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## NUTRITIONAL, ANTINUTRITIONAL AND SENSORY PROPERTIES OF COMPOSITE POUNDED TUBERS FROM YAM (*Dioscorea esculenta*), CASSAVA (*Manihot esculata*) AND SWEET POTATO (*Ipomoea batatas*)

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### ABSTRACT

**Indigenous foods are essential in promoting food diversity and nutrition. Combinations of staples have been developed to improve the nutrient contents of indigenous diets. The study investigated the nutritional, anti-nutritional composition and sensory properties of composite pounded tubers from yam, cassava and sweet potato. The tubers were processed and the composite pounded tubers sample was compared against 100 % pounded yam (control). The results showed that crude protein (g/100 g), fat (g/100 g), fibre (g/100 g) and beta-carotene (mg/100 g) were higher in the composite pounded tubers (1.36; 0.13; 1.34; and 1091.60) compared to 100% pounded yam (1.04; 0.03; 0.75; and 1024.9), respectively. Moisture content (g/100 g), potassium (mg/100 g) and ascorbic acid (mg/100 g) were higher in 100 % pounded yam (71.65; 563.40; and 3.82) compared to composite pounded tubers (65.6; 529.4; and 1.32), respectively. The saponin (0.04, 0.14) mg/100 g, oxalate (0.37, 0.01) mg/100 g, and cyanide contents (0.0, 0.51) mg/100 g were within the safe limits. The sensory properties of the test samples were generally accepted by the panelists. These composite pounded tubers from yam, cassava and sweet potato is nutritious, acceptable and safe for human consumption.**

**Keywords: Nutritional quality, acceptability, tubers, crop utilization**

### INTRODUCTION

Root and tuber crops, including yam (*Dioscorea esculenta*), cassava (*Manihot esculata*) and sweet potato (*Ipomoea batatas*) are largely produced as food crops for about 2.2 billion people in many developing countries around the world (FAOSTAT 2019; Prakash *et al.*, 2020). These three crops account for about 95% of the total root and tuber crop production in Africa and play important roles in income generation and food security; serving as major sources of carbohydrate and contribute up to 50% of the total daily energy intake (Ferraro *et al.*, 2015).

Nigeria is the leading producer of yams and cassava globally, and these crops constitute staple foods in most parts of the country. Yams are consumed in different forms (boiled, fried, roasted or as pounded yam), or combined with cassava cocoyam and other roots and tubers to meet the dietary demands of the nation's fast-growing population (Ihekoronye, 2009; FAOSTAT, 2019). Sweet potatoes on the other hand are considered as a typical food security

crop for disadvantaged populations and contain higher amounts of proteins,  $\beta$ -carotene, essential minerals, bioactive compounds and a wide range of phytochemicals compared to other roots and tubers (Chandrasekara and Kumar., 2016). Pounded yam is a popular delicacy in Nigeria (Olaoye and Oyewole, 2012). Pounding of boiled yam in a mortar with intermittent addition of water makes the yam softer and finer, and increases the surface area upon which enzymes act during digestion thus bringing about a rapid absorption of nutrients (Ayofemi and Jacob, 2014). Earlier studies have provided information on production and quality assessments of pounded yam, pounded cocoyam and composite pounded cassava and yam blends (Adegunwa, *et al.*, 2011; Olaoye and Oyewole, 2012; Adepoju *et al.*, 2017; Kanu and Kingsley, 2020). However, nutrition quality and acceptability of composite pounded yam, cassava and sweet potato remains unknown. Sweet potato is a short duration, low-input, high-yield crop, yet it remains underutilized in Nigeria (Ogbonna *et al.*, 2005).

Globally, attention is shifting towards strengthening the local food system and promoting indigenous underutilized crops in meeting the nutrition and health needs of the population. Knowledge of the quality and acceptability of composite pounded yam, cassava and sweet potato would contribute to promoting optimal use of indigenous crops to meet nutrition and health needs, enhance biodiversity in improving nutrition outcomes, enrich the national food composition database, and encourage diffusion of good dietary practices. Therefore, this study was conducted to determine the nutritional, antinutritional and sensory properties of composite pounded tubers from yam, cassava and sweet potato relative to 100 percent pounded yam..

## MATERIALS AND METHODS

### Sample Collection

Tubers of yam (*Dioscorea esculenta*), cassava (*Manihot esculata*) and sweet potato (*Ipomoea batatas*) were purchased from Oja Oba, Oyan, Osun State, South West Nigeria. All reagents used were of analytical grade.

### Sample Preparation

The tubers were washed under running water to remove extraneous materials, peeled and sliced into pieces, according to the traditional *Iyan oloba meta* (composite pounded tubers) production. The slices in the proportion 50:25:25 for yams, cassavas and sweet potatoes respectively (13.22 kg) were washed in clean water, and boiled in water at 115 °C for 30 minutes. The water was drained, and the cooked tubers were pounded separately for 5 minutes each using a mortar and pestle until a smooth dough was formed. Firstly, the sweet potato was added to the already smooth dough of yam and pounded together for another 5 minutes.. After which, the pounded cassava was added to the mix and it was pounded again for 5 minutes. During this process, the drained hot water was added until a smooth, homogenous and semi-stretchy dough of composite pounded tubers consisting of yam, cassava, and sweet potato was formed. A control sample of 100% pounded yam was prepared using similar method.

### Proximate composition analysis

The proximate composition of the samples was determined using the standard methods of the Association of Official Analytical Chemists (2005). Crude protein (N\*6.25) was determined using Kjeldahl (method 978.04), crude fat was determined by the Soxhlet extraction method (930.09) and moisture content was determined

$$\text{Vitamin B1 (mg/100 g)} = \frac{\text{Absorbance} \times \text{Gradient factor} \times \text{Dilution factor}}{\text{Weight of sample}}$$

using method 967.08. The ash content was determined by ashing the sample in a muffle furnace (Gallenkamp 3) at 550 °C for 4 hours (method 942.05), crude fibre was determined gravimetrically (method 930.10). The total carbohydrate was determined by difference, according to the equation:

$$\begin{aligned} \text{Total carbohydrate} \\ = 100 - (\% \text{ moisture} + \% \text{ fat} \\ + \% \text{ protein} + \% \text{ fibre} + \% \text{ ash}) \end{aligned}$$

The gross energy value was determined by multiplying the proportion of protein, fat, and carbohydrate by their respective physiological energy values and taking the sum of the products -Atwater's conversion factors.

### Mineral analysis

Calcium, potassium and sodium content of the samples were determined by digesting the ash of each sample with perchloric acid and nitric acid, and then taking the readings on Jenway digital flame photometer (PFP7 Model). Phosphorus was determined by vanado-molybdate colorimetric method (AOAC, 2005: 975.16). Iron was determined using Buck 200 Atomic Absorption Spectrophotometer (Buck scientific, Norwalk) and compared with absorption of standards of the minerals (AOAC 2005: 975.23).

### Vitamin analysis

#### Thiamin (Vitamin B<sub>1</sub>) Determination

A gram of sample was weighed into 100ml volumetric flask; 25ml of 0.1M H<sub>2</sub>SO<sub>4</sub> was added and mixed by careful swirling. Additional 25ml of 0.1M H<sub>2</sub>SO<sub>4</sub> was added to rinse any adhering sample particle off the flask. The flask was set in a boiling water bath to ensure a complete dissolution of the sample in the acid. The flask was shaken frequently in the first 5 minutes and subsequently every 5 minutes. 5ml of taka-diastase in 0.5M Sodium acetate solution was added and flask set in cold water to cool content below 50°C. The flask was stoppered and kept at 45-50°C for 2 hours and thereafter made up to 100ml in ark after mixing thoroughly. The mixture was filtered through a 42 Whatman filter paper discarded the first 10ml and keeping the remaining. Ten ml of the remaining mixture filtrate was pipette into a 50ml volumetric flask and 5ml of acid potassium chloride solution was added, shaking thoroughly to mix well. Standard thiamin solution of range 10mg/ml to 50mg/ml were prepared from 100mg/ml stock and treated same way prepared from sample above. The absorbance of the sample and standard was read on a fluorescent UV spectrophotometer (Cecil A20model) at a wavelength of 285nm.

#### Riboflavin (Vitamin B<sub>2</sub>) Determination

A gram of sample was weighed into a 250ml volumetric flask, 5mls of 5 NHCl was added,

followed by the addition of 5mls of dichloroethene. The mixture was shaken and 90mls of deionized water was added. The whole mixture was thoroughly shaken and was heated on a steam bath for 30 minutes to extract all the Riboflavin. The mixture was then cooled and made up to volume with deionized water. It was then filtered, discarding the first 20ml of the aliquot. 2ml of the filtrate obtained was pipetted into another 250ml volumetric flask and made up to mark with deionized water. Standard solutions were prepared by dissolving 0.05mg riboflavin into 100mls of distilled water. Different standard solution concentrations of between 0 to 5ppm were prepared from above to obtain the equivalence. The Absorbance, the standards and samples was read on the Fluorescent Spectrophotometer at 460nm wavelength.

$$\text{Vitamin B2 (mg/100 g)} = \frac{\text{Absorbance} \times \text{Gradient factor} \times \text{Dilution factor}}{\text{Weight of sample}}$$

#### Ascorbic acid Determination

Ascorbic acid in the sample was determined by titrating its aqueous extract with solution of 2, 6-dichlorophenol-indophenol dye to a faint pink end point.

#### $\beta$ -carotene Determination

$\beta$ -carotene content was determined by the method described by Rodriguez-Amaya and Kimura (2004). Two gram of sample was weighed into a 250ml volumetric flask, 50ml of petroleum ether: Acetone (2:1v/v) mixture was added to the extract the  $\beta$ -Carotene. The flask containing the mixture was placed on a shaker to shake at 200rpm for 20min to ensure uniform mixing at room temperature. The mixture was later centrifuged at 4000rpm for 10min and the supernatant collected and made up to 50ml with the solvent mixture. The supernatant was transferred to a 250ml funnel to separate the organic layer (upper-layer). The aqueous layer was discarded and the organic layer was transferred into the 50ml volumetric flask and made up with solvent mixture for reading of  $\beta$ -carotene. Working standard of  $\beta$ -carotene of range 0-50ppm was prepared from stock Beta-carotene solution of 100ppm concentration. The absorbance of samples as well as working standard solutions was read on a Cecil 2483 UV Spectrophotometer at a wavelength of 450nm against blank.

$$\beta - \text{carotene } (\mu\text{g}/100 \text{ g}) = \frac{\text{Absorbance} \times \text{Gradient factor} \times \text{Dilution factor}}{10000}$$

#### Determination of anti-nutrients

Saponin was determined by the method of Makkar and Becker (1996) by comparing the absorbance of the sample extracts with that of the standard at 380 nm. Oxalate was determined using a spectrophotometer (Spectronic20) at 420

nm (Adepoju *et al.*, 2018). Cyanide content was determined according to the method described by Bradbury *et al.* (1991).

#### Sensory Evaluation

Thirty panelists (graduate students and staff of the Department of Human Nutrition and Dietetics, University of Ibadan) with the ability to differentiate and describe the quality attributes of food were selected to evaluate the coded samples for colour, aroma, taste, consistency and overall acceptability using a nine-point hedonic scale (from 1 = extremely dislike to 9 = extremely like). The coded samples were randomly served in clear transparent disposable plates. Samples were served with a common soup, *Egusi*. Each panelist was provided with a glass of clean water to rinse their mouths at intervals after each successive sample.

#### Statistical analysis

The analyses were carried out in triplicates, and the data obtained were subjected to Analysis of Variance (ANOVA) and Duncan Multiple Range Test (DMRT) was used to separate the means at 5% level of significance, using Statistical Package for Social Sciences (SPSS version 22.0).

## RESULTS AND DISCUSSION

### Proximate Composition of the Samples

The proximate composition and the gross energy of the composite pounded tubers from yam, cassava and sweet potato as well as the pounded yam sample is presented in Table 1. The moisture content of composite pounded tubers (65.6%) was significantly lower compared to that of the 100% pounded yam sample (71.65%). The moisture content of the pounded yam sample was similar to the results reported by Adepoju (2012). Since moisture and water activity in food greatly determines the keeping quality of the food, this reduced moisture content of the composite pounded tubers would make it less susceptible to microbial attack and spoilage. The fat content of the composite pounded tubers was significantly ( $P < 0.05$ ) higher (0.13%) than that of the 100% pounded yam (0.03%). This value was in the range reported by Adepoju *et al.* (2010). Cassava has earlier been identified to contain higher amounts of fat than other tubers, while sweet potatoes have been identified to contain higher amounts of protein than other tubers (Scott *et al.*, 2000; Chandrasekara and Kumar, 2016). Fats are an essential part of a healthy diet and those from plant sources have been found to be essential and beneficial for good health (Hall *et al.*, 2021). Fats promote absorption of fat-soluble vitamins and modify the organoleptic qualities of food. Furthermore, the crude fiber (1.34%), carbohydrate (30.62%) contents and energy value (129.09 kcal/100 g) of composite pounded

tubers were observed to be significantly ( $P < 0.05$ ) higher than that of the 100% pounded yam. This can also be attributed to the combined and complementary nutrients of the tubers, with carbohydrates, being the major component of roots and tubers, which constitute a ready source of metabolizable energy. The result of the carbohydrate content agrees with the previous reports by Adepoju (2012) on yam pounded with hot water. The high gross energy content of the

yam explains why it serves as a staple source of energy in Nigeria.

Ash content of the composite pounded tubers (0.95%) was significantly ( $P < 0.05$ ) higher than the 100% pounded yam (0.76%). Generally, ash content of tubers depends solely on the soil type, weather conditions during cultivation period, moisture content and age at harvest of the crops (Baah, 2009).

**Table 1: Proximate composition of samples (g/100 g)**

Parameter	Control (100% yam)	Composite Pounded Tubers
Moisture	71.65 ± 0.05 <sup>a</sup>	65.60 ± 0.03 <sup>b</sup>
Crude protein	1.04 ± 0.03 <sup>a</sup>	1.36 ± 0.02 <sup>b</sup>
Crude fat	0.03 ± 0.00 <sup>a</sup>	0.13 ± 0.01 <sup>b</sup>
Crude fibre	0.75 ± 0.01 <sup>a</sup>	1.34 ± 0.01 <sup>b</sup>
Ash	0.76 ± 0.02 <sup>a</sup>	0.95 ± 0.01 <sup>b</sup>
Carbohydrates	25.77 ± 0.01 <sup>a</sup>	30.62 ± 0.04 <sup>b</sup>
Gross energy (kcal/100 g)	107.51	129.09

Values are means ± standard deviation of triplicate determination

Means on the same row with different superscript are significantly different ( $p < 0.05$ )

Composite Pounded Tubers= 50% yam + 25% cassava + 25% sweet potatoes

#### Mineral Composition of Samples

The result of the mineral composition of the samples as shown in Table 2 revealed that the potassium content of 100% pounded yam (563.40mg/100 g) was significantly higher ( $p < 0.05$ ) than that of composite pounded tubers (529.43mg/100 g). However, the composition of other minerals reflected improvement in composite pounded tubers compared to 100% pounded yam. Calcium (4.01mg/100 g), sodium (3.47mg/100 g), phosphorus (33.80mg/100 g) and iron (0.81mg/100 g) were significantly higher ( $p < 0.05$ ) in composite pounded tubers than in 100% pounded yam (0.52 mg/100g; 3.20

mg/100g; 28.84 mg/100g; 0.43 mg/100g), respectively. The values for potassium, phosphorus and iron obtained in pounded yam sample was higher than the values previously reported by Alinnor and Akalezi (2010) and Adepoju *et al.* (2017), but was in the range of iron value reported by Leng *et al.*, (2019). Also, the calcium content was within the range of values reported by Adepoju *et al.* (2017) for pounded yam samples. Baah (2009) reported that inorganic part of tubers depends largely on the soil type, weather conditions during cultivation period, moisture content and age at harvest of the crops.

**Table 2: Mineral composition of samples (mg/100 g)**

Parameter	Control (100% yam)	Composite Pounded Tubers
Calcium	0.52 ± 0.04 <sup>a</sup>	4.01 ± 0.08 <sup>b</sup>
Potassium	563.40 ± 5.23 <sup>a</sup>	529.43 ± 2.82 <sup>a</sup>
Sodium	3.20 ± 0.21 <sup>a</sup>	3.47 ± 0.23 <sup>a</sup>
Phosphorus	28.84 ± 0.08 <sup>a</sup>	33.80 ± 0.06 <sup>b</sup>
Iron	0.43 ± 0.03 <sup>a</sup>	0.81 ± 0.22 <sup>b</sup>

Values are means ± standard deviation of triplicate determination

Means on the same row with different superscript are significantly different ( $p < 0.05$ )

Composite Pounded Tubers= 50% yam + 25% cassava + 25% sweet potatoes

#### Vitamin Composition of Samples

The result of the vitamin analysis as presented in Table 3 revealed that composite pounded tubers had significantly higher ( $p < 0.05$ ) β-carotene content (1091.60 µg/100g) than sample 100% pounded yam (1024.90 µg/100g). This difference could be attributed to the inclusion of cassava and sweet potato, since Chandrasekara and Kumar (2016) and USDA (2015) highlighted that sweet

potatoes contain higher values of β-carotene than other tubers and this would be relevant to combat vitamin A deficiency (VAD). For riboflavin and thiamin contents, both samples had lower values similar to the values reported by Adepoju *et al.*, (2017) while ascorbic acid content in this study was within the range of values reported by Chandrasekara and Kumar (2016).

**Table 3: Selected vitamin composition of samples (mg/100 g)**

Parameter	Control (100% yam)	Composite Pounded Tubers
β-carotene (µg/100 g)	1024.90 ± 0.36 <sup>a</sup>	1091.60 ± 1.65 <sup>b</sup>
Riboflavin	0.08 ± 0.02 <sup>a</sup>	0.03 ± 0.02 <sup>b</sup>
Thiamin	0.50 ± 0.03 <sup>a</sup>	0.21 ± 0.03 <sup>b</sup>
Ascorbic acid	3.82 ± 0.04 <sup>a</sup>	1.32 ± 0.03 <sup>b</sup>

Values are means ± standard deviation of triplicate determination

Means on the same row with different superscript are significantly different (p<0.05)

Composite Pounded Tubers= 50% yam + 25% cassava + 25% sweet potatoes

#### Antinutrient composition of samples

It is generally known that the presence of antinutrients in foods influences the bioavailability of nutrients. The result of the anti-nutrient analyses shown in Table 4 revealed that saponin (0.14 mg/100 g), oxalates (0.01 mg/100 g) and cyanides (0.51 mg/100 g) contents in composite pounded tubers are within the safe range. The higher saponin content in the composite pounded tubers could be attributed to the inclusion of cassava which is also responsible for the cyanide content. Cassava toxicity in humans is a recognized problem as cassava tubers vary in cyanogen content, although most varieties

contain 15 to 400 mg HCN per kg fresh weight (Cressey and Reeves, 2019). Cyanide doses of 50 to 100 mg are reportedly lethal to adults (Heuberger, 2005). Several diseases are associated with the consumption of inadequately processed tubers, such as tropical ataxic neuropathy, endemic goiter and spastic paraparesis, which is mainly a disease of women and children (Heuberger, 2005). The level of antinutrients obtained in the composite pounded tubers was relatively low, and is within a safe level which would pose no health risk to consumers.

**Table 4: Antinutrient composition of samples (mg/100 g)**

Parameter	100% Pounded Yam	Composite Pounded Tubers
Saponin	0.04 ± 0.00	0.14 ± 0.00
Oxalate	0.37 ± 0.00	0.01 ± 0.00
Cyanide	-	0.51 ± 0.03

Values are means ± standard deviation of triplicate determination

Means on the same row with different superscript are significantly different (p<0.05)

Composite Pounded Tubers= 50% yam + 25% cassava + 25% sweet potatoes

#### Sensory evaluation of the samples

The sensory attributes of the composite pounded tubers and pounded yam is presented in Table 5. The results indicated that there was no significant difference in the mean scores for colour, between composite pounded tubers (7.37) and the 100% pounded yam. On the other hand, significant differences were observed for aroma, taste, texture and overall acceptability. Composite pounded tubers had mean scores of 6.20, 6.80, 6.53 and 6.87 for aroma, taste, texture, and overall acceptability, respectively. Texture is a multidimensional attribute, usually classified by (smoothness/lumpiness, hardness/firmness, stretchability/elasticity and ease of moulding to a spherical mass) to give a response, since these attributes indicate preference for pounded yam and other pounded tubers (Egesi *et al.*, 2003).

The texture of the composite pounded tubers was acceptable to the panelists. This result obtained for the sensory evaluation of the samples is consistent with the consumers' survey that highlighted the importance of texture for acceptance of pounded yam (Adeola *et al.*, 2012; Honfozo *et al.*, 2021). Also this result agrees with previous reports on consumer's acceptability that creamy and fairly yellow coloured pounded yams are preferred (Nindjin *et al.*, 2007). These characteristics are in agreement with the consumers' survey reported by Honfozo *et al.* (2021). Also, Akissoe *et al.* (2009) reported that ideal pounded yam should be elastic, very smooth, sweet, weakly bitter and firm. As indicated by the panelists, the sensory property of the composite pounded tubers was generally acceptable.

**Table 5: Sensory evaluation of samples**

Parameter	100% Pounded Yam	Composite Pounded Tubers
Colour	7.70 ± 0.99 <sup>a</sup>	7.37 ± 1.03 <sup>a</sup>
Aroma	7.40 ± 1.04 <sup>a</sup>	6.20 ± 1.16 <sup>b</sup>
Taste	7.83 ± 1.02 <sup>a</sup>	6.80 ± 1.63 <sup>b</sup>
Texture	7.60 ± 0.97 <sup>a</sup>	6.53 ± 1.38 <sup>b</sup>
Overall acceptability	7.87 ± 0.68 <sup>a</sup>	6.87 ± 1.36 <sup>b</sup>

Values are means ± standard deviation of triplicate determination

Means on the same row with different superscript are significantly different ( $p < 0.05$ )

Composite Pounded Tubers= 50% yam + 25% cassava + 25% sweet potatoes

## CONCLUSION

The composite pounded tubers had a better nutritional quality than the 100% pounded yam, has acceptable sensory properties, and the antinutrient composition are within the safe levels.

The composite pounded tubers is safe and has higher energy, fat, fibre and mineral contents

than conventional pounded yam. However, its sensory attributes though acceptable were poorer than that of the conventional pounded yam. Thus, the inclusion of sweet potato and cassava could be an affordable way to enhance the nutrient composition of pounded yam which is a staple food among several ethnic groups in Africa.

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