



## Industrial Potential of Two Varieties of Cocoyam in Bread Making

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Received 3 March 2011; Revised 8 June 2011, Accepted 2 July 2011

**Abstract:** The evaluation of the chemical (proximate composition, mineral composition, toxicant composition and vitamin composition), nutritional and industrial potentials of two varieties of cocoyam (*Xanthosoma sagittifolium* (XS) and *Colocasia esculenta* (CE)) were carried out using recommended methods of analysis. Baking trials were conducted with the two varieties of cocoyam at different levels of substitution (20%, 30% and 50%). The produced bread samples were analyzed for their physical parameters and proximate composition. Sensory evaluation test was also carried out on the produced bread. The result of the analysis showed that the preferred bread in terms of loaf weight, volume and specific volume was given by sample I (control sample) containing 100% wheat flour with a specific volume of 3.54 cm<sup>3</sup>/g. This was closely followed by sample A with specific volume of 3.25 cm<sup>3</sup>/g containing 20% substitution level of CE. Sample H containing 50% substitution level of XS with specific volume of 2.58 cm<sup>3</sup>/g gave the poorest performance. The sensory evaluation result further revealed that apart from the 100% wheat flour based sample I, sample D with 20% substitution level of XS was rated good and maintained better performance amongst the cocoyam varieties while samples G and C with 100% and 50% substitution level of CE respectively were rated the poorest. The proximate composition of the bread samples was also carried out. CE, XS and wheat bread samples (100%) recorded 15.0633±1.4531, 12.1133±1.5975 and 11.2867±0.7978 respectively for the moisture content. XS bread recorded the highest carbohydrate content of 45.0133±3.0274. In terms of ash, CE bread recorded the highest value of 31.4367±1.6159 while wheat bread recorded the highest value for protein i.e. 20.6033±0.8113. XS performed better in terms of crude fat and energy value of 12.2967±0.8914 and 371.5367 respectively. The use of cocoyam - wheat flour mixture in producing composite bread is therefore strongly recommended from this study.

**Keywords:** Cocoyam, Nutritional, Industrial potentials, Bread

## Introduction

Food nutrients include carbohydrate, lipids, proteins, minerals, vitamins and water. Although food may be derived from plant and animals, plant is the only living organism that is capable of carrying out photosynthesis and is the major source of food in nature's chain<sup>1</sup>. Food of plant origin may be classified into cereals, roots and tubers, sugars and syrups, legumes, pulses, nuts and oil seeds, vegetables and fruits<sup>2</sup>. Roots and tubers used as food include yams, cassava, potatoes, sweet potatoes and cocoyam<sup>3</sup>. Roots and tubers have a high moisture content resulting in short storage life under ambient conditions and because of these, they are highly perishable and huge losses can occur after harvest<sup>4,5</sup>. Roots and tubers contribute about 20-48% of the total calories and about 7.1% protein to the diets of the people of sub-Saharan Africa. In Nigeria, they are the main sources of calories accounting for over 50% of the caloric intake of the people of the south. Yam has less than 6% protein while cassava is a poor source of protein, less than 3%. Cocoyam is fair in protein, 7-9% and calcium. Sweet potatoes are poor in protein but fair in their supply of the  $\beta$ -vitamins. Therefore, cocoyam has some nutritional advantages over the other root and tubers crops.

The most popular and widely consumed species of cocoyam are the *Colocasia*, *xanthosoma*, *alocasia*, *caryotosperma chamissonis* and the *amophophallus Campanulatus* and their chemical constituents vary with varieties<sup>6</sup>. Cocoyams are rich in moisture content with highest values of 75.4%<sup>6</sup> while observing values of 69.1% and 67.1% for *Colocasia esculenta* and *xanthosoma sagittifolium*. The crude protein content for *C. esculenta* is about 2.1%<sup>6,7</sup>. The fat content for *C. esculenta* ranges between 0.1%-0.3%<sup>6-8</sup>. The ash content for *C. esculenta* falls within the range of 0.80%-1.1%<sup>8</sup>. Total oxalate in *C. esculenta* is estimated at 65 mg/100 g and the hydrocyanic acid and phytic acid values of  $1.04 \pm 0.06$  mg/100 g and  $40.9 \pm 2.9$  mg/100 g respectively<sup>1</sup>.

The vitamin A content of cocoyam is very low ranging from 0.007 mg/100 g to 0.02 mg/100 g<sup>6,7,9</sup>. Also, cocoyam is fairly high in crude and true proteins, rich in ash, low in fiber and is not a fair source of oils and fats. Cocoyam is also rich in some micro elements including P, Mg, Zn, etc. Cocoyam is fairly rich in carotene, ascorbic acid, thiamin, riboflavin and nicotinic acid.

Considering the nutritional quality of cocoyam, the high starch content and its quality (*i.e.* fine starch grains), the level of utilization of cocoyam and its products both domestically and industrially is quite low. People and industrialists seem to be ignorant of the nutritional and industrial potential of cocoyam. Investigating the nutritional quality of cocoyam and creating awareness on the nutritive quality and possible industrial potential would increase the utilization of cocoyam and its products domestically and industrially. In spite of the high nutritional value of cocoyam, the rate at which most Nigerians consume cocoyam is still low when compared to other root and tubers crops. The notion that cocoyam is a "poor man" food has been established in most Nigerian homes such that some are not comfortable to be found in the practice of consuming cocoyam. Malnutrition in Nigeria and other developing nations is traced to the consumption of low quality and quantity of food<sup>9</sup>.

Most importantly, because the number of reported cases of diabetes is on the high side the price of diabetes diets (such as wheat bread and plantain flour) are also high. Bread is a preferred meal in most cities. If a diabetic patient must consume bread, it has to be 100% wheat bread. In recent times, efforts have been made by the federal government of Nigeria (through its agencies such as raw materials development and research institute) toward the development of composite bread using a mixture of wheat flour and cassava flour. These

have become an acceptable practice. However, literature is scanty on the production of composite bread from cocoyam and on the chemical composition of such breads. The present research is aimed at investigating the industrial potential of cocoyam in bread making.

## Experimental

The two species of cocoyam (*Xanthosoma sagittifolium* and *Colocasia esculenta*) used for this work were obtained from a farm locally and were identified in the National Root Crops Research Institute (N.R.C.R.I), Umudike, Nigeria. Samples for determination of wet analysis (moisture content) were used immediately after harvest while those for dry weight analysis were washed, peeled, sliced and allowed to dry in the sun for ninety six hours till they became brittle. They were then crushed to powder using Moulinex blender, stored in air-tight bottles labeled and kept in a cool dry place. De-ionized water was used wherever applicable. The ground samples comprised whole corms and cormels in fairly equal proportions.

### *Determination of moisture content<sup>10</sup>*

5 g of Each of the samples were weighed and dried at about 105 °C in a hot air circulating oven for six hours to constant weight. The moisture content was reported as percentage loss in weight expressed in terms of wet weight.

$$\% \text{ Moisture} = \frac{\text{loss in weight of sample}}{\text{Weight of original sample}} \times 100$$

### *Determination of ash content<sup>10</sup>*

The ash content was determined by igniting 10 g of dry sample in a muffle furnace at about 550 °C to constant weight. It was cooled in a dessicator and weighed. The ash content was reported as a percentage dry mass.

$$\% \text{ Dry mass} = \frac{\text{mass of ash}}{\text{mass of oven dried sample}} \times 100$$

### *Determination of crude protein<sup>10</sup>*

5 g of Dry sample were weighed and digested in macro-Kjeldahl apparatus with concentrated sulphuric acid. The ammonia liberated from the resulting ammonium sulphate after adding sodium hydroxide was distilled into 1 M boric acid and then titrated with 0.1 M HCl. The nitrogen value estimated was multiplied by 6.25 (protein factor) to obtain the value of the crude protein, expressed as the percentage of dry sample mass.

$$\% \text{ Nitrogen} = \frac{1.40 \times T}{\text{Weight of sample in grams}} \times 100$$

Where T is the titre value and 1 mL of 0.1 M HCl = 1.4 g.

### *Determination of fat<sup>10</sup>*

The crude fat was extracted from 5 g of each sample using a solvent extraction apparatus (Soxhlet apparatus) with low boiling point petroleum ether (b.p 40-60 °C) as solvent. The weight of the lipid obtained after evaporating off the solvent from the extract gave the weight of the lipid present in the sample.

$$\% \text{ Crude fat} = \frac{\text{weight of extract}}{\text{weight of dry sample}} \times 100$$

*Determination of crude fibre<sup>10</sup>*

5 g of sample were weighed and exhaustive extraction of substances soluble in 1.25% boiling sulphuric acid and 1.25% boiling sodium hydroxide was employed. The residual matter of crude fibre and inorganic material recovered and ash yielded the crude fibre expressed as percentage loss in weight of ashed residue.

$$\% \text{ Fibre content} = \frac{\text{Weight of sample} - \text{Weight of sample after ignition}}{\text{weight of sample used}} \times 100$$

*Estimation of caloric value*

The caloric value of the sample was determined by multiplying the crude protein, lipid and carbohydrate by 4, 9 and 4 respectively and then taking the sum of the products.

*Determination of mineral element composition*

The analysis was carried out in two stages namely, preparation of ash and stock solutions. In order to prepare the ash solution, 6 g each of the cocoyam samples were accurately weighed into a previously dried, cooled and weighed crucible. The samples were dried in an oven at 105 °C after which the samples were introduced into a muffle furnace thermostated at 550 °C. 5 mL of Concentrated HCl (36% purity) was added to the ashed materials and the content was boiled for 5 min on a hot plate placed in a fume cupboard. The content was diluted with deionized water and further diluted to the 1000 cm<sup>3</sup> mark after re-boiling.

Stock solution of the elements was prepared by diluting the stock solution of their respective salt to the required concentration. These values were used to prepare the calibration curve for the respective element. The absorbance of each of the element was determined by aspirating each of the digested samples into the flame. The values of the absorbance for each of the metals were used to determine the concentration of element through the calibration curve. The % element in the food was calculated from the formula;

$$\% \text{ Element} = \text{C/w v}$$

C = concentration of diluted ash solution (from calibration curve), W = weight of the sample used and V = value of ash solution diluted.

*Determination of sodium and potassium by flame photometry*

About 2 g of dry samples were digested with 20 mL acid mixture of 650 mL HNO<sub>3</sub>, 80 mL HClO<sub>4</sub> and 20 mL conc. H<sub>2</sub>SO<sub>4</sub> and aliquots of the diluted clear digest taken for flame analysis using sodium and potassium filters respectively.

*Determination of Ca, Fe, Zn, Mg, Mn, Cd, Ni and Pb, by atomic absorption spectrophotometry*

About 2 g of dry samples were digested with 20 mL of acid mixture (650 mL conc. HNO<sub>3</sub>, 80 mL HClO<sub>4</sub> and 20 mL conc. H<sub>2</sub>SO<sub>4</sub>) and aliquots of the diluted clear digest taken for atomic absorption spectrophotometry using filters that match the different elements.

*Determination of vitamin composition*

The vitamin content present in the sample was determined by the A.O.A.C<sup>10</sup> method as shown below;

*Vitamin C<sup>10</sup>*

10 g of the dry sample was treated with 1% oxalic acid and 2.0 mL of 1 % H<sub>2</sub>C<sub>2</sub>O<sub>4</sub> acid and then diluted to 500 mL using distilled water.

***β.carotene<sup>10</sup>***

2.0 g of the Dry sample were treated with 2 mL of absolute ethanol and 5 mL of the heptane was added. Approximate 3 mL of the heptane layer was transferred to a 10 mm cuvette and the absorbance in a spectrophotometer (Spectronic 20 model) read against heptane of 450 nm.

**Determination of toxicants***Estimation of Hydrocyanic Acid<sup>10</sup>*

About 10 g of dry sample were soaked in 250 mL of distilled water for 4 h and then steam distilled into 2.5% (w/v) NaOH. About 8 mL of 6 N ammonium hydroxide and 2 mL of 5% (w/v) potassium iodide were added to the distillate before titrating with 0.02 N silver nitrate to a faint permanent turbidity. The HCN content was estimated by equating 1 mL of 0.02 N AgNO<sub>3</sub> to 1.08 mg HCN. 1 mL of AgNO<sub>3</sub> = 1.0 mg of HCN, 0.65 mL of AgNO<sub>3</sub> = (1.08×0.18) mg HCN = 0.840 mg/100 g.

*Estimation of phytic acid<sup>11</sup>*

About 20 g of dry sample were weighed and the phytic acid extracted with 0.5 N HCl and then precipitated as ferric phytate using ferric chloride. This precipitate was converted to sodium phytate using NaOH and then digested with an acid mixture of equal portions of conc. H<sub>2</sub>SO<sub>4</sub> and 65 % HClO<sub>4</sub>. The liberated phosphorus was quantified calorimetrically at 620 nm with Spectronic 20 spectrometer model using molybdate solution for colour development.

*Estimation of oxalate<sup>12</sup>*

2.0 g of Dry sample were digested with 6 N diluted HCl and the oxalate precipitated within CaCl<sub>2</sub> as calcium oxalate. The precipitated oxalate was washed with 25 % sulphuric acid and dissolved in hot water before titrating against 0.05 N potassium permanganate to determine its concentration. Oxalate was quantified by equating 1 mL of 0.05 N KMnO<sub>4</sub> to 2.2 mg oxalate.

***Preparation of cocoyam flour***

The cocoyam flour was prepared by peeling and slicing the corms and cormels and then washing the slices thoroughly in water so as to remove as much mucilaginous material as possible. After washing, the slices are left soaked in water overnight, then rewashed and finally immersed for 3 h in 0.25% bisulphite solution. They were blanched in boiling water for 4-5 min, drained and dried, preferably in oven at 57-60 °C. The dried slices were ground, sieved to 40-50 mesh and stored.

***Bread making***

The straight dough method was used in the baking operation. This involves the mixing of the paste (cocoyam, wheat and the composite flour) with other ingredients namely sugar (6%), fat (3%), baking powder (1.5%), yeast (1%) and water. This is closely followed by kneading process which ensures better crumb quality of the bread. After the kneading, the dough is cut into the required weights and molded into the pans, allowed to rest and then leavened by the yeast in a warm room. This is called fermentation stage which determines good or poor rising of the dough. With good formulation, mixing, kneading and favourable condition at the fermentation/proofing stage, the loaves surely turn out good at the baking stage. The dough at the fermentation stage is allowed for six hours and the oven temperature is set 600 °C for forty minutes before taking out the bread.

### Bread evaluation

All the baked bread was evaluated using a panel of judges consisting of 20 people. A 9-point hedonic scale as recommended by Amerine *et al*<sup>13</sup> was used for the assessment to evaluate the colour, texture, taste, flavour and over all acceptability of products. In this scale, 1 represents most disliked while 9 represents most liked for the evaluation of taste, texture, flavour, colour and overall acceptability.

### Results and Discussion

The result of the proximate, mineral, vitamins and toxicant composition, of cocoyam is as shown in Table 1-4. Table 5 shows the physical quality of the bread produced from *Colocasia* species of cocoyam while Table 6 shows the result of the sensory evaluation test carried out on the bread samples. The mean proximate composition of the produced bread samples are shown in Table 7.

**Table 1.** Proximate composition of cocoyam

Parameter	<i>Xanthosoma sagittifolium</i>	<i>Colocasia esculenta</i>
Moisture (% wet weight)	68.28±3.59	70.67±4.65
Ash (% dry mass)	1.10±0.15	0.83±0.17
Crude protein (% dry mass)	1.56±0.33	1.36±0.35
Crude fat (% dry mass)	1.40±0.20	1.10±0.00
Crude fibre (% dry mass)	0.82±0.20	1.39±0.11
Carbohydrate (% dry mass)	41.89±5.00	32.73±4.33
Energy value (cal/100 g)	186.40	146.26

**Table 2.** Mineral element composition of cocoyam

Element, mg/100 g	<i>Xanthosoma sagittifolium</i>	<i>Colocasia esculenta</i>
Zinc	10.523±0.478	2.120±2.000 E-02
Manganese	5.830±0.110	0.249±4.619 E-03
Nickel	0.813±2.516 E-02	0.756±2.425 E-02
Copper	0.235±1.155 E-03	0.877±4.619 E-03
Iron	1.391±1.847 E-02	1.011±2.501 E-02
Sodium	20.200±0.000	24.147±0.129
Potassium	580.483±5.773 E-03	500.510±0.108
Lead	0.608±1.200 E-02	1.0133±3.075 E-02
Calcium	47.733±2.157	13.953±2.355
Cadmium	25.680±0.1150	47.243±0.002
Magnesium	63.240±0.130	51.414±3.536 E-03
Phosphorus		

**Table 3.** Vitamin composition of cocoyam

Parameter (mg/100g)	<i>Xanthosoma sagittifolium</i>	<i>Colocasia esculenta</i>
Vitamin C	23.823±0.2815	26.930±3.000 E-02
β-Carotene	6.823±0.1620	11.066±0.1002

**Table 4.** Toxicant composition of cocoyam

Toxicant (mg/100 g)	<i>Xanthosoma sagittifolium</i>	<i>Colocasia esculenta</i>
Oxalate	0.400±0.000	5.010±0.021
Hydrocyanic acid	1.570±0.013	3.330±0.200
Phytic acid	71.310±1.100	88.210±1.530

**Table 5.** Physical quality of *Colocasia esculenta* flour bread

Sample	I	A	B	C	G
% Wheat	100	80	70	50	0
% Colocasia	0	20	30	50	100
Loaf weight, g	183.43	137.17	165.18	170.15	149.54
Loaf volume, cm <sup>3</sup>	649.39	430.90	498.22	450.14	385.16
Specific volume, cm <sup>3</sup> /g	3.54	3.14	3.02	2.65	2.58

**Table 6.** Sensory evaluation of bread loaves

Parameters	<i>Colocasia esculenta</i>					<i>Xanthosoma sagittifolium</i>				
	A 20%	B 30%	C 50%	G 100%	D 20%	E 30%	F 50%	H 100%	I 100%	
Colour	6.6	6.4	7.5	5.6	5.3	6.4	7.8	3.7	8.4	
Taste	5.0	4.0	4.6	5.6	6.3	6.8	4.5	3.3	7.7	
Flavour	3.6	5.1	4.3	4.0	6.5	5.1	4.9	3.7	7.6	
Texture	5.1	5.0	5.7	4.6	7.9	6.8	7.3	4.8	7.3	
Overall acceptability	5.3	4.8	4.2	4.1	6.6	5.6	5.1	4.8	8.2	

**Table 7.** Mean proximate composition of the bread samples

Parameters	<i>Colocasia esculenta</i>	<i>Xanthosoma sagittifolium</i>	Wheat bread
Moisture (% wet weight)	15.0633±1.4531	12.1133±1.5975	11.2867±0.7978
Ash (% dry mass)	31.4367±1.6159	20.3233±1.0446	21.1633±2.3139
Crude protein	19.3067±0.7129	20.2033±1.3335	20.6033±0.8113
Crude fat (% dry mass)	10.7367±0.4099	12.2967±0.8914	8.3633±0.4104
Crude fibre (% dry mass)	2.8733±0.6294	3.4767±0.5450	1.7000±0.1229
Carbohydrate, %	39.6733±1.3070	45.0133±3.0274	37.8033±0.3782
Energy value (calories/100 g)	332.5503	371.536	308.891

Cocoyam, like other root crops has high water content. *Colocasia esculenta* had higher moisture content ( $70.67\pm4.65\%$  wet weight) compared to *Xanthosoma sagittifolium* with  $68.28\pm3.59\%$ . The result of this analysis agreed with the previous work of bradbury<sup>6</sup>, which showed *Colocasia esculenta* to have 69.2% while *Xanthosoma sagittifolium* had 67.71%. However, this figure differs slightly with some previous report which showed *Xanthosoma sagittifolium* to have 70-77% while *Colocasia esculenta* has about 73-78% moisture. The values of moisture content recorded for the various species explains the texture and shelf life features. *Xanthosoma sagittifolium* with less water content keeps longer than the *Colocasia esculenta* which contains relatively high amount of moisture. So many factors including environmental conditions, age and time of harvest of the samples affect the moisture content of tuber crops. Some of these factors might have contributed to the difference between the measured moisture content and values reported by some other authors.

The values obtained for each ash in the two cocoyam varieties considered in this supports the findings of Nwanekesi *et al*<sup>6</sup>. *Xanthosoma sagittifolium* recorded ash value of  $1.1\pm0.15\%$  while *Colocasia esculenta* recorded  $0.83\pm0.17\%$ . Bradbury<sup>6</sup> in their work recorded the ash content for *Xanthosoma sagittifolium* as 1.04% while that of *Colocasia esculenta* was 0.87%. There is a direct proportionality between ash content and mineral element composition and the result obtained were consistent with this trend<sup>1</sup>.

According to Sinful and Darko<sup>14</sup>, roots and tubers are estimated to contain about 8% of protein. Ciacco *et al.*<sup>5</sup> also stated that among the root crops, cocoyam shows better performance in terms of protein. However, the result of the analysis showed that the protein content of *Xanthosoma sagittifolium* ( $1.56\pm0.33\%$ ) is higher than that of *Colocasia esculenta* ( $1.36\pm0.35\%$ ). These results are at variance with values of 4.64 and 5.08% reported by Nwankezezi *et al.*<sup>6</sup> for *Xanthosoma sagittifolium* and *Colocasia esculenta* respectively.

Nutritionally, with a recommended allowance of 23-36 g in children and 44-56 g for adults (Nutritional Research Council<sup>15</sup>), cocoyam seem to be a poor source of protein and dependence on it will give rise to protein-energy malnutrition (PEM), with kwashiorkor and marasmus threatening the children (FAO<sup>16</sup>). The protein in cocoyam especially *Colocasia esculenta* are rich with essential amino acids, relatively low only in histidine and lysine (FAO/WHO<sup>17</sup>). Protein deficiency causes delayed bone healing and depresses fibroblast repairs and callus formation.

The fat contents of the cocoyam species ( $1.4\pm0.2\%$  and  $1.1\pm0.01\%$  for *Xanthosoma* and *Colocasia* respectively) used in the study were relatively higher than values of 0.88 and 0.83% reported by Nwankezezi *et al.*<sup>6</sup> for *Xanthosoma* and *Colocasia* respectively, it can be deduced that cocoyam is not an excellent source of fat.

High fat intake and obesity appear to relate to the incidence of cancer of the breast, colon and ovary, increasing disease risk by influencing turn over behaviour than actually being causative<sup>11</sup>. This makes cocoyam with its relatively low fat content recommendable for obese patients. Fats stabilize cholesterol solubility in blood as well as provide high energy on combustion.

Perssini and Sensidoni<sup>19</sup> observed that there is a relatively low yield of dietary fibre in cocoyam. Values that ranged between 0.6-1.9% for *Xanthosoma* specie and between 0.4-2.9% for the *Colocasia* specie was reported. The result of this work shows that the fibre content of *Xanthosoma* specie ( $0.82\pm0.2\%$ ) is lower than the fibre content of the *Colocasia* specie ( $1.39\pm0.01\%$ ). This result agrees compares favourably with values (0.36% and 0.20% reported by Nwankezezi *et al.*<sup>6</sup> for *Xanthosoma* and *Colocasia* respectively).

Fibre has physical properties that have the potential of binding fats, cholesterol and minerals such as zinc, copper, Iron and magnesium. A fibre intake in excess of 30-40 g/day means a great loss of these important nutrients<sup>20</sup>. Also symptomless diverticulae, affecting mainly the distal colon is caused by prolonged consumption of diets low in fibre. Fibre, with its bulking properties, is useful in treating irritable bowel syndrome (IBS). Available literature shows that high fibre diets reduce the amount of protein and energy absorbed from food ingested<sup>2,18</sup>.

Of the solid nutrient content in roots and tuber crops, carbohydrates predominate<sup>2</sup>. The two cocoyam varieties used for this work have carbohydrate content of 41.89% and 32.73% for the *Xanthosoma* and the *Colocasia* species respectively. These values are lower than the values of 84.2% and 84.1% for *Xanthosoma* and *Colocasia* respectively<sup>6</sup>.

The samples showed relatively high potassium content. The values obtained were  $580.483\pm5.773$  E-03 mg/100 g and  $500.510\pm0.108$  mg/100 g for both *Xanthosoma* and *Colocasia* respectively. Potassium is a determinant of anion-cation balance in the cell, it also activate numerous enzymes. It is useful for the formation of glycogen, protein and for the maintenance of osmotic pressure<sup>18</sup>. The deficiency of potassium has been implicated in the etiology of oedema and increased risk of arrhythmia. High potassium diets have been found to

be useful in treating hypertension. Potassium is thought to lower blood pressure by lowering the renin-angiotensin receptor levels<sup>11</sup>. The recommended daily requirement of 350 mg in infants and 562 mg in adults<sup>15</sup> makes cocoyam a fairly adequate source of potassium. Potassium salt has been found to be a better substitute for sodium salt because it exerts less effect on the blood sugar compare to sodium salt. Consequently, high potassium salt intake and low sodium salt intake is recommended for a diabetic patient. Therefore cocoyam is a good source of diet for diabetic patient.

The result for the calcium content of *Xanthosoma* and *Colocasia* species obtained were  $47.733 \pm 2.157$  mg/100g and  $13.953 \pm 2.355$  mg/100g respectively. This result show higher values than what was obtained by Nwanekesi *et al.*<sup>6</sup>. The recommended daily allowance by national research council<sup>5</sup> is between 360-1200 mg/100 g. The growing child requires considerably more of calcium than adult. The cocoyam species may serve as good dietary source of calcium for infants. The availability of this mineral can be limited by the presence of anti-nutrients as oxalates and phytates.

The result obtained for the concentration of iron in *Xanthosoma* and *Colocasia* were  $1.391 \pm 1.847$  E-02 mg/100 g and  $1.011 \pm 2.501$  E-02 mg/100 g respectively. There was no significant difference between the two species. Cocoyam species used for this work were actually low in iron compared with the recommended daily intake of 10-18 mg by national research council<sup>15</sup> and 5-28 mg by FAO/WHO<sup>17</sup>. Cocoyam would therefore be considered a good source of iron. Its availability would depend on the presence of other dietary factors enhancing its absorption such as cysteine and ascorbate (reductants), or inhibiting it as phytic acid. Complications leading to anaemia in man occur in low iron intake. Anaemia is a state of iron depletion resulting in low haemoglobin. Infants' store of iron is low as milk is low in iron and supplement with about 7 mg of iron per day to maintain infants iron store has been recommended<sup>21</sup>.

The concentration of zinc for the two species of cocoyam was  $10.523 \pm 0.478$  mg/100 g and  $2.120 \pm 2.000$  E-02 mg/100g for *Xanthosoma* and *Colocasia* species respectively. Comparing these values with the recommended 10.15 mg daily intake of zinc by national research council<sup>15</sup>, it can be deduced that *Xanthosoma* would serve as a good source of zinc. Zinc is needed for normal growth and development of all living cells as it helps in protein metabolism (as component of carboxypeptidase) and as component of carbonic anhydrase. Zinc has also been found helpful in slain disorders such as burns and surgical wounds<sup>20,22</sup>.

The concentration of magnesium obtained for *Xanthosoma* and *Colocasia* were  $25.680 \pm 0.115$  mg/100g and  $47.243 \pm 0.002$  mg/100g respectively. Magnesium is involved in ATP-ADP catalysis and conduction of nerve impulse and is known to promote muscle relaxation. It is involved in the activation of many enzymes in the body<sup>23</sup>. With a recommended daily allowance of 50 mg for infants and 350 mg for adults<sup>15</sup>, cocoyam diets alone (unsupplemented) are not adequate source of magnesium.

The concentration of sodium obtained were  $20.200 \pm 0.000$  mg/100 g and  $24.147 \pm 0.129$  mg/100 g for *Xanthosoma* and *Colocasia* species respectively. Sodium is important in the maintenance of a constant environment for the living cells especially in nerves, muscles and sensory cells when they are involved in transmission of impulses. They are found in extra cellular fluid portion. The low sodium content of cocoyam compare to those of other tubers also makes these two species of cocoyam to be a recommended diet for diabetic patient.

The value obtained for phosphorus content were  $63.240 \pm 0.130$  mg/100 g and  $51.414 \pm 3.536$  E-03 mg/100 g for both *Xanthosoma* and *Colocasia* respectively. These levels of phosphorus are above the recommended daily requirement of 0.6-1.5 g phosphorus<sup>24</sup>. As a dietary phosphate deficiency is relatively rare due to the efficient absorption of phosphate (50-90%), food value up to 300 mg can be used efficiently in metabolic process. About 85% of the body phosphate occurs in bone<sup>21</sup>. Phosphorus involvement in cellular reactions as phosphate esters is an essential step in the metabolism of carbohydrates as well as being a source of energy in the form of ATP in cells and creating phosphate in muscles.

Other elements considered were manganese, nickel, copper, lead and cadmium for the two species. The results obtained were  $5.830 \pm 0.110$  mg/100 g and  $0.249 \pm 4.619$  E-03 mg/100 g,  $0.813 \pm 2.516$  E-02 mg/100 g and  $0.756 \pm 2.425$  E-02 mg/100 g,  $0.235 \pm 1.155$  E-03 mg/100 g and  $0.877 \pm 4.619$  E-03 mg/100 g,  $0.608 \pm 1.200$  E-02 mg/100 g and  $1.0133 \pm 3.075$  E-02 mg/100 g, 0.00 and 0.00 mg/100 g for *Xanthosoma* and *Colocasia* respectively. This result indicates that there is a reasonable concentration of manganese in *Xanthosoma* whereas other elements exist in trace quantities.

The value obtained for the vitamin C content for *Xanthosoma* and *Colocasia* were  $23.823 \pm 0.2815$  mg/100 g and  $26.930 \pm 3.00$  E-02 mg/100 g respectively. The values obtained were higher than those recorded by parkinson<sup>25</sup>. The daily requirements for vitamin C have been given as 35 mg for infants and 60mg for adults<sup>15</sup>. This means that cocoyam is an adequate source for the supply of dietary vitamin C since an adult consuming 500 g of cocoyam can afford the aversion of the symptoms and disorders of ascorbic acid deficiency.

The concentration of  $\beta$ -Carotene content in *Xanthosoma* and *Colocasia* were found to be  $6.823 \pm 0.1620$  mg/100 g and  $11.0667 \pm 0.1002$  mg/100 g respectively.  $\beta$ -carotene is widely used as the vitamin A precursor since it is metabolically oxidized to retinol (vitamin A.) in animals except cat. It is also used as effective sunscreen agent in erythropoietic protoporphyrinia. Perhaps, the most important useful available carotenoids are  $\beta$ -carotene and lycopene, which are found richly in carrot and tomato respectively. These carotenoids are used in industries for the safe colouration of foods as exemplified in the colouring and fortification of margarine and poultry feedstuff<sup>20</sup>.

The result obtained for the total oxalate for *Colocasia* and *xanthosoma* were  $5.01 \pm 0.21$  mg/100 g and  $0.40 \pm 0.00$  mg/100 g respectively. All roots and tubers contain oxalate as calcium oxalate and soluble oxalate<sup>26</sup>. The oxalates have been implicated as mechanical defense mechanism, storage reserves and stores of excess calcium<sup>22</sup>.

Consumption of large doses of oxalic acid causes corrosive gastroenteritis, shock, convulsive symptoms, low plasma calcium, high plasma oxalates and renal damage<sup>27,28</sup>. Oxalate binds with calcium and prevents its absorption in the alimentary canal. The oxalate bound calcium from other foods to give calcium oxalate which is excreted in the faeces<sup>29</sup>. While cows, sheep and goats can utilize calcium oxalate, it is only poorly utilized by man. The amount of soluble oxalate in tubers is comparatively small. The peels of tubers contain more oxalate than the peeled tubers; thus supporting the role of oxalate as allelochemicals. The lethal dose for soluble oxalate is 2-5 g giving cocoyam a safe margin<sup>29</sup>. No incidence of oxalic acid poisoning has been reported in Nigeria<sup>26</sup>.

The result in the antinutrient composition shows a low content of hydrocyanic acid in both *Colocasia* and *xanthosoma*. The values (in %) were  $3.330 \pm 0.200$  mg/100 g and  $1.870 \pm 0.13$  mg/100 g for both *Colocasia* and *xanthosoma* respectively. The lethal dose of cyanide

was reported to be 35.0 mg<sup>29</sup>. This gives cocoyam a safe margin. Goesaert *et al.*<sup>29</sup> reported that hydrocyanic acid exert inhibitory effect at the cytochrome oxidase level in the electron transport chain.

The results obtained for phytic acid concentration were found to be  $88.210 \pm 1.530$  mg/100 g and  $71.310 \pm 1.100$  mg/100 g for *Colocasia* and *Xanthosoma* respectively. Phytates like oxalate are known to limit the availability of calcium, magnesium, iron and phosphorus by formation of insoluble compounds or salts with the minerals. Humans lack the enzyme phytase to hydrolyse the phytate group to release calcium. The inhibitory effect of phytic acid is only a practical problem when calcium food is consumed with food high in phytic acid.

It has been found that foods/food materials having phytic acid concentration greater than 19 mg/100 g showed low iron diffusibility<sup>30</sup>. However, the observations from this work showed that *Xanthosoma* was rather lower in phytate content than *Colocasia* and even richer in vitamin C (ascorbate) which enhances bivalent iron absorption, thus rendering some inconsistency with the earlier chains.

The result of the physical quality characteristics of bread baked from the different cocoyam varieties at various substitution levels is shown in Table 5. The best bread in terms of loaf weight, loaf volume and specific volume was given by sample I (control), containing 100% wheat flour with a specific volume of  $3.54 \text{ cm}^3/\text{g}$ . This was closely followed by sample A containing 20% substitution level of *Colocasia* variety with specific volume of  $3.25 \text{ cm}^3/\text{g}$ ; then sample D which has 20% substitution level of *Xanthosoma* variety with specific volume of  $3.14 \text{ cm}^3/\text{g}$ . This was closely followed by sample B which has 30% substitution level of *Colocasia* variety with specific volume of  $3.10 \text{ cm}^3/\text{g}$  and finally sample E containing 30% substitution level of *Xanthosoma* variety with specific volume of  $3.02 \text{ cm}^3/\text{g}$ .

On the other hand, the poorest performance in terms of loaf weight, loaf volume and specific volume was given by sample H containing 100% of *Xanthosoma* with specific volume of  $2.58 \text{ cm}^3/\text{g}$ , followed by G, with 100% of *Colocasia* with specific volume of  $2.62 \text{ cm}^3/\text{g}$  then sample F with 50% *Xanthosoma* with specific volume of  $2.65 \text{ cm}^3/\text{g}$  and sample C with 50% of *Colocasia* with specific volume of  $2.91 \text{ cm}^3/\text{g}$ .

Of interest is the fact that these two varieties of cocoyam showed optimal performance in the physical quality indices of substitution of 20% and poorer performance at 100% substitution levels. Also to be noted is that amongst all the varieties, *Colocasia* performed best at each level of substitution, followed by *Xanthosoma*.

The sensory quality statistics also show that the control sample was superior in all sensory characteristics compared with the cocoyam based composite flour bread (Table 6). In terms of colour, sample (I) significantly ( $p < 0.5$ ) performed better than any of the other samples. It was noted that as the level of substitution of cocoyam varieties increased, the colour rating decreased (except for samples C and F). The colour of samples F and C were closer to the colour of the control samples implying that in terms of colour rating, these samples are preferred. The poorest colour rating was recorded for sample H. The poorer rating in colour of cocoyam sample as the percentage of substitution of wheat flour with grated cocoyam increased could be attributed to browning reaction in the cocoyam<sup>20</sup>. It was observed that as soon as the peeled raw cocoyams were sliced, they started darkening due to oxidation. This darkening effect is carried into the mixed dough and finally into the bread. Obviously, as more of the grated cocoyam that was added to the sample, the more intense was the darkening effect.

In terms of taste, samples E, D, G, A trailed behind I and were regarded as being good. The strong taste, flavour and texture of cocoyam seemed to have negatively affected the cocoyam based samples and the higher the level of substitution of the wheat flours with the cocoyam, the poorer the rating of the sample irrespective of variety.

In terms of flavour, sample D was rated almost as good as sample (I), control *i.e.* wheat flour. Sample A was rated worst of all the samples. In terms of texture, samples D, F, E, were not significantly different ( $p > 0.05$ ). They were rated soft whereas G and H were rated hard.

The overall acceptability result indicates that the control sample was significantly more acceptable than any other bread samples. This was followed by D with 20% substitution level of *Xanthosoma*. Other fairly rated samples were E with 30% substitution level of *Xanthosoma*, sample A, F with 20% substitution level of *Colocasia* and 50% substitution level of *Xanthosoma* respectively. The worst sample in terms of acceptability was sample G with 100% of *Colocasia*.

Generally, it is worthy of note that the colour contributed greatly to the assessment of the individual samples, followed by texture, taste and flavour. On the whole, apart from sample I which was rated best, the evaluation showed that sample D with 20% substitution level of *Xanthosoma* was rated good followed by sample E with 30% substitution of *Xanthosoma*. Samples A and F were rated as being fair. The worst in terms of performance were G and C.

The proximate composition of the bread samples produced from *Colocasia* flour, *Xanthosoma* and wheat flour were also conducted and the results recorded in Table 7. The moisture content of the bread produced from *Colocassia* spp. (15.06%) of cocoyam was the highest followed by that of *Xanthosoma* spp (12.11%) and least for the wheat bread (11.28 %). According to Khattak *et al*<sup>22</sup>, moisture content of food could influence the shelf life of the food hence the shelf life for the different bread samples would follow the trend; wheat > *Xanthosoma* > *Colocasia*, since all the bread were prepared under similar condition and the additives were essentially the same. Different food materials have different capacity for absorbing and that there could be occluded, adsorbed water in some food samples<sup>4</sup>. Some or all these factors might have been responsible for the differential moisture capacity of the different breads. As expected, the moisture content of the *Xanthosoma* and *Colocasia* bread samples were however found to be lower in the bread samples compared to the original food materials. The reduction in the moisture content might have been due to the effect of change in temperature. According to Ekop *et al.*<sup>12</sup>, when any food material is exposed to a temperature above 100 °C, all or most of the moisture content of that food material would be reduced because the boiling point of water at standard atmospheric pressure is 100 °C. There was no significant difference between the moisture content of the *Xanthosoma* bread and wheat bread ( $t = 3.369$ ,  $n = 3$ ,  $\alpha = 0.05$ ) while there was a significant difference between the moisture content of *Colocassia* bread and wheat bread ( $t = 15.39$ ,  $n = 3$ ,  $\alpha = 0.05$ ). This suggest that the *Xanthosoma* bread is a better substitute to wheat bread than the *Colocassia* bread with respect to moisture content, shelf life and other parameters that are influenced by moisture.

The total ash content of the *Xanthosoma* bread and that of the *Colocassia* bread were found to be higher than the ash content of the raw samples. This might have been due to the additives that were added to the bread prior to their production. According to Eddy<sup>4</sup>, ash content of any food is a measure of the total inorganic component of the food materials hence it can be inferred that the *Colocassia* bread (31.44%) has the highest ash content compared to the *Xanthosoma* bread (20.32%) and the wheat bread (21.16%). This implies that *Colocassia* bread might have a greater tendency to retain minerals elements at the high temperature of the oven more than the *Xanthosoma* bread and the wheat bread. There was no

significant difference between the ash content of the *Colocassia* bread and the wheat bread and also between the *Xanthosoma* bread and the wheat bread. This suggests that *Colocassia* bread and *Xanthosoma* bread might serve as a good substitute for wheat bread with reference to their ash content.

The protein content of the *Xanthosoma* and *Colocassia* bread were increased as a result of baking. The increase might have been attributed to the added additives. There was no significant difference between the protein content of the *Xanthosoma* bread and that of the wheat bread ( $t = 1.26$ ,  $n = 3$ ,  $\alpha = 0.05$ ) and also between the wheat bread and the *Colocassia* bread ( $t = 2.89$ ,  $n = 3$ ,  $\alpha = 0.05$ ). It can therefore be stated that *Colocassia* bread and *Xanthosoma* bread are better substitute for wheat bread with regard to their protein content. There was also an increase in the fat content of *Xanthosoma* and *Colocassia* breads. The increase might have been due to the fat content of the additives. Although the fat content of *Xanthosoma* bread (12.30%) was higher than the fat content of *Colocassia* bread (10.74%) and wheat bread (8.31%), there was no significant difference between the fat content of the different breads. The percentage fat content of the three bread samples was comparable and this implies that *Colocassia* bread and *Xanthosoma* bread could also serve as a substitute for wheat bread with regard to their fat content.

The fibre content of the *Xanthosoma* and the *Colocassia* were found to be increase after baking. This might have been due to the additives that were added to the baked products. Although the fibre content of *Xanthosoma* bread (3.48%) was relatively higher than the fibre content of *Colocassia* bread (2.87%) and that of wheat bread (1.70%), the insignificant difference between them suggest that *Colocassia* bread and the *Xanthosoma* bread could serve as a substitute for wheat bread.

The carbohydrate content of the baked *Colocassia* bread and that of *Xanthosoma* bread were also increased due to the additives which might have contributed to the total carbohydrate content of the different breads. Available literature shows that carbohydrate is less affected by heat and this may account for the non significant difference that was observed between the carbohydrate content of the *Colocassia* bread and the wheat bread and also between the carbohydrate content of the *Xanthosoma* bread and the wheat bread. Thus the *Xanthosoma* and the *Colocassia* satisfied the alternatives for baking bread when compared to wheat. The energy value of any food materials is related to their carbohydrate, fat and protein content<sup>12,20</sup>. Hence the insignificant difference between the energy values of the different bread samples correlates with the content of carbohydrate, fat and protein as discussed above.

## Conclusion

The aim of the study was to analyze samples of *Colocassia* and *Xanthosoma* species of cocoyam for their proximate composition and to utilize the samples for the production of bread. The bread samples produced from *Xanthosoma* and *Colocassia* species of cocoyam flour were comparable to bread produced from wheat flour under the same condition except for their binding properties, weight and shelf life. Thus, cocoyam can be used for the production of bread if a suitable binder is incorporated into the product. The use of additives that can improve the shelf life of the products shall also offer a promising alternative. The carbohydrate, minerals, protein, fats and oils and vitamins composition of cocoyam bread were quite acceptable and comparable to that of wheat bread produced under similar condition. The study therefore complements the work of many researchers on cocoyam.

This study therefore recommends that future research should be aimed toward improving the quality of bread produced from cocoyam flour. Research into the utilization of the other species of cocoyam in bread making should be encouraged.

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