Comparative Study on the Effect of Drying Methods on the Chemical Composition of locally Made Tapioca Grits

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How to cite this article:
Date of Submission: 2019-07-18
Date of Acceptance: 2019-09-04

ABSTRACT

Cassava root is endowed with many food potentials such as garri, lafu, bobozi, abacha, tapioca, starch and other high-quality cassava flour all of which are characterized with different processing methods. In order to curtail post-harvest deterioration after two days of harvest, the need to process into different product becomes important. Possibilities of drying cassava tapioca by firewood and gas flaring as practiced by the indigenes of Agbahar-Otor, have the potential of causing contamination. Results from these findings reveal that there is no significant difference in the proximate content, but the core heavy metals that could be toxic to health were not detected with the exception of Pb and Cd which recorded values of 0.02 mg/10g and 0.01 mg/100g with the use of firewood for drying, which is still within the WHO permissible limit. Thus the process involved in the drying of cassava tapioca as practiced by the indigenes of Agbaha-Otor is safe with caution placed on the use of firewood drying technique as a possible route to heavy metal contamination which could accumulate over time resulting to a serious health concern.

Keywords: Cassava, Roasting, Tapioca Grits, Proximate, Drying

Introduction

Cassava (Manihot esculenta) is a key root crop second to cereals grown throughout tropical countries worldwide as global sources of carbohydrates. The crop is amongst the utmost drought-resistant crop and proficiently produces on marginal soils where many other crops do not thrive. In East Africa and the Sahel, two-thirds of the workforce is engaged in farming while other household enterprises account for 22% of all jobs. Nigeria is rated the largest producer of cassava in the world with about 45 million metric tons and its cassava transformation is the most advanced in Africa producing above 30% than Brazil and having almost as twice the production capacity of Thailand and Indonesia. Despite its large production output, Nigeria does not participate actively in cassava exportation because cassava grown is targeted at the domestic food market. Cassava provides food security, creates employment and generates income for crop producing households. It continues to play a
significant role in alleviating the African food crisis and offers tremendous potentials as a cheap source of feed energy for livestock. Post-harvest deterioration of cassava roots after two days of harvest poses a course for concern. It has to be further processed to surge up the shelf life span, improve their palatability, expedite their transportation and most importantly, detoxify the roots by eliminating the in-built cyanogens. Cassava roots are processed further into food products such as garri, lafun, akpu, bobozi, abacha, starch, tapioca and other high-quality cassava flour all having different processing methods. Tapioca, as the names imply, is a hard whitish substance, processed from cassava and eaten both as snack or a full meal. It is consumed in many parts of Nigeria, especially in the south-south geopolitical zone of the country where it is served as special delicacy eaten with pork, fish and other proteinaceous supplements. It is highly rich in fiber and aids digestion. Indigenous of Agbarha-Otor and its environ take advantage of the gas flaring outlet located along Gana and Owevwe to dry their tapioca grits. There are several claims that the methods of drying this product by firewood and by heat generated from the gas plant, have the potential of causing contamination as a result of pollution by trace metals from emission fumes from the firewood while smoking and the gas flaring activities. Heavy metals are potential environmental contaminants with the capability of finding their way into the food we eat and causing human health problems. They are given special attention throughout the world due to their ubiquitous nature and toxic effects even at very low concentrations. Thus the study aims at ascertaining the effect of both drying techniques on the proximate and mineral contents of tapioca, so as to check for any possible heavy metal pollutants in the product.

**Methodology**

**Sample Preparation**

Agbarha-Otor is located at longitude 6.07°E and latitude 5.53°N. It is situated in Ughelli North Local Government Area of Delta State, Nigeria. The estimated terrain elevation above sea level is 15 meters. The steps involved in the processing of tapioca grits from cassava involve; harvesting the cassava, peeling and washing and then grinding with a motorized grinder, thereafter the moisture is sieved through a porous sac twice. The solid residue left after sieving can further be nourished with other condiments and fried in a big pan. The fried sample is then subjected to either of the drying technique (gas flared or firewood) as shown in Figure 1.

**Chemical Analysis**

**Moisture Content**

The moisture content was determined by gravimetric method described by the AOAC (2000) using an electrothermal oven model DHG-9030A. Exactly 5 g of the prepared samples were weighed into porcelain dish of a known weight and was heated in the oven at 105°C for 3 h. Each sample was cooled in desiccators and weighed. The samples were subsequently heated, weighed and cooled until a constant weight was attained. The moisture content was determined as follows:

\[
\% \text{ Moisture content} = \frac{\text{loss in weight of sample}}{\text{original weight}} \times 100
\]

**Crude Fibre**

The Crude fibre was determined by the method of James (1995). Sample (5.0 g) processed sample was boiled in 150 mL of 1.25% H₂SO₄ solution for 30 min under reflux. The boiled sample was washed in several portions of hot water using a two-fold cloth to trap the particles. It was returned to the flask and boiled again in 150 mL of 1.25% NaOH for another 30 min under the same condition. After washing in several portion of hot water the sample was allowed to dry before being transferred to a weighed crucible where it was dried in the oven at 105°C to a constant weight. It was thereafter taken to a muffle furnace where it was burnt at 550°C for 30 min until only ash was left. The ash was further cooled in desiccator again and reweighed. The weight of...
the fibre was determined by difference and calculated as a percentage of the weight of the sample analyzed thus:

\[
\text{% Crude Fibre} = \frac{\text{weight of residue} - \text{weight of ash}}{\text{weight of sample}} \times 100
\]

**Ash Content**

Ash content of samples was determined using AOAC (1990) method.\(^\text{17}\) Exactly 5.0 g of well mixed samples were weighed into an ignited, cooled and weighed crucible. Few drops of glycerol were added and mixed thoroughly with the sample and were heated gently over a Bunsen burner until the sample charred. The crucible was transferred into a muffle furnace model SX-5-12 at about 550°C until white-grey ash was obtained. The crucible was cooled in a desiccator and reweighed. The percentage of ash content was calculated as follows:

\[
\text{% Ash} = \frac{\text{weight of ash}}{\text{original weight of sample}} \times 100
\]

**Crude Fat**

The crude fat content of samples was determined using AOAC (1990) method.\(^\text{17}\) Exactly 5 g of the sample were weighed into a fat-free extraction thimble and plugged lightly with cotton wool. The thimble was placed in the extractor and fitted up with reflux condenser and a 250 ml soxhlet flask which has been previously dried in the oven, cooled in a desiccator and weighed. The soxhlet flask was then filled to two-thirds of its capacity with n-hexane and boiled on a heating mantle. The heater was put on for 6 h with constant running water from the tap for condensation of hexane vapour. The n-hexane was left to siphon over several times and thereafter drained into a stock bottle. The thimble containing the sample was removed and dried. The extractor, flask and condenser were replaced and the distillation continued until the flask was practically dry. The flask containing the oil was detached, it's exterior cleaned and dried to weights of the distillation flask represented the oil extracted from the sample and the percentage ether extract was calculated as shown below:

\[
\text{% Ether} = \frac{\text{final weight of extract in flask} - \text{initial weight of extract in flask}}{\text{weight of sample}} \times 100
\]

**Crude Protein**

The crude protein was determined by Kjeldahl method described by Chang (2003).\(^\text{18}\) The total nitrogen was determined and multiplied with factor 6.25 to obtain protein content. Sample (2 g) was mixed with 10 mL of concentrated H\(_2\)SO\(_4\) in digestion flask. Selenium tablet catalyst was added to it before it was heated under a fume cupboard until a clear digest was obtained. The digest was diluted to 100 mL in a volumetric flask and used for the analysis. The 10 mL of the digest was mixed with an equal volume of 45% NaOH solution in a Kjeldahl distillation apparatus. The mixture was distilled into 10 mL of 40% boric acid containing 3 drops of mixed indicator (bromocresol green/methyl red).

A total of 50 mL of distillates was collected and titrated against 0.02 N EDTA from green to a deep red endpoint. A reagent blank was also digested, distilled and titrated. The nitrogen content and hence the protein content was calculated using the formula below:

\[
1 \text{ mL of } N \text{ H}_2\text{SO}_4 = 14 \text{ mg}
\]

\[
N_2 (%) = \frac{100}{W} \times \frac{N \times 14}{1000} \times \frac{V_f}{V_a} \times T \times B
\]

\[
\text{Protein} (%) = N_2 (\%) \times 6.25
\]

where W is the weight of sample, N is normality of the acid, V\(_f\) is total digest volume (100 ml), V\(_a\) is volume of digest analyzed (10 mL), T is sample titre value and B is blank titre value.

**Carbohydrate**

The carbohydrate content of each of the sample was calculated by difference.\(^\text{15}\)

**Mineral Analysis**

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).\(^\text{15,19}\) For iron, 2 g of samples were transferred into 25 ml volumetric flasks and 5 ml concentrated HCl was added. The flasks were shaken for 2 hours in an orbital shaker, thereafter; the solution was diluted to level with deionized water and filtered with a filter paper. All analyses were done in triplicates. Model PG990 Atomic Absorption Spectrophotometer (AAS) was employed in this analysis. All reagents used in this study are of analytical grade.

**Statistical Analyses**

Experiments were conducted in triplicates. Data obtained were statistically Analyzed using Analysis of Variance (ANOVA). Means were separated by Fischer’s Least Significance Difference Test and significant difference was accepted at 5% level of probability (p < 0.05) using SPSS version 21.

**Result and Discussion**

**Proximate Analysis**

The effect of the different drying methods on the chemical properties of tapioca grits from Agbarha-Otor in Ughelli, Delta State are presented in Figure 2, 3 and 4. The result reveals that the tapioca grits dried with gas flares had the least moisture content while the locally dried firewood method shows higher moisture content. The moisture content after drying with both methods was above 9.07% as reported in other findings.\(^\text{20}\) Results in other findings are in agreement with values of 11.32% to 15.21 % as reported in this finding.\(^\text{21,22}\) Studies have shown that processed cassava samples with a moisture content of < 16% but > 13% could
be stored for 2-7 months without mould infestation hence projecting a longer shelf life of over 2 months irrespective of either drying techniques. Therefore, the results show more efficiency of the gas flared method of drying accounting for the removal of more moisture content in the fresh sample hence proposing better storage stability of the product.

Drying with firewood recorded the highest ash content (0.40%) while the gas flared dried sample had the lowest value (0.32%) as shown in Figures 2 and 3. The values obtained in this study were lower than the value (1.10 % to 3.30%) reported by Ekuonola obtained from cassava and breadfruit. The result shows no significant difference (p<0.05) in the ash content using either method of drying. The result from this study further concludes that the processed tapioca obtained from either method of drying of the cassava grits present an adequate source of mineral elements.

The crude fibre content of the roasted cassava grits and either method of drying ranged from 2.46% to 2.98% which is still within the nutritionally maximum level of 3.0%. Gas flared dried sample had the highest value (2.98%) while drying with firewood recorded the lowest crude fibre content (2.46%). The higher fibre values for the gas flared dried sample could be due to loss of moisture which increases nutrient density in foods of which fibre is among the nutrients. This confirms that the crude fibre which is a measure of the undigested components of foods such as cellulose, hemicelluloses and lignin also play a very important role in nutrition because it aids proper digestion of food.

The protein content of the roasted cassava grits and either methods of drying ranged from 2.58% to 2.79% with firewood drying exhibiting highest value (2.79%) and gas flared dried sample showing the lowest value of 2.58%. The analysis of variance showed no significant (p<0.05) differences in the protein content of tapioca samples with either technique of drying, a pointer that could be due to no variation with respect to the impact on denaturation of the tapioca protein associated with the various drying methods. The protein contents as shown in this study were higher than1.04 % to 1.20% and 1.30 to 1.40% respectively as reported for other processed sample. Furthermore, other findings reveal results of 0.80 to 1.20% lower than results obtained from these findings.

Results obtained for the fat content reveals that gas flared dried sample had the highest value (1.34%) while drying with firewood recorded the lowest fat content (0.98%). Results from this finding fall within the range of 0.70%, but slightly above 1.84% for gas flared dried sample as reported in other findings. The results from this study further confirm that rancidity will not be a problem during storage due to the low-fat content values exhibited by either of the drying methods as reported by Ajifolokun and Adeniran (2018).

The carbohydrate values in this study ranged from 78.27 % to 81.46 %. The carbohydrate contents show no significant difference (p<0.05) with either method of drying. The carbohydrate content from this study is higher than reports from other findings, but lower than the average value of 94.23 % as reported. Therefore, the high carbohydrate content suggests the need of taking tapioca in combination with other protein sources to improve its nutritional quality since it is one of the most staple foods consumed in Africa especially in Nigeria.
Mineral Contents

Mineral contents of tapioca grits as presented in Figure 5 and 6, reveals that the Calcium content of the grits shows no significant difference (p<0.05) between the methods of drying with values ranging from 14.98 mg/100g to 15.56mg/100g. The gas flared dried sample had the highest value (15.56%) while drying with firewood recorded the lowest calcium content (14.98%). The result shows that none of the drying methods was beneficial to increase Calcium in the tapioca. Results obtained from this study reveals value above published data of 10mg/100g fresh weight basis and below 136 mg/100g to 369mg/100g dry weight basis. Calcium is required for all tissues, hence its deficiency in the body can lead to Rickets in infants and children and osteomalacia in adults. Potassium contents ranged from 66.24 mg/100g to 67.94 mg/100g with gas flared dried sample recording the highest value, while drying with firewood recorded the lowest potassium content. Both drying methods show no significant (p<0.05) different in their potassium contents. The results from these findings are above results of 57 mg/100g reported in other study. Potassium plays an important role in the maintenance of normal cell functions, therefore people with severe dehydration are liable to high blood potassium. It is therefore important to maintain a balance in order to prevent different diseases that could be life-threatening. Sodium contents ranged from 2.57 to 2.98 mg/100g with gas flared dried sample recording the lowest value, while drying with firewood recorded the highest sodium content. The sodium contents from these findings are in agreement with values from other research findings. Both drying methods showed no significantly (p<0.05) different in their sodium contents. The results from these findings are higher than the results obtained in other study. Sodium is essential for the control of blood pressure. It is an electrolyte that controls the extracellular amount of fluid in the body and is needed for hydration. In addition, sodium helps to maintain the fluid and acid-base balance of the body, in the transmission of nerve impulses, in the absorption of glucose, in the relaxation of the muscles and in the maintenance of cell membrane permeability. Zinc contents ranged from 0.22 mg/100g to 2.44mg/100g. Both drying methods were significantly (p<0.05) different in their Zinc contents. Results from these findings are within the range of 1.4 mg/100g fresh weight in cassava roots tubers and below 13 mg/100g in other findings. Zinc is known to be a component of enzymes involved in most major metabolic reactions. About 2 g to 3 g of zinc is found in the body. Zinc aids the production of insulin by the pancreas of protein. A deficiency of zinc leads to diminished sensitivity to taste and odor. Magnesium contents ranged from 4.34 to 7.45 mg/100g with gas flared dried sample recording the lowest value (4.34%), while drying with firewood recorded the highest magnesium content (7.45%). Both drying methods were significantly (p<0.05) different in their magnesium contents. Earlier studies reported magnesium contents in cassava as 30mg/100g, fresh weight and 43mg/100g, dry weight which is higher than values reported in these findings. The low values recorded for both method of drying, indicate that none of the drying methods was beneficial to increase magnesium in the tapioca. Magnesium is required for normal functioning of the muscle and nervous systems, helps in supporting a healthy immune system, keeps bone strong and helps in regulating blood sugar levels, thereby promoting normal blood pressure. Phosphorus contents ranged from 9.47 to 9.86 mg/100g with gas flared dried sample recording the highest value, while drying with firewood recorded the lowest phosphorous content. Results from these findings are higher than the results obtained in other study. Both drying methods shows no significant (p<0.05) different in their phosphorous contents. Phosphorus plays an important role in the storage and release of energy. Iron contents ranged from 6.45 mg/100g to 11.34 mg/100g. These results are above research findings of 1.11mg/100g to 1.58 mg/100g, and below values of 29mg/100g reported in other study. Iron is required for energy production, growth and development, immune functions, red blood cell formation, reproduction and wound healing. Iron is responsible for the ability of hemoglobin to transfer oxygen throughout body tissues for internal respiration to occur. Deficiency of iron causes anemia and fatigue. Core heavy metals such as lead (Pb), Nickel (Ni) and Cadmium (Cd) as shown in Figure 5, that could be toxic to health were not detected for gas flared samples, with the exception for samples dried with firewood that shows values of 0.02 and 0.01 mg/100g for Pb and Cd respectively. These values fall below the WHO acceptable limit. Sequel to the aforementioned, caution should be strictly adhere towards continuous consumption of firewood dried cassava tapioca in order to prevent the periodic accumulation of these heavy metals.
The increasing reliance on cassava tapioca in several parts of Nigeria mostly the southern part of the country will expand the food base in these areas, contributing to food security as a major concern in these food-deficient areas. The results show no significant difference (p<0.05) in the proximate analysis for either method of drying. The high values recorded for Zn and Mg in firewood dried samples indicate that drying method with firewood was beneficial to increase magnesium and zinc in the tapioca grits. But the core heavy metals that could be toxic to health were not detected with exception of Pb and Cd which recorded values of 0.02 mg/100g and 0.01 mg/100g respectively which is still within the WHO acceptable limit of 0.2 mg/kg and 1 mg/kg for Cd and Pb respectively, indicating that the use of these processed cassava tapioca obtained from either method of drying (i.e. drying with gas flares and drying with firewood) for consumption purposes will have no negative health impact when nourished with other proteinaceous blends. However, heavy metals most commonly found in biosolids such as Pb, Ni, Cd, Cr, Cu and Zn, the metal concentrations are governed by the nature and the intensity of the activity, as well as the type of process employed during the treatment [39, 40]. This activity could have led to the possible detection of these heavy metals with the use of firewood for drying unlike the gas flaring that shows no serious hazardous implications on the processed cassava tapioca which could be as a result of the release of NO\textsubscript{x} and SO\textsubscript{2} gases which are contained in gas flares which upon reaction with water form acidic compounds.\textsuperscript{27} This study has established the possibility of drying cassava tapioca as practiced by the indigenes of Agbarha-Otor as safe with caution placed on the use of firewood drying techniques a possible route to heavy metals contamination which could accumulate over time resulting to a serious health concern.

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