



NUTRITIONAL AND TOXICOLOGICAL COMPOSITION ANALYSIS OF SELECTED CASSAVA PROCESSED PRODUCTS

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ABSTRACT

Cassava (*Manihot esculanta* Crantz) is an important food source in tropical countries where it can withstand environmentally stressed conditions. Cassava and its processed products have a high demand in both local and export market of Sri Lanka. MU51 cassava variety is one of the more common varieties and boiling is the main consumption pattern of cassava among Sri Lankans. The less utilization of cassava is due to the presence of cyanide which is a toxic substance. This research was designed to analyse the nutritional composition and toxicological (cyanide) content of Cassava MU51 variety and selected processed products of cassava MU51 (boiled, starch, flour, chips, two chips varieties purchased from market) to identify the effect of processing on cassava MU51 variety. Nutritional composition was analysed by AOAC (2012) methods with modifications and cyanide content was determined following picric acid method of spectrophotometric determination. The Flesh of MU51 variety and different processed products of cassava had an average range of moisture content (3.18 – 61.94%), total fat (0.31 – 23.30%), crude fiber (0.94 – 2.15%), protein (1.67 – 3.71%) and carbohydrates (32.68 – 84.20%) and where they varied significantly in between products and the variety MU51, where no significance difference ($p > 0.05$) observed in between MU51 flesh and processed products' ash content where it ranged (1.02 – 1.91%). However, boiled product and MU51 flesh had more similar results in their nutritional composition where they showed no significant difference at any of the nutrient that was analysed. Thus, there could be no significant effect on the nutrient composition of raw cassava once it boiled. Cyanide content of the MU51 flesh and selected products (boiled, starch, flour and chips prepared using MU51 variety), showed wide variation ranging from 4.68 mg.kg⁻¹ to 33.92 mg.kg⁻¹ in dry basis. But except boiled cassava all processed products had cyanide content <10 mg.kg⁻¹, which is the safe level recommended by the Codex Alimentarius Committee of the FAO/WHO. Thus, preparing products such as flour, starch and chips using MU51 variety could be safe for human consumption.

Keywords: Cassava; cyanide; MU51; nutritional composition; toxicological content

INTRODUCTION

Cassava (*Manihot esculanta* Crantz) is long tuberous root crop which is first originated in Brazil and then dispersed to other parts of the world such as Africa, India and South East Asia. Cassava belongs to the family of Euphorbiaceae and cassava root has three distinctive areas as phelloderm (peel), parenchyma and central vascular core in its raw form (Somendrika et al., 2016). World production of Cassava is around of about 160 million tons per year (Lincoln and John, 2009). In Africa and tropical Asia cassava has become established as an important human food source supplying carbohydrates and energy. Over 500million people around the world relies on cassava as a food (Abu et al., 2006). Cassava is the third most important food source after rice and maize and in the tropics, it is a major metabolic source of energy for millions in world (Somendrika et al., 2016).

Cassava can be considered as a solution for the food insecurity problems as it can tolerate drought conditions and grow well. Therefore, it can be grown in highly environmentally stressed areas where most of the other crops cannot grow and yield crops. In Democratic Republic of Congo, processed cassava is a major staple food which may provide more than 60% of the daily energy requirements (Ngudi et al., 2002). Although it grows well in stressed conditions cassava is highly perishable root crop where it can be stored only for 2 to 3 days after harvesting for human consumption (Hahn, 1989; Oyewole and Aibor, 1992). Reasons for high perishability of cassava are physiological deterioration due to mechanical damage during harvesting and handling (Booth, 1976) and secondary deterioration due to microbial spoilage (Booth and Coursey, 1974).

Cyanogenic glucoside is the toxicological factor which present in cassava root and leaves in three different forms as linamarin, acetonehydrin (lotaustralin) and free HCN (Emmanuel et al., 2012). Enzymatic breakdown of linamarin & lotaustralin make them into free cyanide which is toxic for both humans and animals. Under tropical conditions cyanogenic glucoside readily hydrolysed liberating HCN (Udedibie et al., 2008). However, there are some other compounds in cassava such as amygladin which form cyanide as well (Kováčová et al., 2016). Long-term consumption of lower amount of cyanide may cause several health disorders in human such as neuropathy, glucose intolerance and when combined with low iodine intake, goiter (Delange et al., 1994; Harris and Koomson, 2011) as well. According to the FAO/WHO (1991), in order to prevent acute toxicity in human cassava or its derivative products should contain HCN <10 mg.kg⁻¹.

In Sri Lanka most common cassava varieties are CARI 555, MU51 & Kirikawadi (Wickramasinghe et al., 2009) and most popular form of consumption of cassava is domestic consumption in boiled or curry form. In Sri Lanka, cassava has higher harvesting amount than its production (Somendrika et al., 2016) where major limitations to the utilization of cassava are low shelf life of tubers, presence of toxicological factors such as cyanogenes (Nartey, 1968; Rickard, 1985). The estimated annual production of cassava in year 2014 was 302,767 Metric tons (National Accounts of Sri Lanka, 2014). According to Sri Lanka Export Development Board (2013), export value of Cassava was 1.29 US\$ Mn at 2010, Where it was 2.89 US\$ Mn at 2011 showing 124.03% of growth rate (EDB, 2013).

Although *Manihot esculanta* tubers are widely consumed in Sri Lanka for years, there is, to our knowledge, no much available data concerning the nutritional composition and toxicological content of these tubers. The purpose of the study was to determine nutritional composition and cyanide content as a toxicological factor in MU51 variety and its selected processed products (boiled, flour, starch, chips) and to determine if there were any statistical differences in the nutrient content of fresh MU 51 tubers due to its processing method and to determine the variation of toxicological content between fresh MU 51 tubers and its processed conditions: boiled, chips, flour and starch products. This study will cause to increase the industrial uses of cassava in Sri Lanka and will improve its processing patterns to both local and export market at Sri Lanka. Also, it will provide knowledge on the nutritional and toxicological composition of commonly consuming cassava variety of MU51 in Sri Lanka, which will help to ensure better health condition of people who consuming cassava as a major food source.

MATERIALS AND METHODS

Sample collection

Random samples of cassava MU51 raw tuber were selected and collected from market areas of Homagama, Sri Lanka. Collected samples were immediately transported carefully to the laboratory of the Department of Food Science and Technology, University of Sri Jayewardenepura. At the laboratory, the samples were

sealed and packed in airtight containers for further analysis and were stored in refrigerated condition (Temperature 4 °C to 0 °C) until taken to analysis and sample preparations (Maximum duration 2 weeks).

The selected cassava products taken for analysis were 3 samples of cassava Chips, Flour, starch which were popular processed products and boiled cassava which was commonly consumed pattern by Sri Lankan community. Out of three Cassava chips categories, two were market samples which obtained using large scale and small scale industrial processes to closely reflect the way that people consume these products. These market samples were randomly selected from market at Wijerama area.

Rest of the products were prepared using the cassava MU51 which were previously collected and stored at the refrigerated conditions in the laboratory.

Sample preparation

The processing method for every product was mentioned as follows:

Cassava Chips:

The tubers were washed, hand peeled, and trimmed to remove defective parts. Then the tubers were cut into thin slices (about 0.2 cm) and were deep fried using coconut oil. The chips samples were sealed and packed in airtight containers for further analysis.

Cassava Flour:

The tubers were washed, hand peeled, and trimmed to remove defective parts. Then the tubers were cut into thin pieces (about 2 cm x 2cm) and dried in an air convection oven at 40 °C for 24 h. The dried pieces were powdered using a laboratory scale grinder and sifted through a 300 µm sieve. The flour samples were sealed and packed in airtight containers for further analysis.

Cassava Starch:

Fresh tubers were washed, peeled, and grated. These grated tubers were wet milled at low speed in a laboratory scale blender with 1:4 weight/volume of tap water for 2 min(s) and filtered through a gauze cloth. Residue was repeatedly wet milled and filtered for four times and suspension was kept overnight for settling of starch. The supernatant was decanted and the settled residue was collected into a drying tray and was dried at 40 °C for 5h, sifted through a 300 µm sieve, sealed, and packed in airtight containers for analysis.

Boiled cassava:

Fresh tubers were washed, peeled, and cut into cubes (about 5 cm of thickness). The cubes were added to a cooking vessel full of water and cooked until the middle part of the cubes were become soft. The excess water was filtered and boiled cassava was analysed for its moisture content. The rest was chopped and dried in dehydrator at 400 °C for 5 h, sealed and packed in airtight containers for further analysis.

All the prepared samples were stored at room temperature (18 °C – 32 °C), until they were taken into further analysis.

Sample preparation for analysis

The MU51 tubers stored in refrigerator were taken and the peel was removed carefully from the flesh. The flesh of the tubers were ground using mortar and the pestle to decrease the particle size and taken in to analysis. All the other selected products which were stored in airtight containers, were grounded using mortar and pestle and taken into proximate analysis.

Proximate composition analysis of samples

The moisture, crude protein (N x 6.25), fat, ash and crude fibre contents were determined by following AOAC (2012) methods with modification. Every determination of composition values were performed in triplicates. The carbohydrate content was calculated by the difference.

Analysis of moisture %

Moisture content was determined gravimetrically using oven drying method of AOAC (2012) through drying 5 g of the samples in a moisture oven (Model B3535S) until obtained a constant weight at 105 °C.

Analysis of crude protein %

The protein content was determined using AOAC (2012), micro kjeldhal method of nitrogen analysis with VELP scientific F30200120 Kjeldhal digestion kit.

About 0.05 g of each sample was digested with concentrated sulphuric acid using Murcury containing kjeldhal tablet catalyst. The digest was distilled with 32% NaOH and liberated ammonia is collected in to 5 mL of 4% boric acid solution and titrated with 0.02 M HCL acid in the presence of Kjeldhal indicator. The crude protein in the samples was obtained by multiplying the Nitrogen content of the sample from a conversion factor 6.25.

Analysis of ash %

Ash content was determined gravimetrically by using AOAC (2012) method.

About 5 g of each sample was added in to previously weighed porcelain crucible and was incinerated. Then ashing was done in a Muffle furnace (Wisetherm) at 550 °C until it obtained completely white color residue in the crucible.

Analysis of crude fat %

Total fat or crude fat content of each sample was determined by extracting the fat of the dried food material with 6N HCl acid as refer to the AOAC (2012) method.

Analysis of crude fiber %

Crude fiber content was determined using an acid followed by alkaline hydrolysis method as refer to the AOAC (2012) method with modifications.

Approximately 2 g of the dried sample was weighed and defatted by pet ether washing. Wet sample was added into a conical flask and boiled with 200 mL of 1.25% sulphuric acid and 200 mL of 1.25% Sodium hydroxide respectively

and filtered the content through a Buchner funnel in to an ash less filter paper. Then filter paper with the filter bad was dried in the moisture oven (Model B3535S) at 105 °C and ashed at 550 °C.

Carbohydrate content %

Carbohydrate content was calculated with following formula:

Carbohydrate = 100 - (Moisture + ash + protein + fat + crude fiber)

Toxicological composition analysis (Cyanogenic glucoside content) - Spectrophotometric Determination of Cyanide Picric acid method

Cyanide content was determined refer to the methods described by Wood (1965) and Vogels Text Book of Quantitative Inorganic Analysis (1978).

About 20 g of sample was weighed and the initial weight was taken. Then the sample was introduced in to a round bottom distillation flask containing 200 mL of distilled water. About 50 mL of 2N H₂SO₄ was added to the round bottom distillation flask. Immediately the flask was connected to the steam generator and the distillate was collected in 50 mL of 5% Na₂CO₃ solution till it becomes 200 mL. The solution was transferred in to a 250 mL volumetric flask and the volume was made up to the volume.

To the 10.00 mL of the distillate, 4.00 mL of 1% Picric acid was added and it was immersed in a boiling water bath for 12 minutes. Then the solution was let to cool to room temperature and volume was made up to 25 mL. The readings of sample solutions were achieved using a spectrophotometer (UV mini 1240, SHIMADZU, A109347) at 530 nm. The concentration was calculated based on the equation of (Absorbance = - 0.01200 + 0.004680 Concentration), which was been first developed using standard concentration series of KCN solution for the machine UV mini 1240, SHIMADZU, A109347 under the same conditions.

Statistical Analysis

The collected data were analysed using Minitab (17 version) statistical software packages. One way ANOVA used to analyse the significant differences of mean values of each sample, followed by Dunnett multiple comparison test to analyse the samples that had significant difference from control (MU51 flesh) sample. Samples which had significant difference from control sample, was analysed to identify the relationship and regression equation was developed in between the samples which had Pearson correlation > ±0.85. All test procedures were made at 5% significant level. Microsoft Office Excel 2013 package was used to graphical representation of data.

RESULTS AND DISCUSSION

Proximate analysis

Table 1 Nutritional Composition of fresh cassava MU51, market products and processed products (Mean \pm SD, n = 3).

Sample	Moisture (%)	Ash Content* (%)	Total Fat Content* (%)	Protein Content* (%)	Crude fiber Content* (%)	Carbohydrate* (%)
MU51 flesh	61.00 \pm 0.60 ^a	1.37 \pm 0.06 ^a	0.71 \pm 0.18 ^a	2.09 \pm 0.22 ^a	2.15 \pm 0.43 ^a	32.68 \pm 1.35 ^a
Boiled ¹	61.94 \pm 1.61 ^a	1.28 \pm 0.37 ^a	0.31 \pm 0.04 ^a	1.67 \pm 0.15 ^a	1.95 \pm 0.76 ^a	32.84 \pm 2.24 ^a
Flour ¹	12.15 \pm 0.47	1.09 \pm 0.04 ^a	0.68 \pm 0.02 ^a	2.00 \pm 0.21 ^a	1.10 \pm 0.49 ^a	82.98 \pm 0.14
Starch ¹	11.13 \pm 0.63	1.14 \pm 0.08 ^a	0.52 \pm 0.05 ^a	2.07 \pm 0.26 ^a	0.94 \pm 0.42	84.20 \pm 1.22
Chips ¹	3.65 \pm 0.03	1.02 \pm 0.00 ^a	23.30 \pm 1.47	3.71 \pm 0.53	2.02 \pm 0.26 ^a	66.64 \pm 1.61
Large scale chips ²	3.18 \pm 0.12	1.71 \pm 0.14 ^a	17.05 \pm 1.69	3.60 \pm 0.05	1.58 \pm 0.46 ^a	72.88 \pm 2.40
Small scale chips ²	5.69 \pm 0.11	1.91 \pm 0.65 ^a	20.49 \pm 1.65	3.52 \pm 0.21	1.36 \pm 0.55 ^a	67.03 \pm 1.25

Note: In each column means not labeled with the letter ‘a’ are significantly different from the control level mean (MU51 flesh) at $p < 0.05$.

¹processed products from MU51 variety and ²products randomly purchased from Market * values reported in dry weight basis.

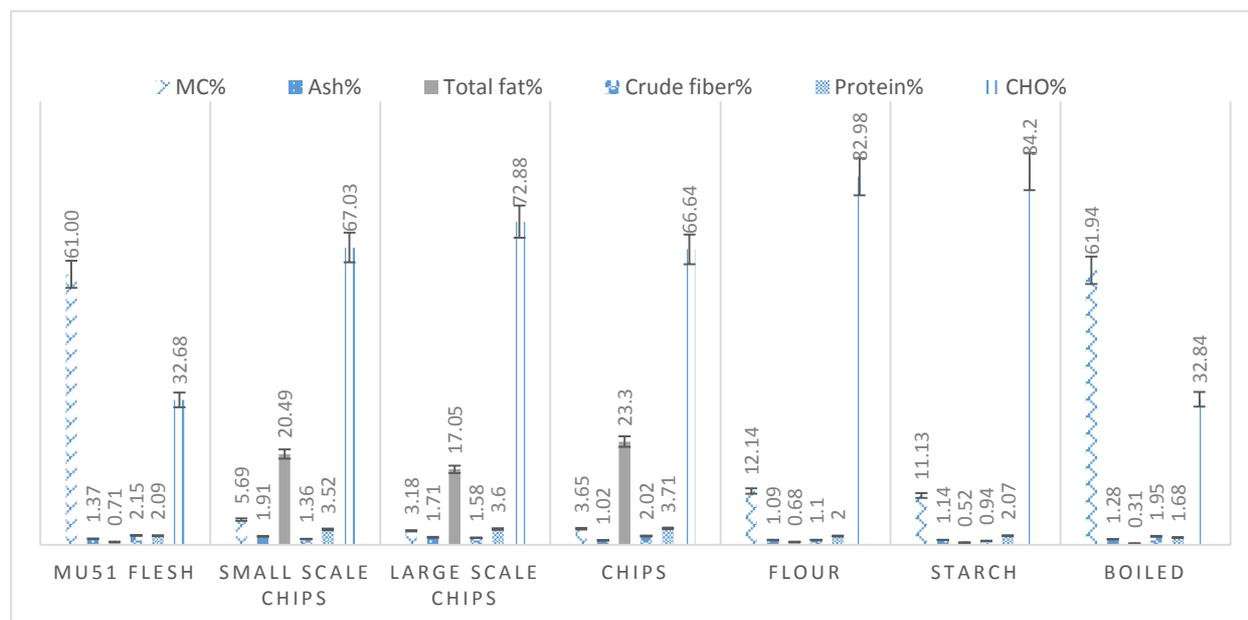


Figure 1 Average proximate composition of MU51 flesh and differently processed products.

The results of proximate composition of MU51 flesh and cassava products (Table 1) showed variations in each nutrient with processing. The nutritional composition of the MU51 flesh and cassava products showed that except ash content all the other nutrients were affected by the processing, where they showed significant differences ($p < 0.05$) with the control sample (MU51 flesh). The variation of nutrients with the processing can be clearly seen with the Figure 1, which it showed what happens to each nutrient when MU51 flesh processed to boiled, chips, and flour and starch forms.

The moisture content of cassava products ranged from 3.18% to 61.94% in which boiled sample had the highest percentage of 61.94 \pm 1.61%. Flesh of MU51 tuber and

Boiled product were similar in their moisture percentage ($p < 0.05$) where all the other products were less in their moisture percentage compared to the flesh MU51. This results from the processing techniques involved in preparation of products such as drying, frying and grinding. The observed ranges (61.00 \pm 0.60%) of MU51 flesh was higher, those (33.14% – 45.86%) reported by Emmanuel et al. (2012) on four improved cultivars and two traditional cultivars obtained from Ghana. But the observed moisture percentage of MU51 flesh was much lower compared to the range 75% to 80% which was reported by Oluwole et al. (2004). The variation probably be due to the climatic changes and varietal differences. According to Somendrika et al. (2016) reported moisture



Figure 2 Small scale chips.



Figure 3 Casava flour.



Figure 4 Large scale chips.



Figure 5 Cassava starch.



Figure 6 Cassava MU 51 tubers.

content of Kirikawadi variety flesh ranged $62.92 \pm 1.85\%$ in Sri Lanka which is more similar to the observed range. And also, the observed range comparable to the range of 60.3% to 87.1% reported by **Padonou et al. (2005)** on twenty improved cassava cultivars. As **Chijindu and Boateng (2008)** reported, the moisture percentage of the chips prepared in Ghana had a range of 8.0% to 9.3% which is much higher compared with the observed moisture range of 3.18% to 5.69% for different chips samples. This reduction of observed values, could be as a result of different processing methods that employed. Cassava flour had the moisture content of $12.15 \pm 0.47\%$ which was accordance to the codex standard (13%) for edible cassava flour (**CODEX, 1989**).

Ash content represents the all the inorganic minerals consist within the sample (**Somendrika et al., 2016**). The

observed ranges of all the samples were similar in their ash content ($p < 0.05$) with the control sample (MU51 flesh) which says there's no effect on the ash content due to the processing method. Although there were no significant difference between the samples, the figures of ash content in small scale and large scale chips were $1.91 \pm 0.65\%$ and $1.71 \pm 0.14\%$ respectively where they were higher than the ash content observed with MU51 flesh, $1.37 \pm 0.06\%$. This might due to addition of salt with chips processing because the chips processed in laboratory without addition of salt, showed less ash content ($1.02 \pm 0.00\%$) than in MU51 flesh. MU51 variety had $1.37 \pm 0.06\%$ ash content which is somewhat similar to the ash percentage reported as $1.32 \pm 0.03\%$ for the flesh of Kirikawadi by **Somendrika et al. (2016)**. The varietal difference might cause to the little variation. The observed values of ash content of the flesh

was comparable to the range 0.4% – 1.7% as reported by **Montagnac et al. (2009)**.

Fat can act as an alternative energy source. The total fat content of all the chips samples were high and it ranged from 17.05% to 23.30%, while in all the other samples' total fat content was much lower (0.31% – 0.71%) and significantly different ($p < 0.05$) from all the chips samples. The reason might due to the deep-frying condition involved with the production of chips increase the amount of fat in the cassava chips. Further analysis showed that chips sample had a positive correlation with MU51 flesh with its fat percentage as the Pearson correlation factor was 0.971 ($> \pm 0.85$) in between those two. Therefore, the regression equation was calculated between chips sample & MU51 flesh and it was, (Chips = 17.84 + 7.684 MU51 flesh) with 94.2% R-Sq value.

Large scale and small scale chips had lower ($< \pm 0.85$) Pearson correlation value which showed no relationship of the variation in total fat content with MU51 flesh. As reported by **Somendrika et al. (2016)** fat content of Kirikawadi flesh was 0.41 \pm 0.14% where it was lower than the observed value of 0.71 \pm 0.18% for MU51 flesh. The variation could probably due to the varietal difference and the observed values were taken in dry weight basis where the reported values of **Somendrika et al. (2016)** were taken in wet basis.

The results of the protein content showed that, protein content of MU51 flesh and all the chips samples were significantly difference ($p < 0.05$). This could be when preparing chips, raw cassava flesh get concentrated and dried than that of the other products preparation (Boiled, Flour, Starch). The protein content of MU51 flesh showed a much higher value than that of the reported value of 0.72 \pm 0.09% by **Somendrika et al. (2016)**. The variation could be due to the reported figures were from wet basis and observed figures were from dry basis and also the variation in the soil, variety might also can be reasons. However, the observed value for protein content of MU51 flesh (2.09 \pm 0.22%) comparable with the range (0.3% – 3.5%) reported by **Montagnac et al. (2009)**. Pearson correlation analysis between significant difference variables showed that only MU51 flesh and Large scale chips had a significant positive correlation value of 0.910 ($> \pm 0.85$) followed by derivation of regression equation, (Large scale chips = 3.138 + 0.2224 MU51 flesh) with 82.9% R-Sq value. Except chips samples, Protein content of all the other samples were lower than MU51 flesh probably due to processing conditions that involved with.

However, flour had much lower protein value (2.00 \pm 0.21%) than starch which had 2.07 \pm 0.26% of protein percentage. This may probably due to that in starch making cassava was grated while in making flour it was cut in to pieces. In starch making these grated samples were mixed with water and grinded where the temperature increment was much lower compared to the grinding process in flour making process. Therefore, it could state that, in flour making grinding process might cause to lose some of the protein. In starch making process grinded content was kept for sedimentation where some of the protein could leached out and in the sedimentation process the leached protein would again settled down with starch as it was kept for overnight. The lowest protein value was

Table 2 Cyanide content of flesh of MU51 cassava variety and its processed products.

Sample	Cyanide Content* (mg.kg ⁻¹)
Fresh MU51	33.92
Boiled	15.12
Flour	6.03
Starch	7.05
Chips	4.68

Note: * Values were reported in dry weight basis.

observed in boiled sample (1.67 \pm 0.15%) which might be due to the leaching of protein with cooking of raw cassava. Crude fiber is made up with cellulose and lignin (**Somendrika et al., 2016**) and cause to increase the satiety after consumption. Constipation and colon diseases may result from consumption of lower amount of fiber (**Okon, 1983; Rock, 2007**). Observed crude fiber content of MU51 flesh (2.15 \pm 0.43%) was much similar ($p < 0.05$) to the crude fiber content in all the products that analysed except in starch. Starch had the lowest fiber content where it was 0.94 \pm 0.42%. The reason was in processing starch all most all the fiber was removed before sedimentation. The observed fiber content in MU51 flesh was much higher (2.15 \pm 0.43%) than the reported value of **Gil and Buitrago (2002)**, crude fibre content which does not exceed the limit 1.5%. This might due to the difference in variety and geography. The Pearson correlation analysis between MU51 flesh and starch had much lower value - 0.138 ($< \pm 0.85$) which said there was no correlation between these variables.

The main source of energy in human nutrition is carbohydrates (**Kouřimská et al., 2014**). Except for boiled product, all the other products showed significant difference ($p < 0.05$) with control sample in their carbohydrate content. Lowest carbohydrate content 32.68 \pm 1.35% was observed in MU51 flesh due to the presence of high amount of moisture. Boiled sample also had carbohydrate content of 32.84 \pm 2.24% which was similar to the MU51 flesh and due to same reason. As **Montagnac et al. (2009)** reported carbohydrate in fresh cassava roots had a range from 25.3% to 35.7% and 33.73 \pm 1.69% of carbohydrate content was reported by **Somendrika et al. (2016)**, the both figures were comparable with the carbohydrate content of MU51 flesh and boiled sample. Although MU51 flesh and boiled sample had more similar carbohydrate figures, boiled sample had higher carbohydrate content than in MU51 flesh. That showed boiling could increase the amount of carbohydrate than in raw form. And all the other products were also had high carbohydrate content than in raw form which showed processing techniques could increase the amount of carbohydrate present in final product. Highest carbohydrate content of 84.20 \pm 1.22% showed by starch, because in production of starch it causes to separation of much of the total carbohydrates from other parts of the tuber specially separating fiber part. Three chips samples showed comparable amount in their carbohydrate content which might due to the similarity with their processing method.

Toxicological analysis

The cyanide level observed with each product was mentioned in Table 2. According to that, raw MU51 flesh showed highest cyanide level of 33.92 mg.kg⁻¹ in dry weight basis.

Boiled product showed the low cyanide level of 15.12 mg.kg⁻¹ in dry basis. This might due to the heating which can cause to liberate more free cyanide in its gaseous form (HCN) and according to **Pieris and Jansz (1975)** heating cause to decomposition of the cyanohydrins. The observed cyanide content of boiled product was higher than the cyanide content reported 5.4 – 10.2 mg.kg⁻¹ by **Okolie et al. (2012)** for selected garri samples in Lagos Metropolis. The variation might due to the changes in the processing methods. Chips had lowest cyanide content as 4.68 mg.kg⁻¹ in dry basis, as chips were processed to high temperatures while deep frying the same phenomena could occur as in boiled sample. In chips the extent of heating and temperature increment (about 172 °C) was much higher than boiled product (about 110 °C), and also when making chips cassava tuber was sliced into much thin layers which might cause to increase the linamarin-linamarase reaction and liberate much of the free cyanide available. But in boiling cassava was cut into cubes which might cause to lower the enzyme substrate contact. Thus, chips production could give much lower cyanide content than with boiling. Starch had cyanide content of 7.05 mg.kg⁻¹ in dry basis. This might due to the processing conditions such as grating and overnight sedimentation caused to increase the enzyme substrate contact and enzyme activity which caused to release more bound cyanide (**Pieris and Jansz, 1975**) thus reduce the residual cyanide level in starch. However, the cyanide content in starch was higher than that of the chips because in chips processing conditions were much harsh than starch processing conditions that involved. Flour had second lowest cyanide content 6.03 mg.kg⁻¹ than in fresh MU51. This reduction might due to the processing methods such as drying & grinding that followed in flour preparation (**Jansz et al., 1974**). According to **Pieris and Jansz (1975)** flour can liberate much of its cyanide by moistening because with flour processing steps such as cutting, drying, grinding most of the bound cyanide and linamarase enzyme was not fully destroyed. However, the observed cyanide content of flour was lower than the reported value of 17.5 ± 6.2 mg.kg⁻¹ by **Adindu, Olayemi and Nze-Dike, (2003)**.

CONCLUSION

From this study boiled sample showed more comparable results with the control sample (MU51 flesh) with all the analysed nutritional composition which showed that boiling had no significant effect for the nutritional composition of the raw form. But production of flour, starch and chips had a significant effect on the nutrition composition of the raw cassava (MU51 flesh). And also, production of starch can cause to increase the carbohydrate value and production of chips can increase the food value of protein in raw cassava. The studied cassava products (flour, chips, starch and boiled) had low cyanide levels which were all below the WHO/FAO recommendations (<10 mg.kg⁻¹) and thus could all be safely recommended for consumption without acute toxicity to humans. The

impact of producing chips for the cyanide content were higher. Therefore, chips can be identified as a suitable product for consumption of cassava as much of the problems in raw cassava such as low protein content, presence of cyanide, high perishability and bulkiness can be reduced with chips which it had more protein value and lower cyanide value compare to the raw cassava.

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