer method (Spectrotomic 20D M-Tech Instrument, USA) as described by Radley [19] with slight modification. Freshly harvested tuber of cassava was cut into ten small pieces of 10.0 g each and boiled in water. After every 15 minutes interval, a piece of the boiled sample was removed and 2.0 g weighed out and used for the analysis. The 2.0 g of the sample was blended and dissolved in 50 mL of cold water and allowed to stand for an hour. 20 mL of HCl and 150 mL of distilled water were added to the sample and refluxed for 2 hours in a round bottom flask. This was later cooled and neutralized with 0.5N NaOH. The contents were used for glucose determination using anthrone reagent. Series of glucose solution was prepared containing 0 ppm, 2 ppm, to 10 ppm to calibrate the glucose standard concentration. 5 mL anthrone reagent was added to each of the standard and test sample and boiled in a water bath for 20 minutes for colour development. The test tubes were cooled and absorbance was taken at 620nm against a black containing only 1 mL of water and 5 mL of anthrone reagent.
Calculation;

Starch= A XS.R X 100 X20/V XW

Where A is absorbance
SR is slope ratio
V is volume of sample
W is weight of sample

Starch =Glucose X 0.9

Standard Curve Equation

Y= 0.0102X*0.3325

2.5 Calculation for Percentage Reduction of Starch

$$\frac{\text{Control value} - \text{sample value}}{\text{Control value}} \times 100$$

2.6 Statistical Analysis

The data was analyzed using Statistical Package for Social Sciences (SPSS) version 20.0. The means of the various cassava species were compared using ANOVA. Statistical significance tests included the use of *p-value* to assess for the role of chance. In this study, p-value = 0.05 was used to disapprove the null hypothesis.

3. RESULTS

Table 1 shows the effect of cooking time on starch content of freshly harvested cassava tubers. The uncooked cassava tuber which serves as the control has 13.37 g starch. However cooking for 15 minutes reduced the starch content to 8.11 g (39.34% reduction). At 60 minutes of cooking, the starch content reduced further to 6.56 g (50.93% reduction), but at 90 minutes of cooking, 65.22% of the starch was reduced.

Table 2 shows the effect of cooking time on cyanide content of fresh cassava tubers. After 15 minutes of cooking, the cyanide content of 36.56±0.16 was reduced to 19.62±0.07 mg/kg (46.5% reduction). After 60 minutes, the cyanide reduced further to 6.28±0.15 (i.e. 82.9% reduction) while at 90 minutes, 93.2% reduction of cyanide was obtained. The statistical analysis on the effect of cooking time and cyanide content showed there is a significant mean difference ($P < 0.0001$) of cyanide at both 5% and 1% levels of the various cooking time of the cassava.

4. DISCUSSION

Tapioca is a traditionally prepared cassava meal in most part of the world. However, the preparation differs from one locality to the other. In the eastern part of Nigeria, tapioca preparation starts with peeling the freshly harvested cassava tuber. The cassava is then washed and boiled in water, sliced or shredded before soaking overnight in water. This study investigated the effect of cooking time on starch and cyanide contents of freshly harvested cassava tubers used for tapioca. The results obtained showed that cooking time decreased both the starch and cyanide contents of cassava. Boiling the cassava tubers for 15 minutes reduced the starch content from 13.37% to 8.11%, giving a 46.5% reduction. However, at 90 minutes cooking time, 65.22% reduction was obtained. These findings agree with the reports of other authors where increased temperature resulted to loss of amylase and starch [20,21]. FAO [17] reported that nutrients may be lost during cooking by leaching into the cooking medium. However, the presence of starch in the cooking medium was not carried out in this study. Noranizan et al. [22], working on the effects of heat on the physico-chemical properties of starch from different botanical sources, observed that all starches excluding wheat starch, showed a decreasing pattern as heating condition increased. Regardless of the decrease in percentage starch obtained from this study due to cooking in water at 90 minutes (65.22% for every 2 g of starch), its essentiality as a source of carbohydrate is not substantially diminished.

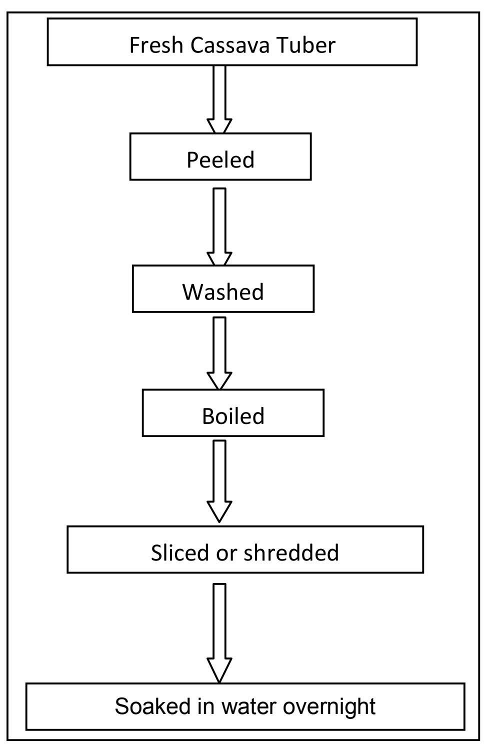

Fig. 1. Flow chart for tapioca processing in Eastern Nigeria

Table 1. Effect of cooking time on starch content of cassava tubers

Cooking time	Absorbance	SR	W(g)	V(mL)	Glucose	Starch (2g)	% reduction
0 Mins (ctrl)	0.758	98	2	5	14.85	13.37	0
15 Mins	0.460	98	2	5	9.016	8.11	39.34
30 Mins	0.398	98	2	5	7.800	7.02	47.49
60 Mins	0.372	98	2	5	7.291	6.56	50.93
75 Mins	0.345	98	2	5	6.769	6.08	54.52
90 Mins	0.264	98	2	5	5.174	4.65	65.22

Table 2. Effect of cooking time on cyanide content of fresh cassava tubers

Cooking time	Mean ± SD (mg/kg)	% reduction of cyanide	F calculated	p-value	Remark
0 Mins (ctrl)	36.65±0.16	0			
15 Mins	19.62±0.07	46.5			
30 Mins	12.58±0.10	65.7			
45 Mins	8.76±0.22	76.1	9633.773	p-value < 0.0001	Significant
60 Mins	6.28±0.15	82.9			
75 Mins	4.81±0.05	86.9			
90 Mins	2.49±0.08	93.2			

Cooking time on cyanide content also resulted in the reduction of cyanide from 36.65±0.16 to 2.29±0.08 (mg/kg) after 90 minutes, giving a 93.2% reduction. Tewe [23] obtained a 90.0% removal of free cyanide within 15 minutes of boiling fresh cassava chips, while Cooke and Maduagwu [13] recorded a 55.0% reduction in bound cyanide after 25 minutes. However, Tchacondo et al. [24] obtained a 53.6% reduction, though the cooking time was not specified. Bradbury and Denton [25] noted that warm water favours the elimination of HCN vapour. It is therefore necessary to create awareness on the importance of cooking time in the elimination of cyanide as a way of ensuring food safety, yet not diminishing the use of starch as a source of carbohydrates.

5. CONCLUSION

Cyanogenic glycosides in cassava tubers have greatly affected the utilization of cassava as food source. Boiling has shown to be one of the major processes of reducing the chemical (cyanide). Although starch as a good source of carbohydrate was also reduced (as observed from this study), the percentage reduction does not substantially diminish its purpose as a carbohydrate source. Relevant Government agencies should mount aggressive campaign to sensitize and educate the peasant farmers and consumers of tapioca on the dangers of taking poorly processed cassava meals and the diseases associated with the intake of these meals. Consumers should be advised to boil cassava tubers adequately before consumption.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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