Asian Journal of Physical and Chemical Sciences

3(4): 1-10, 2017; Article no.AJOPACS.36502
ISSN: 2456-7779

Proximate Analysis and Mineral Composition of Peels of Three Sweet Cassava Cultivars

Monday Abel Otache[1*], Simon Terver Ubwa[2] and Agbajor Kparobo Godwin[3]

[1]Department of Industrial Chemistry, Michael and Cecilia Ibru University Delta State, Nigeria.
[2]Department of Chemistry, Benue State University, Makurdi, Nigeria.
[3]Department of Industrial Physics, Michael and Cecilia Ibru University Delta State, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Authors MAO and STU designed the study, managed the analyses of the study, wrote the protocol and managed the literature searches. Author MAO wrote the first draft of the manuscript. Authors MAO and AKG performed the statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJOPACS/2017/36502
Editor(s):
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Complete Peer review History: http://www.sciencedomain.org/review-history/21854

Original Research Article

Received 30th August 2017
Accepted 12th October 2017
Published 10th November 2017

ABSTRACT

The nutrient yields from three different peels of sweet cassava cultivars (*Manihot esculenta* Crantz) from three local government areas of Otukpo, Apa and Ushongo in Benue State were investigated. These cultivars include; TMS 98/0581, TMS 98/0505, and TMS 98/0524. The proximate analysis and mineral contents were determined according to the method of A.O.A.C. (1990) and triple acid digestion respectively. The results of the proximate analysis of the peels reveal the various ranges of values (69.03 -72.00) %, (85.97 – 89.32) %, (1.06 -3.55) %, (0.40 -1.33) %, (5.44 -8.63) % and (1.28 -4.05) % of moisture, dry matter, crude protein, fat, crude fiber and ash content respectively. Altogether the three cultivars have an appreciable high value of carbohydrates with the highest value (73.07 -77.28) % found in TMS 98/0524 while TMS 98/0505 has the lowest value (69.35 - 74.64) %. The mineral contents show ranges of (9.90 -19.81) mg/100 g, (7.86 -14.21) mg/100 g, (70.72 -123.98) mg/100 g, (7.04 -17.38) mg/100 g, (5.16 -7.57) mg/100 g for Ca, Mg, K, Na and Zn

**Corresponding author: E-mail: fillupotache@yahoo.com;*

respectively for the various varieties of the local Government areas. The outcome of the three cassava cultivar showed that cassava peels contained some nutrients. These peels which are presently disposed as environmental waste can be modified and used as animal feed. The codes (TMS) are depicting characteristic espoused from the international plants as Tropical Manihot Specie.

Keywords: Tropical manihot specie (TMS); waste peels; nutrient composition; cultivars.

1. INTRODUCTION

In Nigeria the amount of wastes produced by cassava processing factories is tremendous and the impacts on the environment could be annihilated thus giving rise to the need for proper management and release of these wastes. Cassava, *Manihot esculenta* Crantz, has roughly 98 species belonging to the genus Manihot [1]. In developing countries, cassava serves as a major staple food and is a secure source of energy [2]. The waste peels of cassava represent about 15% of the root [3,4]. They are mechanically obtained by peeling the tubers and further washed with water [3]. The tubers can easily be damaged if not properly handled during harvesting [5,6,7]. A transverse section of cassava root reveals three distinct layers; the periderm, cortex and pulp [8,9]. Cassava roots contain a number of mineral elements such as iron, phosphorus and calcium in appreciable amount and are relatively rich in vitamin C [10]. Nevertheless, the role of cassava peels as feed for non- ruminant animals are determined by its hydro-cyanic acid, which poses a menace to their growth and development [11]. Sun-drying, Parboiling, Soaking in water and retting are the major processing techniques that have been employed to enhance the feeding value of cassava [12-15]. In Nigeria, drying cassava peels on black plastic sheets has been attracting the attention of smallholders who used these waste peels to raise goats" [16].

More of the waste product from cassava processing come from mainly Garri and starch processing factories and will only be useful if the peels can be incorporated into the livestock diet formulation. The use of cassava peels in livestock feeding would help to solve the trouble of its disposal as waste product and likewise to bring down the monetary value of livestock production [17]. During processing, large quantities of liquid pulp and cassava peels are generated [18]. More or less of these wastes are used as animal feedstuff while others become solid municipal wastes [19,20,21]. Withal, the liquid residue obtained from cassava processing can be gathered up and fermented to bioethanol while the gunk deposits obtained can be applied as manure in improving the soil nutrient value [22]. Beneficial management practices of these cassava wastes involve analysis and valuation of the nutrients composition and mineral contents of different forms of cassava produced thereby providing documented information that will be useful in cassava waste management, production of improved varieties and raw materials for the production of animal feeds, chemical and pharmaceutical industries. This research is penciled towards investigating the nutrient content of three samples of cassava peel collected from Apa, Otukpo and Ushongo Local Government Areas of Benue State, Nigeria, West Africa, to establish their quality for potential uses.

2. MATERIALS AND METHODS

2.1 Materials

Crude Protein, Crude Fibre, Ash, fat and carbohydrate content of each cultivar of the cassava peels were determined according to the method of A.O.A.C. (1990) [23]. The moisture content was determined in a thermostatic oven at a temperature of 105°C until constant weight was obtained; Ash was determined in a muffle furnace at 550°C for 8 hours; Crude protein by Kjeldahl method (N, X, 6.25); the lipids were extracted with petroleum ether using soxhlet extractor while the carbohydrate was determined using difference method. The mineral constituents were determined by wet-ashing 2 g each of sample, taken from the treatment groups, with a mixture of nitric acid, Perchloric acid (60%) and Hydrochloric acid (10:4:1) [24,25]. Model PG990 Atomic Absorption Spectrophotometer (AAS) was employed in this analysis. All reagents used in this study are of analytical grade.

2.2 Sample Collection and Preparation

Peels of the three cassava varieties were collected from Otukpo, Apa and Ushongo local

Government areas of Benue State. Samples were gathered up in triplicate for each of the studied areas. The samples were; TMS 98/0581, TMS 98/0505, and TMS 98/0524. Their trade identities were determined at the Benue State Agricultural Research and Development Agency Makurdi, Benue State (BNARDA). The cassava tubers were hand peeled with a table knife to rid off the two outer coverings. The skins were collected and the cortex (peel) separated out from the periderm (bark) and properly washed severally with tap water to get rid of grit and other dirt particles. The samples were carefully spread out on a tray and sundry for one day to get rid of the initial moisture and then dried in a moisture extraction oven at 105°C until it was dry enough to be milled. The dried samples were milled with a blender to obtain smooth powdery samples. The powdery samples were weighed using a digital electronic balance which was then packaged in three different labeled dry sample bottles for further analysis.

2.3 Statistical Analysis

Analysis of variance (ANOVA) was used to compare the mean and the level of significant difference determined at $p<0.05$ using an SPSS programme (Version 21) (IBM).

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

The proximate composition of the cassava varieties as shown in Tables 1, 2 and 3, reveals that variations in the moisture content of the fresh peals from Otukpo were observed with values ranging from (67.03 to 71.25) % (Fw) with TMS 98/0524 having the lowest value and TMS

Table 1. Proximate composition of cassava peels from Otukpo (%)

Varieties		Protein	Fat	Fibre	Ash	Carbohydrate	MC(Fw)	MC(dw)	DM
TMS 98/0581	Mean	2.84^b	0.46^b	5.44^c	3.04^a	75.20^b	69.33^b	14.03^b	85.97^c
	SD	0.48	0.07	0.47	0.07	0.14	0.98	0.21	0.21
TMS 98/0505	Mean	4.33^a	1.09^a	6.62^a	1.28^c	75.20^b	71.25^a	12.49^c	87.51^a
	SD	0.11	0.12	0.45	0.89	0.58	0.48	0.28	0.28
TMS 98/0524	Mean	2.41^c	0.40^c	6.13^b	2.52^b	75.82^a	67.03^c	14.05^a	86.95^b
	SD	0.24	0.16	0.14	0.39	0.21	0.19	0.17	0.17

a, b and c indicate the variance of the three cultivars measured at different sites, as determined by ANOVA at P < 0..05.

DM= Dry matter, Fw=Fresh weight, dw=Dry weight, MC=Moisture Content, SD=standard deviation.

Table 2. Proximate composition of cassava peels from Apa (%)

Varieties		Protein	Fat	Fibre	Ash	Carbohydrate	MC(Fw)	MC(dw)	DM
TMS98/0581	Mean	4.04^b	1.19^a	8.02^b	4.05^a	69.35^c	72.00^a	14.01^a	89.32^a
	SD	0.08	0.18	0.51	0.14	0.65	1.543	0.03	5.77
TMS 98/0505	Mean	4.55^a	0.69^b	8.63^a	2.63^b	71.42^b	69.07^b	13.07^b	86.92^b
	SD	0.28	0.16	0.41	0.36	0.38	0.131	0.09	0.09
TMS98/0524	Mean	3.41^c	0.40^c	7.13^c	2.52^c	74.64^a	67.03^c	12.89^c	87.11^c
	SD	0.24	0.16	0.14	0.35	0.34	0.19	0.13	0.13

a, b and c indicate the variance of the three cultivars measured at different sites, as determined by ANOVA at P < 0.05. DM= Dry matter, Fw=Fresh weight, dw=Dry weight, MC=Moisture Content, SD=standard deviation.

Table 3. Proximate composition of cassava peels from Ushongo (%)

Varieties		Protein	Fat	Fibre	Ash	Carbohydrate	MC(Fw)	MC(dw)	DM
TMS 98/0581	Mean	2.94^b	1.07^b	5.08^c	1.55^c	77.28^a	71.24^a	13.08^a	86.92^b
	SD	0.08	0.13	0.11	0.24	0.26	0.46	0.03	0.03
TMS 98/0505	Mean	3.85^a	0.85^c	6.07^b	2.05^b	75.16^b	67.99^c	13.01^c	86.99^a
	SD	0.24	0.08	0.12	0.07	0.20	0.17	0.14	0.14
TMS 98/0524	Mean	2.06^c	1.33^a	8.04^a	2.74^a	73.07^c	69.63^b	13.04^b	86.24^c
	SD	0.14	0.11	0.09	0.28	0.27	0.53	0.25	0.25

a, b and c indicate the variance of the three cultivars measured at different sites, as determined by ANOVA at P < 0.05.DM= Dry matter, Fw=Fresh weight, dw=Dry weight, MC=Moisture Content, SD=standard deviation.

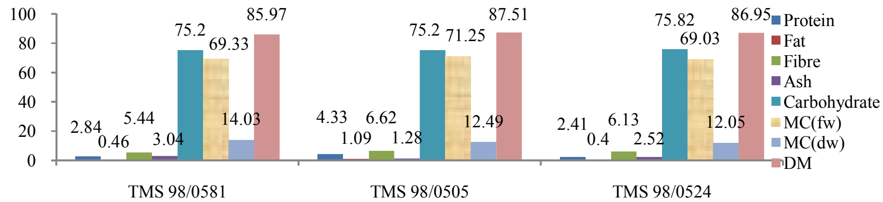

Fig. 1. A bar chart showing the % yield of the nutrient value of sample from Otukpo local government area

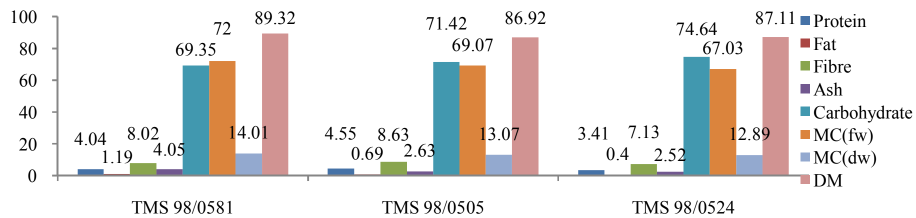

Fig. 2. A bar chart showing the % yield of the nutrient value of samples from Apa local government area

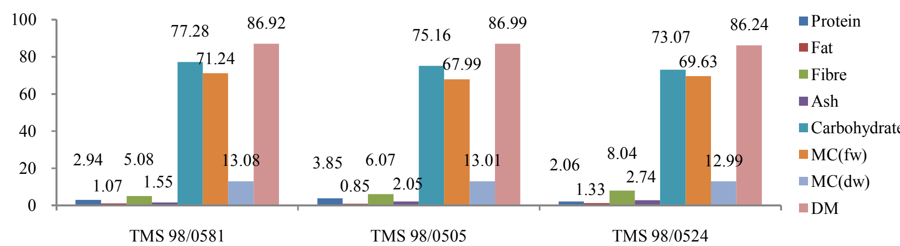

Fig. 3. A bar chart showing the % yield of the nutrient value of samples from Ushongo local government area

98/0505 the highest value. From Apa values ranged from (67.03 to 72.00) % (fw) with TMS 98/0524 having the lowest value and TMS 98/0581 the highest value. From Ushongo, the values are in the range (67.99 to 71.24) % (fw) were TMS 98/0505 has the lowest value and TMS 98/0581 the highest value. Significant differences ($p<0.05$) existed amongst the varieties. The observed ranges were below values reported for other findings on four cultivars harvested at various historic periods and seasons [26,27], but falls within the range of 60.3% to 87.1% [25]. On dry ground, the moisture content ranged between (12.49 to 14.03) % for samples from Otukpo while those of Apa and Ushongo ranges from (12.89 to 14.01) % and (13.01 to 13.78) % respectively. The values obtained were high relative to values of 9.2% to 12.3% and falls within the range of 11% to 16.5% [28,29]. TMS 98/0581 variety recorded the highest value in all the three regions, while TMS 98/0524 variety recorded the lowest in these regions. Moisture is an important parameter in the preservation of cassava flour; very high levels greater than 14% allow for microbial growth and therefore low levels are favourable and give relatively long shelf life [30]. All the TMS 98/0524 cultivar shows good moisture levels and hence delivers the potential for better shelf life.

The crude protein content of the three varieties from Otukpo investigated ranged from 2.41% (TMS 98/0524) to 4.33% (TMS 98/0505), while those from Apa and Ushongo ranged from 3.41% (TMS 98/0524) to 4.55% (TMS 98/0505) and 2.06% (TMS 98/0524) to 3.85% (TMS 98/0505) respectively. Significant differences ($p<0.05$) existed amongst the varieties with TMS 98/0505 sample recording the highest values in the three regions. The difference observed amongst the studied variety may be attributed to varietal differences. The outcomes are in accord with the values reported in other study [31,32].

The ash content of the cassava samples from Otukpo ranged from 1.28% to 3.04% with TMS 98/0505 having the lowest and TMS 98/0581 the highest respectively. Samples from Apa ranged from 2.52% to 4.05% with TMS 98/0524 having the lowest and TMS 98/0581 the highest respectively. Samples from Ushongo ranged from 1.55% to 2.74% with TMS 98/0581 having the lowest and TMS 98/0524 the highest respectively. Significant differences (p<0.05) in the ash content were observed among the cassava varieties. Values obtained were comparable to values obtained from other study [33,34]. Other findings show that the results obtained from this study are low [35]. The ash content is used as a benchmark to determine the mineral constituent [36].

The Fat content of the cassava samples from Otukpo ranged from 0.40% to1.09%, with TMS 98/0505 having the highest value and TMS 98/0524 the lowest. Samples from Apa ranged from 0.40% to 1.19% with TMS 98/0524 having the lowest value and TMS 98/0581 the highest respectively. Samples from Ushongo ranged from 0.85% to 1.33% with TMS 98/0505 having the lowest and TMS 98/0524 the highest respectively. This result shows that cassava peels have low fat content. These results correspond to values reported in other findings [33,34]. Nevertheless, these values were higher than those reported in other study [28], There were significant differences (p<0.05) in the fat content amongst the cultivars. The fibre content of the cassava samples from Otukpo ranged from 5.44% to 6.62%, With TMS 98/0505 having the highest and TMS 98/0581 the lowest. Samples from Apa ranged from 7.13% to 8.63% with TMS 98/0524 having the lowest and TMS 98/0505 having the highest value. Samples from Ushongo ranged from 5.08% to 8.04% with TMS 98/0581 having the lowest and TMS 98/0524 the highest respectively. The result obtained is low compared to 21.1% as observed in the pulp and 8.2% in the peels, reported in another study [37]. These values were higher than reported values of (0.60 – 0.88) %, but comparable with reported values in other surveys [38], [39]. There were significant difference (p<0.05) in the fibre content among the cultivars.

Carbohydrate values ranged from 75.20% to 75.82% for samples from Otukpo, With TMS 98/0581 having the highest value and TMS 98/0524 the lowest. Samples from Apa ranged from 69.35% to 74.64% with TMS 98/0581 having the lowest value and TMS 98/0524 having the highest. Samples from Ushongo ranged from 73.07% to 77.28% with TMS 98/0524 having the lowest value and TMS 98/0581 the highest. There were significant (p < 0.05) variations in the carbohydrate content of the varieties except for TMS 98/0505 and TMS 98/0581 varieties that show no difference in carbohydrate content of 75.20% in Otukpo local government area. The results obtained were in agreement with reported values of 62.0% and 72.50% [35,40]. Lower than values ranging from 87% to 89% [38] and higher than values of 35.83% reported in other findings [33]. This generally shows that cassava peels are rich in sugar, which is a serious source of vitality in the animal feed stuff.

Considering the importance of carbohydrate, moisture and protein as essential nutrients for energy production, transport of metabolic product, and for repair of lost cells and tissues, a 3-D plot of these nutrient components as shown in Fig. 4, reveals that there was an increase in the percentage content of carbohydrate and moisture content (dw), with a corresponding decrease in the protein content across the cultivars from Otukpo, but were inconsistent in the other study areas.

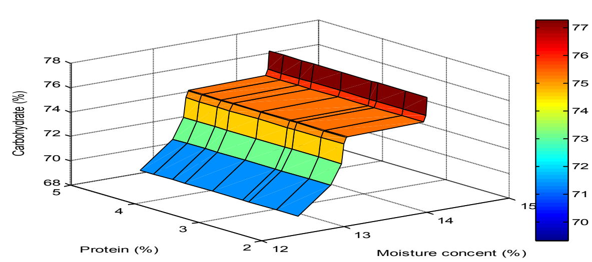

Fig. 4. A 3-D plot of the carbohydrate, protein and moisture contents of the samples across the study areas

3.2 Mineral Composition

The mineral substance of the peels of the three cassava cultivars studied as shown in Table 4, 5 and 6, shows that the Calcium content ranged from (13.74 to 19.81) mg/100 g for sample from Otukpo, (9.9 to 16.06) mg/100 g and (14.41 to 16.73) mg/100 g from Apa and Ushongo local government respectively, with TMS 98/0505 recording the highest value and TMS 98/0524 the lowest value across the studied countries. All varieties showed significant ($p<0.05$) variability in calcium content. Values obtained in this study were comparable to 10 mg/100 g [41], but lower than 33 mg/100 g [25,35] and higher than 4.25 mg/100 g [42].

Sodium content ranged from (13.70 to 14.23) mg/100 g for sample from Otukpo, with TMS 98/0505 recording the highest and TMS 98/0524 the lowest. The result also shows the range of (7.04 to 10.40) mg/100g and (11.12 to 14.78) mg/100 g from Apa and Ushongo local government respectively, The cultivars differed significantly at $p<0.05$. The Sodium contents obtained were lower than the reported values of 7.6 mg/100 g except for the TMS 98/0505 variety from Apa local government that is comparable to other findings [41]. Likewise, the values obtained from this analysis are lower compared to reported values of 50 mg /100 g [43].

Magnesium content ranged from (12.80 to 14.81) mg/100g for samples from Otukpo with TMS 98/0581 recording the highest value and TMS 98.0524 the lowest. Values for samples from Apa and Ushongo recorded (10.44 to 16.80) mg/100 g and (7.86 to 13.10) mg/100 g respectively, with TMS 98/0505 recording the highest value in both studied areas. All varieties showed significant ($p<0.05$) variability in Mg contents. Values obtained showed that the magnesium content were lower as compared to reported values from published data which include 30 mg/100g and 43 mg/100 g [41,43]. These values are also higher than values of 1.36 mg/100 g [42].

Potassium content ranged from (78.72 to 123.98) mg/100 g for sample from Otukpo, with TMS 98/0505 recording the highest and TMS 98/0524 the lowest. The result also shows the range of (70.67 to 113.39) mg/100 g and (70.72 to 91.30) mg/100g from Apa and Ushongo studied areas respectively with TMS 98/0505 recording the highest in the two areas. The outcome indicates that all the cultivars were significantly different ($p<0.05$). The effects obtained were generally lower than the reported ranges of 324 to 554 mg /100 g dry weight basis, 250 mg/100g and 302 mg/100 g fresh weight basis [35,41,43].

Zinc content ranged from (5.36 to 6.72) mg/100 g for samples from Otukpo, with TMS 98/0505 recording the highest and TMS 98/0581 the lowest. The result also indicated the range of (7.28 to 7.57) mg/100 g and (5.16 to 6.28) mg/100 g from Apa and Ushongo district respectively. There were significant differences amongst the varieties at $p<0.05$. Values obtained in this study were lower than the reported values of 10 mg/100 g fresh weight basis and (13 to 19) mg/100 g dry Weight reported in other findings [41,43].

Table 4. Mineral composition of cassava peels from Otukpo (mg/100g)

Varieties		Ca	K	Na	Zn	Mg
TMS 98/0581	Mean	16.23^b	98.51^b	14.04^b	5.36^c	14.81^a
	SD	4.36	0.52	0.17	0.11	0.51
TMS 98/0505	Mean	19.81^a	123.98^a	14.23^a	6.72^a	14.40^b
	SD	2.33	4.45	1.71	0.05	1.01
TMS 98/0524	Mean	13.74^c	78.72^c	13.70^c	5.65^b	12.80^c
	SD	1.46	0.76	0.68	0.19	0.56

a, b and c indicate the variance of the three cultivars measured at different sites, as determined by ANOVA at P < 0.05. SD=Standard Deviation.

Table 5. Mineral composition of cassava peels from Apa (mg/100g)

Varieties		Ca	K	Na	Zn	Mg
TMS 98/0581	Mean	13.17^b	70.67^c	8.88^b	7.57^a	10.44^c
	SD	0.263	1.854	1.45	0.015	0.519
TMS 98/0505	Mean	16.06^a	113.39^a	7.04^c	7.28^c	16.80^a
	SD	0.928	10.11	1.16	0.020	0.356
TMS 98/0524	Mean	9.90^c	87.07^b	10.40^a	7.43^b	11.17^b
	SD	1.699	1.068	0.526	0.156	0.297

a, b and c indicate the variance of the three cultivars measured at different sites, as determined by ANOVA at P < 0.05. SD=Standard Deviation

Table 6. Mineral composition of cassava peels from Ushongo (mg/100g)

Varieties		Ca	K	Na	Zn	Mg
TMS 98/0581	Mean	15.56[b]	80.11[b]	13.18[b]	5.95[b]	9.36[b]
	SD	3.23	1.80	2.78	0.10	0.46
TMS 98/0505	Mean	16.73[a]	91.30[a]	14.78[a]	5.16[c]	13.10[a]
	SD	2.16	1.49	0.51	0.05	0.23
TMS 98/0524	Mean	14.41[c]	70.72[c]	11.12[c]	6.28[a]	7.86[c]
	SD	1.96	3.06	1.01	0.06	0.08

a, b and c indicate the variance of the three cultivars measured at different sites, as determined by ANOVA at P < 0.05. SD=Standard Deviation

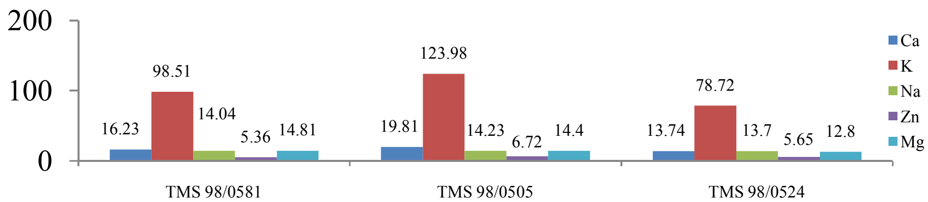

Fig. 5. A bar chart showing the mineral value (mg/100 g) of sample from Otukpo local government area

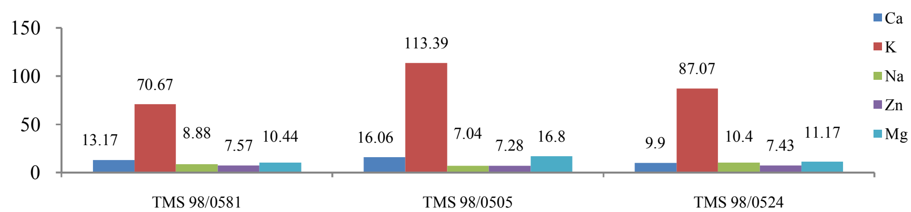

Fig. 6. A bar chart showing the mineral value (mg/100 g) of sample from Apa local government area

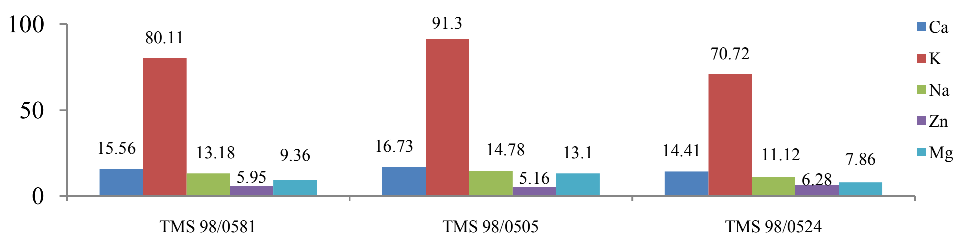

Fig. 7. A bar chart showing the mineral value (mg/100 g) of sample from Ushongo local government area

4. CONCLUSION

The survey reveals that the peels of the three cassava cultivars examined, have appreciable levels of food compositions. The proximate and mineral analysis of cassava peels revealed that cassava peels are rich in nutrients especially in carbohydrate. It also contains moderate amounts of minerals. With these findings, cassava peels can be incorporated into animal feed formulation. Their utilization for this purpose should be encouraged so as to enhance solid waste management and minimize environmental pollution. One danger the use of peels for livestock feed might pose is the presence of hydrogen cyanide, which has been reported to be high in other findings [34]. The differences in nutrient values observed across the cultivars could be due to seasonal variation, plant maturity, and environmental components such as soil quality, etc. This study recommends that research should be aimed at processing technique geared towards possible reduction in the concentration of hydrogen cyanide without depreciation in the nutritional values.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rogers D, Appan C. Manihot, manihotoides, euphorbiaceae. Flora Neotropica. Hafner Press, New York, NY; 1973.
   DOI: jstor.org/stable/4393691
2. Dimensions of Need: An atlas of food and agriculture. Food and Agriculture Organization of the United Nations;1995.
   DOI: fao.org/docrep/U8480E/U8480E00.
3. Aro SO, Aletor VA, Tewe OO, Agbede JO. Nutritional potentials of cassava tuber wastes: A case study of a cassava starch processing factory in south-western Nigeria. Livest. Res. Rural Dev., 2010;22(11).
4. Nwokoro SO, Adegunloye HD, Ikhinmwin AF. Nutritional composition of garrisievates collected from some locations in Southern Nigeria. Pakistan J. Nutr. 2005;4(4):257-261.
5. Ubwa ST, Otache MA, Igbum GO, Shambe T. Determination of cyanide content in three sweet cassava cultivars in three local government areas of Benue State, Nigeria. Food and Nutrition Sciences. 2015;6:1078-1085.
   Available:http://dx.doi.org/10.4236/fns.2015.612112
6. New World Encyclopedia. Cassava; 2008.
   Available:http://www.newworldencyclopedia.org/entry/Cassava
   (September14, 2014)
7. Okigbo BN. Nutritional implications of projects giving high priority to the production of staples of low nutritive, in the case for Cassava (*Manihot esculenta*, Crantz) in the humid tropics of West Africa. Food and Nutrition Bullentin. 1980;2:1-10.
8. Diasolua D, Kuo Y, Lambein F. Cassava cyanogens and free amino acids in raw and cooked leaves. Food and Chemical Toxicology. 2003;41:1193–1197.
9. Wheatley C, Chuzel G. Cassava: the nature of the tuber and the use as a raw material, In: Macrae R., Robinson R. and Sadler M. (eds). Encyclopaedia of Food Science, and Food Technology and Nutrition. Academic press, San Diego, Califonia. 1993;734–743.
10. Miya E, Dedeca S, Pereira A, Shirose I, Angelucci E. Sensory chemical evaluation of new manioc cultivars. Cole t Inst Tecnol Aliment. 1975;6:257-275.
11. Apata DF, Babalola TO. The use of cassava, sweet potato and cocoyam, and their by products by non –ruminants. International Journal of Food Science and Nutrition Engineering. 2012;2(4):54-62.
    DOI: 10.5923/j.food.20120204.02
12. Ooye DA, Oso GK, Olalumade BB. Effects of different processing methods on the proximate and cyanogenic composition of flour from different cassava cultivar. Journal of Agriculture and Allied Sciences. 2014;2319- 9857.
    ISSN: E 2347-226X,
13. Ekwe OO, Nweze BO, Uchewa EN. Effects of sun-dried cassava peels supplementation on the performance of weaner pigs. Asian Journal of Applied Sciences. 2011;4:794-800.
    DOI: 10.3923/ajaps.2011.794.800
14. Salami RI. The use of two empirical methods of substitution of feedstuffs: Parboiled cassava peel meal versus maize in the diets of growing cockerels. Nigeria. Journal of Animal Production. 1999; 26:78–83.
15. Salami RI, Odunsi AA. Evaluations of processed cassava peel meal as substitutes for maize in the diets of layers. International Journal of Poultry Science. 2003;2:112-116.
16. Adebayo AO. Using cassava waste to raise goats. Project 2008-4345. World Bank Development Marketplace; 2008.
17. Obioha FC. Forms and quality of root crop productions in livestock feeds. In: Proceedings of the Firs t National Seminar on Root and Inter Crops, MRCRI. Ewe, L. S. O. et al. (eds).Umudike. 1977; 177- 194.
18. Jideofor IM. Chemical adjustment of effluent from cassava processing plant prior to safe disposal. Nigerian Journal of Technology (NIJOTECH). 2015;34(4):883–889.
    DOI: doi.org/10.4314/njt.v34i4.30
19. Adesanya OA, Oluyemi KA, Josiah SJ, Adesanya RA, Shittu LAJ, Ofusori D, Bankole N, Babalola G. Ethanol production by saccharomyces cerevisiae from

cassava peel hydrolysate. The Internet Journal of Microbiology. 2008;5:1-5.
20. Onabolu AO, Bokanya M. Cassava processing in Nigeria community affected by neuropathy attributed to dietary cyanide exposure. Tropical Science. 1999;39:129-135.
21. Obadina AO, Oyewole OB, Sanni LO, Abiola SS. Fungal enrichment of cassava peels proteins. African Journal of Biotechnology. 2006;5:302- 304.
22. White B, Arias-Garzon I, Mc Mahon M, Sayre T. Cyanogenesis in cassava, the role of hydroxynitrile lyase in root cyanide production. Plant Physiology. 1998;116(4).
23. AOAC. Official Methods of Analysis (15th edn), Association of Official Analytical Chemists, Washington, DC; 2000.
24. A.O.A.C. Official methods of analysis of the association of official analytical chemists, 15th ed., Association of Official Analytical Chemists, Arlington VA. 1995;1058-1059.
25. Sarkiyayi S, Agar TM. Comparative analysis on the nutritional and anti-nutritional contents of the sweet and bitter cassava varieties. Adv. J. Food Sci. Technol. 2010;2(6):328-334.
26. Wheatley CC, Chuzel G. Cassava: The nature of the tuber and use as a raw material. In: Macrae, R., Robinson, R.K. and Sadler, M.J. (eds) Encyclopedia of Food Science, Food Technology and Nutrition. Academic Press, San Diego, California. 1993;734-743.
27. Kuda Dewage Supun Charuni Nilangeka Rajapaksha, Madame Arachchige DulanSomendrika, Indira Wickramasinghe. Nutritional and toxicological composition analysis of selected cassava processed products. Potravinarstvo Slovak Journal of Food Sciences. 2017;11(1).
28. Charles AL, Sriroth K, Huang TC. Proximate composition, mineral contents, hydrogen cyanide and phytic acid of 5 cassava genotypes. Food Chemistry. 2005;(92)4:615-620.
DOI: 10.1016/j.foodchem.2004.08.024
29. Padonou W, Mestres C, Nago MC. The quality of boiled cassava roots: Instrumental characterization and relationship with physicochemical properties and sensorial properties. Food Chemistry. 2005;89:261–270.
30. Edet EE, Onwuka GI, Orieke COM. Nutritonal properties of composite flour (Blends of Rice (*Oryza sativa*), acha (*Digitaria exilis*) and soybeans (*Glycine max*) and sensory properties of noodles produced from the flour. Asian Journal of Advances in Agricultural Research. 2017;1(2):1-13.
DOI: 10.9734/AJAAR/2017/34429
31. Idugboe OD, Nwokoro SO, Imasuen JA. Chemical composition of cassava peels collected from four locations (Koko, Warri, Okada and Benin City), brewers` spent yeast and three grades of “caspeyeast”. International Journal of Science and Research (IJSR); 2017.
ISSN (Online): 2319-7064 Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391.
DOI: 10.21275/ART20172389.
32. Olufunke OE, Ogugua CA, Hans PB, Thaddeus CE. Protein enrichment of cassava pee by submerged fermentation with *Trichoderma viride* (ATCC 36316). African Journal of Biotechnology. 2010;9(2):187-194.
33. Somendrika MAD, Wickramasinghe I, Wansapala MAJ, Peiris S. Nutritiona l composition of cassava cultivar "CARI-555". Pakistan Journal of Nutrition. 2017;16:216-220.
DOI: 10.3923/pjn.2017.216.220.
34. Akpabio UD, Akpakpan AE, Udo IE, Nwokocha GC. Comparative study on the physicochemical properties of two varieties of cassava peels (*Manihot utilissima* Pohl). International Journal of Environment and Bioenergy. 2012;2(1):19-32.
35. Adegbola AA, Asaolu O. Preparation of cassava peels for use in small ruminant production in Western Nigeria. In: Proceeding of a Workshop Held at the University of Alexandria, Egypt, Preston T. R. and Nuwanyakpa, M. Y. (eds). 1986;105-115.
36. Adepoju OT, Adekola YG, Mustapha SO, Ogunlola SI. Effects of processing methods on nutrients retention and contribution of cassava (*Manihot* spp) to nutrient intake of Nigerian consumers. Afr. J. Food Agric. Nutr. Dev. 2010;10:2099-2111.
37. Ganiyu Oboh. Nutrient enrichment of cassava peels using a mixed culture of *Saccharomyces cerevisae* and *Lactobacillus* spp solid media fermentation techniques. Electronic Journal of Biotechnology. 2006;(9)1.
ISSN: 0717-3458.
DOI: 10.2225/vol9-issue1-fulltext-1

38. Christopher IN, Onyekwe CE, Justus IO, Nkwoada A. The proximate analysis and biochemical composition of the waste peels of three cassava cultivars. International Journal of Scientific Engineering and Applied Science (IJSEAS). 2016;(2)11. ISSN: 2395-3470
39. Ravindran V, Kornegay Webb Jr, KE, Rajaguru ASB. Nutrient characterization of some feed stuffs of Sri Lanka. J. Nut. Agric. Soc. 1982;19:19-32.
40. Okpako CE, Ntui VO, Osuagwu AN, Obasi FI. Proximate composition and cyanide content of cassava peels fermented with *Aspergillus niger* and *Lactobacillus rhamnosus.* Food, Agriculture and Environment (JFAE). 2008;6(2):251-255.
41. Buitrago A.JA. La yucca en la alimentacion animal. Centro Internacional de Agricultura Tropical, Cali, Colombia. 1990;446.
42. Etukudo MM, Osim SE, Egbe A. Assessment of fresh and dry cassava peels for nutrients potentials on growth of *Telfairia occidentalis* hook in tropical soil. Journal of Advanced Scientific Research. 2016;7(1):49-52. DOI: .sciensage.info/jasr.
43. Charles AL, Sriroth K, Huang TC. Proximate composition, mineral contents, hydrogen cyanide and phytic acid of 5 cassava genotypes. Food Chemistry. 2005;92:615–20.

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