NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 51 Number 2, August 2020 Pg. 214-224
Available online at: http://www.ajol.info/index.php/naj

EFFECT OF PROCESSING ON THE PROXIMATE AND ANTI-NUTRITIONAL COMPOSITION OF CASSAVA ROOTS AND DRIED CHIPS

Nwohu, N.O., Kanu, A. N., Nwafor, J.O. and Oriaku, L.C.

National Root Crops Research Institute, Umudike, Umuahia, Abia State, Nigeria
Corresponding Authors' email: nwohunicodemus@gmail.com

Abstract
Evaluation of proximate and anti-nutritional composition analysis of three varieties of cassava roots (TMS 30572, TMS 98/0505, and TMS 01/1368), and dried chips were carried out using standard methods. The result shows that soaking + sun drying improves and retains the proximate composition of the dried chips when compared with the fresh pulp across the varieties except moisture and fat for TMS 98/0505 which incurred loss of 4.2% in dried chips. Sun drying only improves and retains the proximate composition of the dried peels when compared with the fresh peels across the varieties except moisture. Also, soaking + sun drying and sun drying alone led to significant loss ($p<0.05$) of anti-nutrients in the dried chips and the dried peels across the varieties making the dried chips and the dried peels safe for human consumption and livestock feed respectively. Significant variation ($p<0.05$) in proximate and anti-nutritional composition exist between the fresh pulp and the dried chips, fresh peels and the dried peels across the varieties.

Keywords: Soaking + Sun drying, proximate composition, anti-nutritional composition, fresh pulp, dried chips, and dried peels

Introduction
Cassava (*Manihot esculenta Crantz*) has about 98 species belonging to the genus Manihot (Monday *et al*., 2017). Cassava serves as a major staple food in the developing countries and is a source of energy (Juanatey, 2018). A semi-perennial root crop, cassava can stay in the ground for up to 3 years. This makes it an excellent food security crop. When all other crops have been exhausted, cassava roots can still be harvested piece meal. It is naturally drought resistant and resilient to climatic changes, high temperatures, and poor soils, and in addition, cassava responds extremely well to high CO_2 concentrations, making it a very important crop for the 21st century (Peace, 2015). Cassava roots contain anti-nutrients and toxic substances that interfere with the digestibility and the uptake of some nutrients (Francis *et al*., 2001). Depending on the amount consumed, these substances are also useful to humans. Some common anti-nutrients and toxic substances found in cassava roots include the cyanide, phytate, tannins, oxalates, saponins, trypsin inhibitors etc. Cassava is classified into two main categories; the sweet varieties and the bitter varieties. The bitter varieties have cyanide level higher than the recommended, which is <10mg cyanide equivalent/kg DM (FAO and WHO, 2011). To prevent acute toxicity in humans, consumption of 50 to 100mg of cyanide has been associated with acute poisoning and has been reported to be lethal in adults (Benson and Christopher, 2017).

There are several methods of processing cassava roots; parboiling, retting, soaking in water and sun drying are the major processing techniques that have been employed to enhance the utilization value of cassava (Ooye *et al*., 2014). The idea of soaking in water is to bring about fermentation due to the introduction of moisture. The implication is that the use of the products made from these varieties of cassava subjected to these processing methods for human consumption may not confer any toxic effect to the user (Eleazu *et al*., 2011). To increase the shelf-life of harvested cassava roots, it must be produced into dried chips. Dried chips is a shelf stable intermediate product of cassava made from the fresh roots which can be converted to other cassava based products as the need arises. The cassava root, as the most economically important part of the crop, can be processed into several products for human consumption which include: *gari*, '*farhina de mandioca*' cassava flour, and '*abacha*' (Okaka, 2007). Studies have shown that cassava chips can be converted into gari of good chemical and functional quality, though some nutritional composition could be lost during processing (Oluwole *et al*., 2004 and Lukuyu *et al.,* 2014). Industrially, dried cassava chips are used as animal feeds and can also be used to produce other useful products. During processing of cassava roots into dried chips, it is expected that the nutritive quality of the root may be affected. Therefore, this study evaluated the effect of processing on the proximate and anti-nutritional content of three varieties of cassava roots and dried chips.

Materials and Methods

Sample Collection and Pre-treatment

The study was carried out at the National Root Crops Research Institute (NRCRI), Umudike, Abia State. Three cassava roots (TMS 30572, TMS 98/0505, and TMS 01/1368) were obtained from the experimental farm of NRCRI, Umudike. The samples were washed and peeled. The pulp and the peels for each of the samples were divided into two separate portions such that the fresh pulp and the dried chips on one hand, and the fresh peels and the dried peels on the other were obtained each. The fresh sample (fresh pulp and fresh peels) were cut into smaller sizes, and oven dried at 70°C for 4 hours. Each of the samples were ground to its powder form using mortar and pestle, and used for the proximate and anti-nutritional composition analysis. The dried sample (dried chips and dried peels) were produced by first cutting the pulp into chunks and soaking in water for 24 hours, then cut into smaller sizes and sundried into chips. The peels were directly cut into smaller sizes and sun dried into chips without undergoing steeping. The chips were of irregular pieces of about 1.5cm thick and 2-3cm long and were produced within 2-3 days. The chips were ground and used for the proximate and anti-nutritional composition analysis.

Proximate and Anti-Nutritional Composition Analysis of Samples (fresh pulp, dried chips, fresh and dried peels)

Proximate Composition Analyses*:* The nutritional composition of the samples was determined by the method of AOAC, (2019). The carbohydrate content of the samples was determined by subtracting the sum of the percentage moisture, ash, crude lipid, crude protein and crude fiber from 100. The energy content of the samples was determined from the proximate composition using the equation described by (Nazim *et al*., 2013).

Anti-Nutritional Composition Analyses*:* Hydrogen Cyanide content, trypsin Inhibitors, phytic acids, tannins, oxalates, saponins, alkaloids and phenol content of the samples were determined using the alkaline picrate method by Sarkiyayi and Agar, (2010), Anbuselvi and Balarumugan, (2014), (Ismaila *et al*., (2018), Akaninyene *et al*., (2016), Marta *et al*., (2017), AOAC, (2010), Okwu and Morah, (2007) and Pasko *et al*., (2008).

Statistical Analysis*:* Data were subjected to analysis of variance using the Statistical Package for Social Sciences (SPSS), version 20. Results were presented as Mean±standard deviations.

Results and Discussion

Proximate Composition*:* The proximate composition of the fresh pulp, dried chips, fresh and dried peels of the three varieties of cassava roots (TMS 30572, TMS 98/0505, and TMS 01/1368) are shown in Table 1. Also, the % gains and losses incurred by the dried chips and the dried peels in the proximate composition of the samples are shown in Figures (1) and (2). The fresh pulp, dried chips, fresh peels and dried peels had moisture content ranging from 26.59±0.20% to 35.28±0.74%, 10.87±0.04% to 12.77±0.02%, 18.77±0.04 % to 19.56±0.23 % and 10.69±0.33% to 11.32±0.03% respectively. The results show that the moisture content of the fresh pulp and the fresh peels were higher than that of dried chips and the dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that soaking + sun drying reduced the moisture content of the dried chips, hence leading to loss of moisture in the dried chips from 56.6-69.2% across the varieties with TMS 30572 (69.2%) recording the highest moisture loss, followed by TMS 98/0505 and TMS 01/1368 (56.6% each) . Sun drying only, reduced the moisture content of the dried peels, hence leading to the loss of moisture in the dried peels from 39.7-45.3% across the varieties, with TMS 30572(45.3%) as the highest, followed by TMS 01/1368(44.8%) and TMS 98/0505 (39.7%). Significant ($P<0.05$) variations in moisture exist between the fresh pulp and the dried chips, and the fresh peels and the dried peels across the varieties studied.

The observed ranges in the fresh pulp were below 65 to74% as reported by Wheatley and Chuzel, (1993) on four cultivars harvested at various ages and seasons and fresh peels below the value 58.88% reported by Somendrika *et al.,* (2017). The observed ranges in the dried chips and the dried peels were below the recommended 13% moisture level for dried cassava chips (FAO, 2006). All the samples had good moisture level and hence have the potential for better shelf life. The dried peels are in good shape for the production flour for livestock feeds.

The fresh pulp, dried chips, fresh peels and dried peels had ash ranging from 0.95±0.01% to 1.10±0.03%, 1.53±0.01% to 2.08±0.02%, 1.20±0.01% to 1.25±0.01%, and 3.31±0.01 % to 3.67±0.03% respectively. The results show that the ash content of the fresh pulp and the fresh peels were lower than that of dried chips and the dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that soaking + sun drying improves and retains the ash content of the dried chips from 61.6–89.1% across the varieties with TMS 30572 (89.1%) the highest, followed by TMS 98/0505(64.5%) and TMS 01/1368(61.1%). Sun drying only improves and retains the ash content of the dried peels from 175-196% across the varieties with TMS 01/1368 (196%) the highest, followed by TMS 98/0505(175.8%) and TMS 30572(175%). Significant variations ($P<0.05$) in ash exist between the fresh pulp and the dried chips, and the fresh peels and the dried peels across the varieties studied. Ash is the reflection of inorganic mineral elements present in a sample. The observed ranges in the fresh pulp were below the values 1.44 to 2.35% reported by Eleazu and Eleazu, (2012), while the observed ranges in dried chips is comparable to the values 1 to 2.84% on dry weight basis reported by Aryee *et al*., (2006). The difference in values obtained in this study compared with the values obtained by other studies may be because of the effect of different treatments, variety and ecological factors.

The fresh pulp, dried chips, fresh peels, and dried peels had fat ranging from 0.67±0.02% to 0.75±0.01%, 0.68±0.00% to 0.74±0.02%, 0.72±0.03% to 0.82±0.00% and 1.63±0.01% to 1.71±0.01 % respectively. The results show that there is a difference in composition of fat between the fresh pulp and the dried chips, and the fresh peels and the dried peels across the varieties. This could be attributed to the effect of the processing methods applied in the study. This tends to suggest that Soaking + sun drying did not significantly ($p<0.05$) affect the fat composition in TMS 30572 (between the fresh pulp and the dried chips) but affected ($p<0.05$) the fat composition in TMS 98/0505 by reducing the dried chips by 4.2%. TMS 01/1368 had fat lower in the fresh pulp than in the dried chips, implying that soaking + sun drying improves and retains the fat composition of the dried chips to 7.5% in the variety. The fat composition of the fresh peels was lower than that of the dried peels across the varieties. This shows that sun drying only improves and retains the fat composition of the dried peels from 98.8-131.9% across the varieties. Fat are vital to the structure and biological functions of cells and are used as an alternative source of energy. The observed values in the fresh pulp were higher than 0.1 to 0.4% as reported by Charles *et al*., (2005) and 0.65% by Padonou *et al.,* (2005), while in dried chips are within the range 0.56 to 0.82% (Oluwole *et al*., 2004) on white gari made from dried cassava chips. The observed values in the dried peels would be comparable to the values 2.50 to 3.52% (Okpako *et al*., 2008) on fresh weight.

The fresh pulp, dried chips, fresh and dried peels had protein ranging from 3.32±0.03% to 3.45±0.04%, 3.94±0.00% to 4.79±0.01%, 4.84±0.02% to 5.62±0.03% and 6.81±0.04% to 7.87±0.04% respectively. The result shows that the protein content of the fresh pulp and the fresh peels were lower than the protein content of the dried chips and the dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that soaking + sun drying improves and retains the protein content of the dried chips (16.6-38.8%) across the varieties with TMS 30572(38.8%), the highest, followed by TMS 98/0505(28.9%) and TMS 01/1368(16.6%). Sun drying only, improves and retains the protein content of the dried peels (40-40.7%) across the varieties with TMS 01/1368(40.7%), the highest, followed by TMS 30572 and TMS 98/0505(40% each). Significant ($P<0.05$) variations in protein exist between the fresh pulp and the dried chips, and the fresh peels and the dried peels across the varieties studied. The range of values in the fresh pulp were high when compared with 0.9% obtained in raw cassava as reported by Somendrika *et al*., (2017), while that obtained in the dried chips were higher than 0.70 to 1.09% for gari processed in South-South Nigeria (Ekwu, 2015). The range of values in the fresh peels was higher than 1.23% as reported by Buitrago, (1990), while that obtained in the dried peels were higher than 4.86% sun dried cassava peels as reported by Bradbury and Holloway, (1998). The differences in values obtained in this study compared with the values obtained by other studies may be due to the effect of different treatments, variety and ecological factors.

The fresh pulp, dried chips, fresh and dried peels had crude fibre values ranging from 0.91±0.02% to 1.08±0.02%, 1.64±0.02% to 1.83±0.01%, 1.52±0.00% to 1.67±0.05% and 2.54±0.08% to 3.18±0.00% respectively. The results show that the crude fibre content of the fresh pulp and the fresh peels were lower than that of dried chips and the dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that soaking + sun drying improves and retains the crude fibre content of the dried chips (62-86.7%) across the varieties with TMS 01/1368(86.7%), the highest, followed by TMS 98/0505(80.2%), and TMS 30572(62%). Sun drying only, improves and retains the crude fibre content of the dried peels (57.8-109.2%) across the varieties with TMS 01/1368(109.2%), the highest, followed by TMS 98/0505(64.1%), and TMS 30572(57.8%). Significant ($P<0.05$) variations in crude fibre exist between the fresh pulp and the dried chips, the fresh peels and the dried peels across the varieties studied. Crude fibre is the measure of the level of cellulose and lignin inherent in a sample. The range of values in the fresh pulp were lower than 1.10% fibre content reported by Buitrago, (1990), and 1.4% by Bradbury and Holloway, (1990), while for dried chips were within the range of values 1.72 to 1.93% obtained in 'abacha' slices derived from dried cassava chips as reported by Ekwu *et al.,* (2012). The range of values in the fresh peels were lower compared with 4.7% fresh cassava peel reported by Okah *et al.,* (2017), while that in the dried peels were lower compared with 5.2% sun dried cassava peel (Okah *ibid*). The difference in values obtained in this study compared with the values obtained by other studies may be due to the effect of different treatments, variety and ecological factors.

The fresh pulp, dried chips, fresh and dried peels had carbohydrate values ranging from 58.35±0.84% to 67.44±0.78%, 78.89±0.04% to 80.44±0.11%, 71.14±0.18% to 72.34±0.03% and 73.54±0.03% to 73.89±0.04% respectively. The results show that the carbohydrate content of the fresh pulp and the fresh peels were lower than the carbohydrate content of the dried chips and the dried peels across the varieties. This tends to suggest that soaking + sun drying improves and retains the carbohydrate content of the dried chips (19.3-36.7%) across the varieties, with TMS 30572(36.7%), the highest, followed by TMS 98/0505(22.2%) and TMS 01/1368(19.3%). Sun drying only improves and retains the carbohydrate content of the dried peels (1.7-3.8%) across the varieties with TMS 30572(3.8%), the highest, followed by TMS 01/1368(2.4%) and TMS 98/0505(1.7%). There was a significant (P<0.05) variation in carbohydrate between the fresh pulp and the dried chips, the fresh peels and the dried peels across the varieties studied. The range of values obtained in the fresh pulp were lower compared with the values (80 to 90%) reported by Montagnac *et al.,*(2009) on fresh weight basis, while that in dried chips were low compared with the values (83.60 to 84.89%) obtained in 'abacha' slices derived from dried cassava chips reported by Ekwu *et al.,*(2012). The carbohydrate values of the fresh peels were high compared to the values (11.91 to 22.33%) reported by Adeleke *et al*., (2017).

The fresh pulp, dried chips, fresh and dried peels had energy ranging from 1078.27±13.06 kJ/100g to 1228.46±0.54kJ/100g, 1438.88±0.00kJ/100g to 1464.89±0.06kJ/100g, 1335.26±3.61kJ/100g to 1347.49±0.31kJ/100g and 1433.42±0.01kJ/100g to 1449.38±7.17 kJ/100g respectively. The results show that the energy content of the fresh pulp and the fresh peels were lower than that of dried chips and dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that soaking + sun drying improves and retains the energy content of the dried chips (18.9-35.9%) across the varieties with TMS 30572(35.9%), the highest, followed by TMS 98/0505(21.9%) and TMS 01/1368(18.9%). Sun drying only improves and retains the energy content of the dried peels (1.7-8.5%) across the varieties with TMS 30572(8.5%), the highest, followed by TMS 01/1368(7.3%) and TMS 98/0505(6.7%). Energy value of food measures the chemical energy inherent in the bonds of the organic components of the food. The range of values in the fresh pulp were high compared with the values 526 kJ/100g to 611 kJ/100g reported by Charles *et al.,* (2005) and USDA, (2015). The values from the dried chips is comparable to the values (1406 kJ/100g to 1465 kJ/100g) on dry weight basis reported by Charles *et al.,* (2005). The difference in values obtained in this study compared with the values obtained by other studies may be due to the effect of different treatments, variety and ecological factors.

Anti-Nutritional Composition: The anti-nutritional composition of the fresh pulp, dried chips, fresh and dried peels of three varieties of cassava roots are shown in the Table 2. Also, the anti-nutritional % losses incurred by the dried chips and the dried peels in the samples are shown in Figures (3) and (4). The fresh pulp, dried chips, fresh and dried peels had saponins ranging from 0.51±0.01mg/100g to 0.69±0.01mg/100g, 0.25±0.01mg/100g to 0.32±0.00mg/100g, 0.74±0.03mg/100g to 0.84±0.02mg/100g and 0.29±0.00mg/100g to 0.39±0.01mg/100g respectively. The results show that the saponins content of the fresh pulp and the fresh peels were higher than the saponins content of the dried chips and the dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that the saponins content of the dried chips were reduced by soaking + sun drying, hence leading to the loss of saponins from the dried chips (48.1-53.6%) across the varieties with TMS 30572(53.6%), the highest, followed by TMS 98/050 (51%) and TMS 01/1368(48.1%). The saponins content of the dried peels were reduced by sun drying only, hence, leading to the loss of saponins in the dried peels (52-60.8%) across the varieties with TMS 98/0505(60.8%), the highest, followed by TMS 30572(53.6%) and TMS 01/1368(52%). Saponins form complexes with metals, and are the bioactive component of ginseng responsible for its metabolic and potential health effects (Christensen, 2009).

The range of values from the fresh pulp and the dried chips obtained in this study were lower than 13mg/100g to 21mg/100g from sweet and bitter cassava varieties for gari production (Obueh and Kolawole, 2016). The fresh peels and the dried peels obtained in this study were lower than 76mg/100g obtained from cassava peels fed to ruminants (Ukanwoko and Nwachukwu, 2017). The difference between the results obtained in this study and the results of other studies may be due to the effects of different variety, ecological factors and treatments applied.

The fresh pulp, dried chips, fresh and dried peels had tannins ranging from 1.17±0.01 mg/100g to 1.28±0.03 mg/100g, 0.49±0.01mg/100g to 0.59±0.01mg/100g, 1.24±0.01mg/100g to 1.56±0.02mg/100g and 0.74±0.00mg/100g to 0.86±0.0 mg/100g respectively. The results show that the tannins content of the fresh pulp and the fresh peels were higher than that of dried chips and dried peels respectively across the varieties, and this could be because of the effect of the processing methods applied in the study. This tends to suggest that the tannins content of the dried chips were reduced by soaking + sun drying, hence leading to the loss of tannins in the dried chips (52.1-58.1%) across the varieties with TMS 01/1368(58.1%), the highest, followed by TMS 30572(53.9%) and TMS 98/0505(52.1%). The tannins content of the dried peels were reduced by sun drying only, hence leading to the loss of tannins in the dried peels (40.3-44.9%) across the varieties with TMS 30572(44.9%) being the highest, followed by TMS 01/1368(43.5%) and TMS 98/0505(40.3%). Significant (P<0.05) variation in tannins exist between the fresh pulp and the dried chips, and the fresh peels and the dried peels across the cassava varieties studied. Tannin can inactivate thiamin, bind certain salivary and digestive enzymes, and enhance secretion of endogenous protein. Consequently, they inhibit non-heme-Fe absorption, reduce thiamin absorption and the digestibility of starch, protein (Silva and Silva, 1999), and lipids, and also interfere with protein digestibility (Bravo, 1998). The range of values 0.4 mg/100g to 0.6 mg/100g from sweet and bitter cassava variety reported by Sarkiyayi and Agar, (2010) are lower than the range of values in the fresh pulp, but comparable to the values in the dried chips obtained in this study. The range of values in the fresh and dried peels obtained in this study was lower than 31 mg/100g cassava peels from kitchen waste reported by Obueh and Kolawole, (2016). The difference between the results obtained in this study and the results of other researchers may be due to the effect of different variety, ecological factors and treatments applied.

The fresh pulp, dried chips, fresh peels and the dried peels had cyanide ranging from 18.58±0.18mg/kg to 21.77±0.04mg/kg, 6.78±0.00mg/kg to 7.70±0.14mg/kg, 22.49±0.01mg/kg to 23.64±0.23mg/kg and 8.56±0.20mg/kg to 9.53±0.11mg/kg respectively. The results show that the cyanide content of the fresh pulp and the fresh peels were higher than the cyanide contents of the dried chips and the dried peels respectively across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that the cyanide content of the dried chips were reduced by soaking + sun drying, hence leading to the loss of cyanide in the dried chips (63.5-64.6%) across the varieties with TMS 98/0505(63.5%) being the least, but TMS 30572 and TMS 01/1368 had same percentage loss of cyanide (64.6%). The cyanide content of the dried peels were reduced by sun drying only, hence leading to the loss of cyanide in the dried peels (59.7-62.3%) across the varieties with TMS 98/0505(62.3%) being the highest, followed by TMS 01/1368(61.9%) and TMS 30572(59.7%). Cyanide is the most toxic factor restricting the consumption of cassava roots and peels. Cyanide is poisonous because it binds with cytochrome oxidase and stops its action in respiration in the body or other living tissues (Tewe, 1992). The values for the dried chips and the dried peels obtained in this study are within the safe FAO/WHO recommended value of <10mg cyanide equivalent/kg DM, to prevent acute toxicity in humans (FAO/WHO, 2006). The range of values for the fresh pulp and the dried chips obtained in this study are comparable to 7.58mg/kg and 20.13mg/kg from fresh and bitter cassava variety reported by Obueh and Kolawole, (2016), but lees than 44mg/kg for unfermented cassava peel as reported by Valero and Salmeron, (2003). The difference between the results obtained in this study and the results of other researchers may be due to the effect of different variety, ecological factors and treatments applied.

The fresh pulp, dried chips, fresh and dried peels had oxalate ranging from 1.73±0.01mg/100g to 1.93±0.01mg/100g, 0.67±0.03mg/100g to 0.81±0.01mg/100g, 2.37±0.04mg/100g to 2.76±0.04mg/100g and 1.24±0.01mg/100g to 1.44±0.02mg/100g respectively. The results show that the oxalate content of the fresh pulp and the fresh peels were higher than that of dried chips and the dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that the oxalate content of the dried chips were reduced by soaking + sun drying, hence leading to the loss of oxalate in the dried chips (57.8-62.1%) across the varieties with TMS 98/0505(62.1%) being the highest, followed by TMS 30572(58%) and TMS 01/1368(57.8%). The oxalate content of the dried peels were reduced by sun drying only, hence leading to the loss of oxalate in the dried peels (47.3-47.8%) across the varieties with TMS 30572 (47.8%) being the highest, followed by TMS 98/0505(47.7%) and TMS 01/1368(47.3%). Oxalates can bind to calcium and other metals rendering these metals unavailable for normal physiological and biochemical roles such as maintenance of strong bones, teeth and nerve transmission (Ladeji *et al*., 2004). The values 1.3mg/100g and 3.27mg/100g from sweet and bitter cassava variety for gari production (Obueh and Kolawole, 2016) may be comparable to the values in the fresh pulp, but higher than the values in the dried chips obtained in this study. The difference between the results of this study and the results of other researchers could be attributed to the effect of different variety, ecological factors and treatments applied.

The fresh pulp, dried chips, fresh and dried peels had phytate ranging from 1.17±0.01mg/100g to 1.22±0.03mg/100g, 0.37±0.02mg/100g to 0.54±0.00mg/100g, 1.24±0.02mg/100g to 1.53±0.11mg/100g and 0.59±0.01mg/100g to 0.77±0.01mg/100g respectively. The results show that the phytate content of the fresh pulp and the fresh peels were higher than that of dried chips and the dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that the phytate content of the dried chips were reduced by soaking + sun drying, hence leading to loss of phytate in the dried chips (54.2-68.4%) across the varieties with TMS 98/0505(68.4%) being the highest, followed by TMS 01/1368(67.2%) and TMS 30572 (54.2%). The phytate content of the dried peels were reduced by sun drying only, hence leading to the loss of phytate in the dried peels (49.7-52.4%) across the varieties with TMS 98/0505(52.4%) being the highest, followed by TMS 01/1368(51.5%) and TMS 30572(49.7%). Phytate is capable of chelating divalent cationic minerals like calcium, iron, magnesium and zinc, thereby inducing dietary deficiency (Akindahunsi and Oboh, 1999). The range of values from the fresh pulp and the dried chips obtained in this study are considerably lower than 53mg/100g and 62.4mg/100g from sweet and bitter cassava variety reported by Obueh and Kolawole, (2016). The range of values from the fresh and the dried peels obtained in this study are considerably lower than 921mg/kg cassava peels from crop residues and kitchen wastes fed to small ruminants (Ukanwoko and Nwachukwu, 2017). The difference between the results of this study and the results of other researchers reported in this study could be attributed to the effect of different variety, ecological factors, and treatments applied.

The fresh pulp, dried chips, fresh peels and dried peels had alkaloids ranging from 0.47±0.01mg/100g to 0.64±0.02mg/100g, 0.24±0.01mg/100g to 0.31±0.01mg/100g, 0.78±0.00mg/100g to 0.84±0.02mg/100g and 0.28±0.01mg/100g to 0.42±0.00mg/100g respectively. The results show that the alkaloid content of the fresh pulp and the fresh peels were higher than the alkaloid content of the dried chips and the dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that the alkaloid content of the dried chips were reduced by soaking + sun drying, hence leading to loss of alkaloids in the dried chips (34-62.5%) across the varieties with

TMS 30572(62.5%) being the highest, followed by TMS 98/0505(52.6%) and TMS 01/1368(34%). The alkaloids content of the dried peels were reduced by sun drying only, hence leading to the loss of alkaloids in the dried peels (50-64.1%) across the varieties with TMS 98/0505(64.1%) being the highest, followed by TMS 30572 (56.6%) and TMS 01/1368(50%). Significant ($P<0.05$) variation in alkaloids exist between the fresh pulp and the dried chips, and the fresh peels and the dried peels across the cassava varieties studied. Though alkaloids comprise a large group of nitrogenous compounds widely used as cancer chemotherapeutic agents, they interfere with cell division and almost uniformly invoke bitter taste in foods (Valero and Salmeron, 2003). The range of values from the fresh pulp and the dried chips obtained in this study were considerably lower than 27mg/100g and 32mg/100g obtained from sweet and bitter cassava variety for gari production reported by Obueh and Kolawole, (2016). The difference between the results of this study and the results of other researchers reported in this study could be attributed to the effect of different variety, ecological factors, and treatments applied.

The fresh pulp, dried chips, fresh peels and dried peels had trypsin inhibitor ranging from 3.89±0.04mg/100g to 4.78±0.03mg/100g, 2.28±0.03mg/100g to 3.47±0.01mg/100g, 4.80±0.00mg/100g to 5.54±0.08mg/100g and 3.67±0.04mg/100g to 4.74±0.02mg/100g respectively. The results show that the trypsin inhibitor content of the fresh pulp and the fresh peels were higher than the trypsin inhibitor content of the dried chips and the dried peels across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that the trypsin inhibitor content of the dried chips were reduced by soaking + sun drying, hence leading to the loss of trypsin inhibitor in the dried chips (27.4-46%) across the varieties with TMS 98/0505(46%) being the highest, followed by TMS 01/1368(28.8%) and TMS 30572(27.4%). The trypsin inhibitor content of the dried peels were reduced by sun drying only, hence leading to the loss of trypsin inhibitor from the dried peels (14.4-28.7%) across the varieties with TMS 98/0505(28.7%) recording the highest percentage loss, followed by TMS 01/1368(23.1%) and TMS 30572 (14.4%). Significant ($P<0.05$) variation in trypsin inhibitor exist between the fresh pulp and the dried chips, and the fresh peels and the dried peels across the cassava varieties studied. Trypsin inhibitor is an example of protein inhibitor with specificity for trypsin. Its presence forms an irreversible enzyme-trypsin inhibitor complex which causes trypsin drop in the intestine and a decrease in protein digestibility leading to slower animal growth (Al-marzooqi *et al*., 2010). The range of values in the fresh pulp and the dried chips obtained in this study were higher than 1mg/100g to 4mg/100g obtained from sweet and bitter cassava variety (Sarkiyayi and Agar, 2010). The difference between the results of this study and the results of other researchers reported in this study could be attributed to the effect of different variety, ecological factors, and treatments applied.

The fresh pulp, dried chips, fresh peels and dried peels had phenol ranging from 0.31±0.02mg/100g to 0.48±0.01mg/100g, 0.18±0.01mg/100g to 0.24±0.01mg/100g, 0.51±0.01mg/100g to 0.64±0.01mg/100g and 0.25±0.01mg/100g to 0.32±0.00mg/100g respectively. The results show that the phenol content of the fresh pulp and the fresh peels were higher than the phenol content of the dried chips and the dried peels respectively across the varieties, and this could be attributed to the effect of the processing methods applied in the study. This tends to suggest that the phenol content of the dried chips were reduced by soaking + sun drying, hence leading to the loss of phenol in the dried chips (41.9-50%) across the varieties with TMS 30572(50%) being the highest, followed by TMS 01/1368 (48.7%) and TMS 98/0505(41.9%). Significant ($P<0.05$) variation in phenol exist between the fresh pulp and the dried chips, and the fresh peels and the dried peels across the cassava varieties studied.

Conclusion

The result shows that soaking + sun drying and sun drying methods traditionally used for processing fresh cassava roots showed ability to -improve and retain the proximate composition of the dried chips and the dried peels when compared with the fresh pulp and the fresh peels respectively. -Reduce moisture in the dried chips and the dried peels, and fat in TMS 98/0505 which had incurred loss of 4.2% in the dried chips. -Reduce the anti-nutritional content of the dried chips and dried peels to the safe levels for human and animal consumption.

Table 1: Proximate composition of the fresh pulp, dried chips, fresh and dried peels of the three varieties of cassava roots (TMS 30572, TMS 98/0505, and TMS 01/1368)

Variety	Treatments	MC (%)	ASH (%)	FAT (%)	CP (%)	CF (%)	CHO (%)	E.V (kJ/100g)
TMS 30572	Fresh Pulp	$35.28^{a}\pm0.74$	$1.10^{i}\pm0.03$	$0.75^{de}\pm0.01$	$3.45^{i}\pm0.04$	$1.08^{h}\pm0.02$	$58.35^{i}\pm0.84$	$1078.27^{h}\pm13.06$
	Dried Chips	$10.87^{hi}\pm0.04$	$2.08^{d}\pm0.02$	$0.74^{de}\pm0.02$	$4.79^{f}\pm0.01$	$1.75^{de}\pm0.04$	$79.78^{b}\pm0.03$	$1464.89^{a}\pm0.06$
	Fresh Peels	$19.56^{d}\pm0.23$	$1.25^{g}\pm0.01$	$0.82^{c}\pm0.00$	$5.62^{d}\pm0.03$	$1.61^{fg}\pm0.03$	$71.14^{f}\pm0.18$	$1335.26^{e}\pm3.61$
	Dried Peels	$10.69^{i}\pm0.33$	$3.44^{b}\pm0.02$	$1.63^{b}\pm0.01$	$7.87^{a}\pm0.04$	$2.54^{c}\pm0.08$	$73.84^{d}\pm0.41$	$1449.38^{b}\pm7.17$
TMS 98/0505	Fresh Pulp	$29.42^{b}\pm0.05$	$1.07^{i}\pm0.03$	$0.71^{ef}\pm0.01$	$3.32^{j}\pm0.03$	$0.91^{i}\pm0.02$	$64.58^{h}\pm0.04$	$1180.57^{g}\pm0.28$
	Dried Chips	$12.77^{f}\pm0.02$	$1.76^{e}\pm0.00$	$0.68^{fg}\pm0.00$	$4.28^{g}\pm0.04$	$1.64^{f}\pm0.02$	$78.89^{c}\pm0.04$	$1438.88^{c}\pm0.00$
	Fresh Peels	$18.77^{e}\pm0.04$	$1.20^{h}\pm0.01$	$0.76^{d}\pm0.03$	$5.27^{e}\pm0.01$	$1.67^{ef}\pm0.05$	$72.34^{e}\pm0.03$	$1347.49^{d}\pm0.31$
	Dried Peels	$11.32^{gh}\pm0.03$	$3.31^{c}\pm0.01$	$1.71^{a}\pm0.01$	$7.38^{b}\pm0.03$	$2.74^{b}\pm0.00$	$73.54^{d}\pm0.03$	$1438.41^{c}\pm0.18$
TMS 01/1368	Fresh Pulp	$26.59^{c}\pm0.20$	$0.95^{j}\pm0.01$	$0.67^{g}\pm0.02$	$3.38^{j}\pm0.00$	$0.98^{i}\pm0.08$	$67.44^{g}\pm0.78$	$1228.46^{f}\pm0.54$
	Dried Chips	$11.54^{g}\pm0.08$	$1.53^{f}\pm0.01$	$0.72^{def}\pm0.00$	$3.94^{h}\pm0.00$	$1.83^{d}\pm0.01$	$80.44^{a}\pm0.11$	$1461.10^{a}\pm1.92$
	Fresh Peels	$19.54^{d}\pm0.06$	$1.24^{g}\pm0.01$	$0.72^{def}\pm0.03$	$4.84^{f}\pm0.02$	$1.52^{g}\pm0.00$	$72.15^{e}\pm0.78$	$1335.30^{e}\pm0.64$
	Dried peels	$10.79^{hi}\pm0.01$	$3.67^{ab}\pm0.03$	$1.67^{b}\pm0.04$	$6.81^{c}\pm0.04$	$3.18^{a}\pm0.00$	$73.89^{d}\pm0.04$	$1433.42^{c}\pm0.01$

MC = Moisture content; CP = Crude protein; CF = Crude fibre; CHO = Carbohydrate; E.V = Energy value. Values are mean ± SD of duplicate determination. Mean values with the same superscript within the same column are not significantly different (P > 0.05)

Table 2: Anti-nutritional composition of the fresh pulp, dried chips, fresh and dried peels of the three varieties of cassava roots (TMS 30572, TMS 98/0505, and TMS 01/1368)

Variety	Treatments	Saponins (mg/100 g)	Tannins (mg/100 g)	HCN (mg/kg)	Oxalate (mg/100 g)	Phytate (mg/100 g)	Alkaloids (mg/100 g)	Trypsin Inhibitor (mg/100 g)	Phenol (mg/100 g)
TMS 30572	Fresh Pulp	$0.69^{c}\pm0.01$	$1.28^{c}\pm0.03$	$21.77^{c}\pm0.04$	$1.93^{d}\pm0.01$	$1.18^{c}\pm0.00$	$0.64^{c}\pm0.02$	$4.78^{c}\pm0.03$	$0.48^{c}\pm0.01$
	Dried Chips	$0.32^{h}\pm0.00$	$0.59^{g}\pm0.01$	$7.70^{h}\pm0.14$	$0.81^{h}\pm0.01$	$0.54^{f}\pm0.00$	$0.24^{i}\pm0.01$	$3.47^{g}\pm0.01$	$0.24^{g}\pm0.01$
	Fresh Peels	$0.84^{a}\pm0.02$	$1.56^{a}\pm0.02$	$23.64^{a}\pm0.23$	$2.76^{a}\pm0.04$	$1.53^{a}\pm0.11$	$0.83^{a}\pm0.01$	$5.54^{a}\pm0.08$	$0.64^{a}\pm0.01$
	Dried Peels	$0.39^{f}\pm0.01$	$0.86^{e}\pm0.01$	$9.53^{f}\pm0.11$	$1.44^{f}\pm0.02$	$0.77^{d}\pm0.01$	$0.36^{g}\pm0.00$	$4.74^{c}\pm0.02$	$0.32^{e}\pm0.00$
TMS 98/0505	Fresh Pulp	$0.51^{e}\pm0.01$	$1.17^{d}\pm0.01$	$18.58^{e}\pm0.18$	$1.77^{e}\pm0.04$	$1.17^{c}\pm0.01$	$0.57^{d}\pm0.04$	$4.22^{d}\pm0.05$	$0.31^{ef}\pm0.02$
	Dried Chips	$0.25^{j}\pm0.01$	$0.56^{g}\pm0.00$	$6.78^{j}\pm0.00$	$0.67^{j}\pm0.03$	$0.37^{g}\pm0.02$	$0.27^{i}\pm0.02$	$2.28^{i}\pm0.03$	$0.18^{h}\pm0.01$
	Fresh Peels	$0.74^{b}\pm0.03$	$1.24^{c}\pm0.01$	$22.77^{b}\pm0.04$	$2.37^{c}\pm0.04$	$1.24^{c}\pm0.02$	$0.78^{b}\pm0.00$	$5.15^{b}\pm0.04$	$0.51^{b}\pm0.01$
	Dried Peels	$0.29^{i}\pm0.00$	$0.74^{f}\pm0.00$	$8.58^{g}\pm0.25$	$1.24^{g}\pm0.01$	$0.59^{ef}\pm0.01$	$0.28^{hi}\pm0.01$	$3.67^{f}\pm0.04$	$0.25^{g}\pm0.01$
TMS 01/1368	Fresh Pulp	$0.54^{d}\pm0.00$	$1.17^{d}\pm0.04$	$20.72^{d}\pm0.11$	$1.73^{e}\pm0.01$	$1.22^{c}\pm0.03$	$0.47^{e}\pm0.01$	$3.89^{e}\pm0.04$	$0.39^{d}\pm0.01$
	Dried Chips	$0.28^{i}\pm0.00$	$0.49^{h}\pm0.01$	$7.34^{i}\pm0.08$	$0.73^{i}\pm0.00$	$0.40^{g}\pm0.00$	$0.31^{h}\pm0.01$	$2.77^{h}\pm0.02$	$0.20^{h}\pm0.00$
	Fresh Peels	$0.75^{b}\pm0.01$	$1.47^{b}\pm0.02$	$22.49^{b}\pm0.01$	$2.64^{b}\pm0.02$	$1.32^{b}\pm0.04$	$0.84^{a}\pm0.02$	$4.80^{c}\pm0.00$	$0.53^{b}\pm0.01$
	Dried Peels	$0.36^{g}\pm0.01$	$0.83^{e}\pm0.01$	$8.56^{g}\pm0.20$	$1.39^{f}\pm0.01$	$0.64^{e}\pm0.01$	$0.42^{f}\pm0.00$	$3.69^{f}\pm0.13$	$0.28^{f}\pm0.00$

Values are mean ± SD of duplicate determinations. Mean values with the same superscript within the same column are not significantly different (P > 0.05).

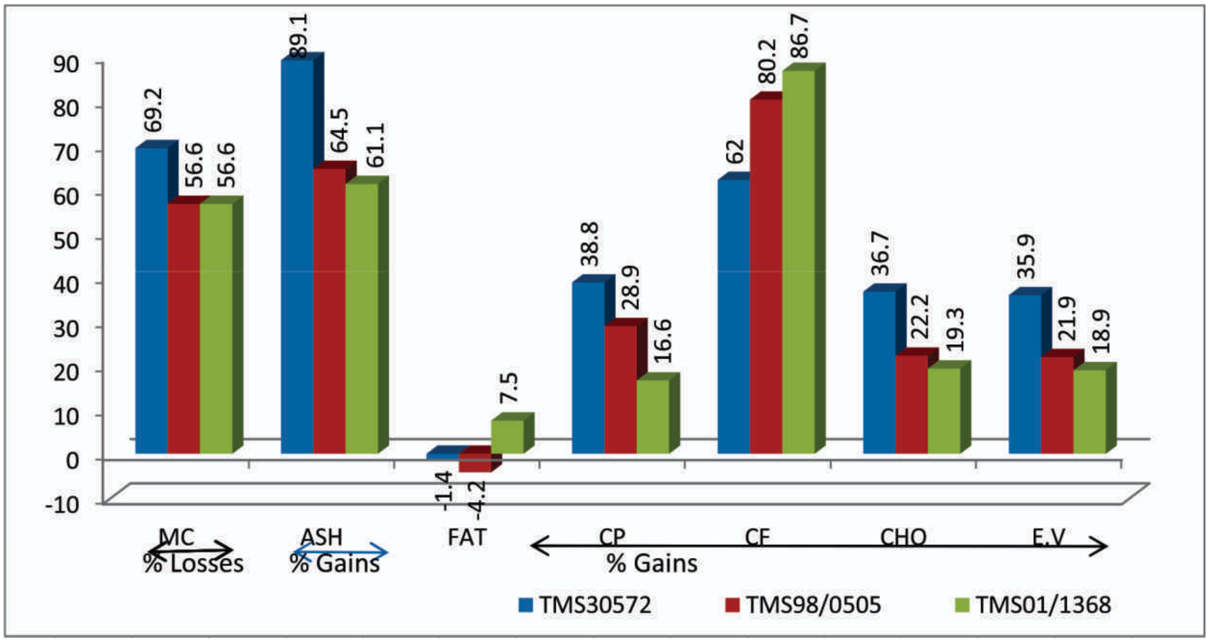

Fig. 1: Proximate analyses of % gains and losses incurred by the dried chips

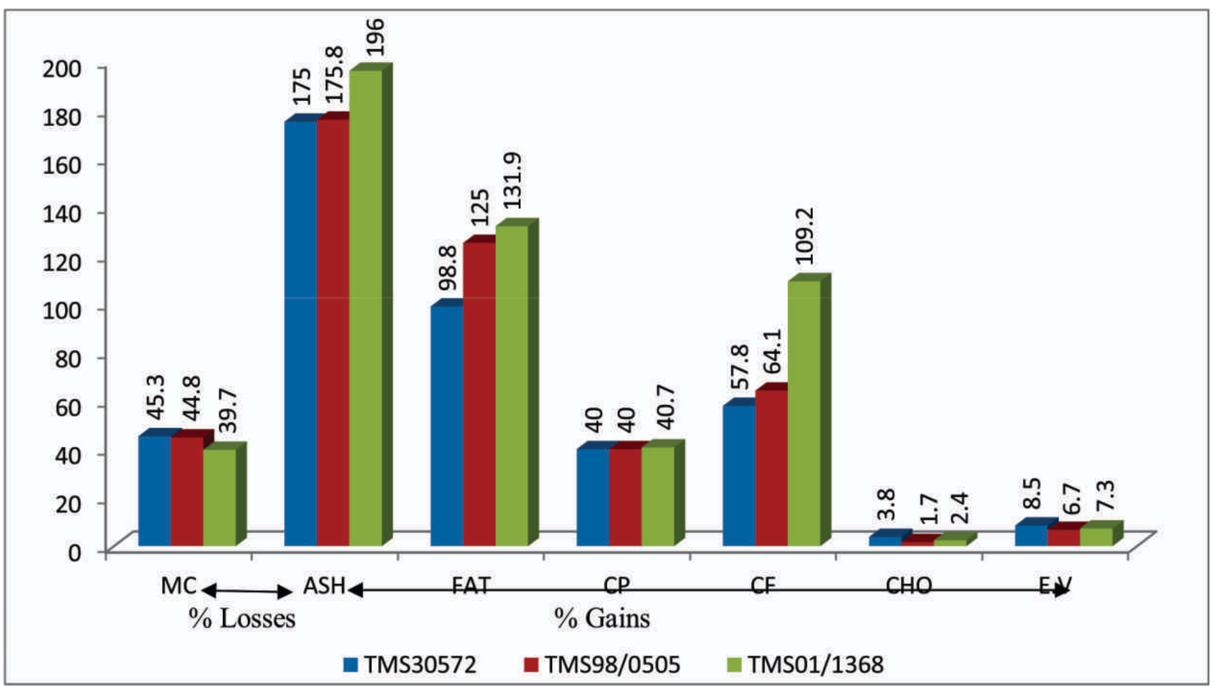

Fig. 2: Proximate analyses of % gains and losses incurred by the dried peels

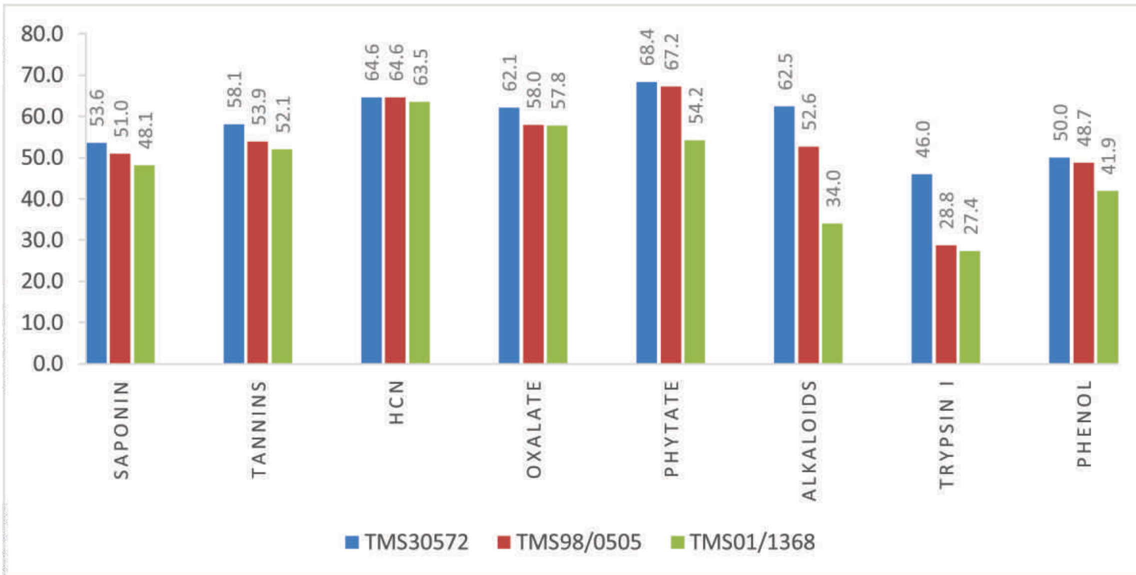

Fig. 3: The anti-nutritional chart presentation of % losses incurred by the dried chips

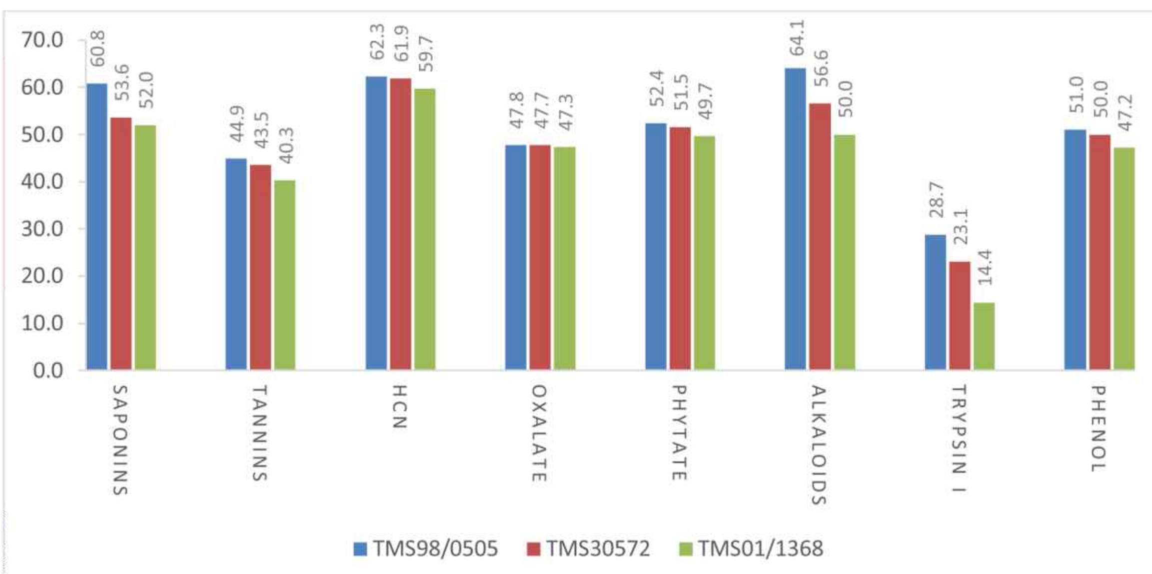

Fig. 4: The anti-nutritional chart presentation of % losses incurred by the dried peels

References

Adeleke, B.S., Akinyele, B.J., Olaniyi, O.O. and Jeff-Agboola, Y.A. (2017). Effect of Fermentation on Chemical Composition of Cassava Peels. *Journal of Plant Science and Research*, 7(1):31-38.

Akaninyene, U. U. and Uwemedimo, E. U. (2016). Nutritive and Anti-Nutritive Evaluation of Cnidoscolus Aurifolia Leaves. *Annals. Food Science and Technology,* 17(2):340-344.

Akindahunsi, A. A. and Oboh, G. (1999). Effect of fermenting cassava with Rhizopus oryzae on the chemical composition of its flour and gari products. La Rivista Italiana Delle Sostanze Grasse 76: 437-40.

Al-Marzooqi, W., Al-Farsi, M.A., Kadim, I.T., Mahgoub, O. and Goddard, J. S. (2010). The Effect of Feeding Different Levels of Sardine Fish Silage on Broiler Performance, Meat Quality and Sensory Characteristics under Closed and Open-sided Housing Systems. *Asian-Aust. J. Anim. Sci.*, 23(12): 1614 – 1625.

Anbuselvi, S. and Balamurugan, T. (2014). Phytochemical and Antinutrient Constituents of Cassava and Sweet Potato. *World Journal Of Pharmacy And Pharmaceutical Sciences*, 3(3):1440-1449.

AOAC (2010). Association of Official Analytical Chemists. Official Methods of Analysis. 18th Edition, Revision 3, , Washington DC.

AOAC (2019). Official Methods of Analysis of the Association of Official Analytical Chemist International, 21st Edition.

Aryee, F.N.A., Oduro I., Ellis W.O. and Afuakwa J.J. (2006). The physicochemical properties of flour samples from the roots of 31 varieties of cassava. *Food Control*, 17: 916–922.

Benson, O. and Christopher, A. (2017). Cyanogenic Potential of Selected Cassava Varieties in Zombo District, Uganda. *International Journal of Nutrition and Food Sciences*, 6(3): 144-148.

Bradbury, J.H. and Holloway, W.D. (1988). Cassava, M. esculenta. Chemistry of tropical root crops: significance for nutrition and agriculture in the Pacific. Australian Centre for International Agricultural Research, monograph nr 6, Canberra, Australia, pp. 76–104.

Bravo, L. (1998). Polyphenols: chemistry, dietary sources, metabolism, and nutritional significance. *Nutr Rev,*56:317–33.

Buitrago, A.J.A. (1990). La yucca en la alimentacion animal. Centro Internacional de Agricultural Tropical, Cali, Colombia, 446pp.

Charles, A.L., Sriroth, K. and Huang, T.C. (2005). Proximate composition, mineral contents, hydrogen cyanide and phytic acid of 5 cassava genotypes. *Food Chemistry,* 92: 615–20.

Christensen, L. P. (2009). Ginsenosides chemistry, biosynthesis, analysis and potential health effects. *Advances in Food and Nutrition Research*, 55:1–9.

Ekwu, F.C. (2015). Study of mechanical, physico-chemical and sensory properties of products from four cassava varieties (unpublished Ph.D Thesis). Department of Food Science and Technology, Faculty of Agriculture, University of Nigeria, Nsukka.

Ekwu, F.C., Uvere, P.O., Chinwero, O.M. (2012). *Nigeria Food Journal*. Volume 30, Issue 1, pages 124-130.

Eleazu, C.O. and Eleazu, K.C. (2012). Determination of the Proximate Composition, Total Carotenoid, Reducing Sugars and Residual Cyanide Level of Flours of 6 New Yellow and White Cassava (Manihot esculenta Crantz) Varieties. *American Journal of Food Technology*, 7: 642-649.

Eleazu, C.O., Oti, E., Amajor, J.U., Ikpeama, A.I., Awa, E. and Eleazu, K.C. (2011). Nutritional evaluation and microbial load of cassava (*Manihot esculenta*) sieviates and peels fermented in brine. Int. J. Adv. Sci. Tech. Res., 1: 1-23.

FAO (2006). Food and Agriculture Organization. Processing of Roots and Tubers In: Storage and Processing of Roots and Tubers: Agriculture and Consumer Protection paper.

FAO/WHO (2006). Joint FAO/WHO food standards programme. In: Codex Alimentarius Commission Thirteen Session. Rome, Italy.

FAO/WHO (2011). Joint FAO/WHO food standards programme. In: Codex Alimentarius Commission Thirty-fourth Session Geneva, Switzerland.

Francis, G., Makkarb, H.P.S. and Becker, K. (2001). Anti-nutritional factors present in plant derived alternate fish feed ingredients and their effects in fish. Review article. *Aquaculture,* 199:197–227.

Ismaila, A. R., Alakali, J. S. and Atume, T. G. (2018). Effect of Local Processing Techniques on the Nutrients and Anti-Nutrients Content of Bitter Cassava (*Manihot Esculenta Crantz*). *American Journal of Food Science and Technology.* 6(3):92-97. doi: 10.12691/ajfst-6-3-1.

Juanatey, A.G. (2018). Reconciling Human Rights and the Environment: A Proposal to Integrate the Right to Food with Sustainable Development in the 2030 Development Agenda : DOI: https://dx.doi.org/10.4314/jsdlp.v9i1.2.

Ladeji, O., Akin, C.U. and Umaru, H.A. (2004). Levels of anti-nutritional factors in vegetables commonly eaten in Nigeria. *African J Natural Sci*., 7: 71-3.

Lukuyu, B., Okike, I., Duncan, A.J., Beveride, M. and Blummel, M. (2014). Use of Cassava in livestock and aquaculture feeding programs. ILRI Discussion Paper 25. Nairobi. Kenya. International livestock Research Institute.

Marta, G., Jordi, M., Qi, S., Montse, F., and Jordi S. (2017). Dietary Polyphenols, Mediterranean Diet, Prediabetes, and Type 2 Diabetes: A Narrative Review of the Evidence. *Oxidative Medicine and Cellular Longevity*, 2017, 16 pages https://doi.org/10.1155/2017/6723931.

Monday, A.O, Simon, T.U and Agbajor, K.G. (2017). Proximate Analysis and Mineral Composition of Peels of Three Sweet Cassava Cultivars. *Asian Journal of Physical and Chemical Sciences,* 3(4): 1-10.

Montagnac, J. A., Davis, C. R. and Tanumihardjo, S. A.

(2009). Nutritional value of cassava for use as a staple food and recent advances for improvement. *Compr. Rev. Food Sci. Food Saf.*, 8 (3):181–94.

Nazim, M. U., Mitra, K., Rahman, M. M., Abdullah, A. T. M. and Parveen, S. (2013). Evaluation of the nutritional quality and microbiological analysis of newly developed soya cheese. *International Food Research Journal*, 20(6): 3373-3380.

Obueh, H. O. and Kolawole, S. E. (2016) Comparative Study on the Nutritional and Anti-Nutritional Compositions of Sweet and Bitter Cassava Varieties for Garri Production. *J Nutr Health Sci,* 3(3): 302. doi: 10.15744/2393-9060.3.302.

Okah, U., Adedokun, O. O. and Ebere, C. N. (2017). Effect of Processing Methods on the Chemical Composition of Cassava Peel as Livestock Feed Resource. A PhD Thesis submitted to the College of Animal Science and Animal Production, Michael Okpara University of Agriculture Umudike, P.M.B. 7267, Umuahia, Abia State, Nigeria.

Okaka, J.C. (2007). Tropical Plant Perishables. Handling, Storage and Processing, Sill Valley Publishers, New Heaven, Enugu, Nigeria, Pp. 97–148.

Okpako, C.E., Ntui, V.O., Osuagwu, A.N. and Obasi, F.I. (2008). Proximate composition and cyanide content of cassava peels fermented with Aspergillus niger and Lactobacillus rhamnosus. *Journal of Food, Agriculture & Environment,* 6 (2): 251-255.

Okwu, D.E. and Morah, F.N.I. (2007). Isolation and characterization of flavanone glycoside 4l, 5, 7 trihydroxy flavanone rhamnoglucose from *Garcinia kola* seed. *Journal of Applied Sciences,* 7 (2):306-309.

Oluwole, O.B., Olantunji, O. and Odunfa, S.A. (2004). Process technology for Conversion of dried cassava chips into gari. *Nigerian Food Journal*, 22:66–77.

Ooye, D.A., Oso, G.K. and Olalumade, B.B. (2014).Effects of different processing methods on the proximate and cyanogenic composition of flour from different cassava cultivar. Research and Reviews: *Journal of Agriculture and Allied Sciences,* 3 (3):1-6.

Padonou, W., Mestres, C. and Nago, M.C. (2005). The quality of boiled cassava roots: instrumental characterization and relationship with physicochemical properties and sensorial properties. *Food Chemistry,* 89: 261–270.

Pasko, P., Sajewicz, M., Gorinstein, S. and Zachwieja, Z. (2008). Analysis of selected phenolic acids and flavonoids in *Amaranthus cruentus and Chenopodium quinoa seeds* and sprouts by HPLC. *Acta Chromatographica*, 4: 661 - 672.

Peace, C. (2015). The relevance of Cassava as a Food Security Crop in Africa. FIIRO Compound, Cappa Bus-Stop, Oshodi, Lagos – Nigeria. Pp. 163

Sarkiyayi, R.S. and Agar, T.M. (2010). Comparative Analysis on the Nutritional and Anti-Nutritional Contents of Sweet and Bitter Cassava Varieties. *Advance Journal of Food Science and Technology*. 2(6): 328-334.

Silva, M.R. and Silva, MAAPd. (1999). Nutritional aspects of phytates and tannins. *Revista de Nutrição,* 12:21–32.

Somendrika, M.A.D., Wickramasinghe, I., Wansapala, M.A.J. and Peiris, J. (2017). Nutritional Composition of Cassava Cultivar "CARI-555". *Pakistan Journal of Nutrition,* 16: 216-220.

Tewe, O.O., (1992). Detoxification of cassava products and effects of residual toxins on consuming animals. In: Machin, D.; Nyvold, S., 1992. Roots, tubers, plantains and bananas in animal feeding. Proceedings of the FAO Expert Consultation held in CIAT, Cali, Colombia 21–25 January 1991; FAO Animal Production and Health Paper . 95pp.

Ukanwoko, A. I. and Nwachukwu, J. (2017). Nutrient and Anti-nutritional composition of crop Residues and Kitchen wastes Fed to small Ruminants in Choba, Port Harcourt. ISSN: 2276-7770.

USDA (2015). National Nutrient Database for Standard Reference http://ndb.nal.usda.gov/ndb/foods/show/2943?fg=andman=andlfacet=andcount=andmax=25andsort=andqlookup=cassavaandoffset=andformat=Statsandnew=andmeasureby=Accessed 10 February 2015.

Valero, M. and Salmeron, M. C. (2003). Antibacterial activity of 11 essential oils against Bacillus aureus in tyndallized carrot broth. *Int J Food Microbiol.*, 85: 73-81.

Wheatley, C. and Chuzel, G. (1993). 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. 734–743.