QUALITY EVALUATION OF COCOYAM-COWPEA FLOUR BLENDS AND SENSORY ATTRIBUTES OF THEIR COOKED PASTE (*AMALA*)

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Abstract
Cocoyam, as an indigenous starchy food crop, is a desirable vehicle in alleviating the endemic protein malnutrition in Nigeria. This study evaluated some quality attributes of cocoyam-cowpea flour blends and the sensory attributes of their cooked paste (amala). Fermented cocoyam flour (FCF) was substituted with cowpea flour (CWF) at 0 (control), 10, 20, 30, 40 and 50% levels. The proximate and mineral composition, functional and pasting properties of FCF-CWF mixtures, and sensory properties of cooked paste obtained from the mixtures were determined using standard methods. Range of values for moisture, protein, fat, ash, crude fibre and carbohydrate contents of the FCF-CWF blends were 8.88 - 9.40%, 6.05 - 14.2%, 0.72 - 1.76%, 3.20 - 3.44%, 1.86 - 2.46% and 69.3 - 78.8%, respectively. The calcium, sodium and magnesium contents of the flour blends increased with increase in CWF. The bulk density of the control sample was not significantly (p>0.05) affected by substituting with CWF. The water absorption and swelling power of the control were not significantly (p>0.05) affected by CWF up to 40% and 30% substitution levels, respectively. Apart from the peak, trough and breakdown viscosities, there was no significant (p>0.05) difference in the pasting characteristics of both control and flour blends. Substituting FCF with CWF up to 20% level did not significantly (p>0.05) affect the texture, taste and overall acceptability of the paste. An acceptable cooked paste (amala) could be produced from fermented cocoyam flour enriched with 20% cowpea flour.

Keywords: cocoyam flour, cowpea flour, cooked paste, proximate composition, sensory properties

Received: 13.03.2017 Received in revised form: 31.05.2017 Accepted: 05.06.2017

1. INTRODUCTION

Cocoyam (Colocasia esculenta) is a staple root crop in Africa, Asia, and the Pacific (Temesgen and Retta, 2015). Among root crops in Nigeria, cocoyam ranks third in importance after cassava and yam, in terms of cultivation and consumption (Olayiwola et al., 2012). It is consumed in Nigerian homes either as boiled or cooked paste (*amala*), mostly during periods preceding yam harvest, and this underscores its importance as a possible substitute for yam (Ajijola et al., 2003). Cocoyam is high in carbohydrate, but low in protein (1-2 %), especially sulphur-containing amino acids (Temesgen and Retta, 2015).

Cowpea (Vigna unguiculata) is a popular legume in many parts of West Africa, including Nigeria (Olayiwola et al., 2012). Cowpea seeds are consumed as boiled either alone or in combination with other foods such as rice, maize and plantain. According to Henshaw et al., (2000) cowpeas could be processed into paste or flour for the preparation of various traditional foods such as akara (fried cowpea paste), *moinmoin* (steamed cowpea paste) and gbegiri (cowpea soup). Cowpea seed contains about 20.42-32.60% protein, and it is increasingly being acknowledged as an alternative protein source to animal proteins (Sing and Singh, 1992; Bradbury and Holloway, 1998; Xiong et al., 2013). Hence, cowpea seeds are valuable in the supplementation of starchy traditional meals such as *amala*. Blends of flour from legumes and tubers have been reported to possess superior nutritional quality than the one produced from either tuber or legume alone (Awoyale et al., 2010; Igbabul et al., 2015).

Amala is a generic term in Nigeria that is used to describe thick pastes prepared by stirring flour from yam, cocoyam, cassava or unripe plantain, in hot water, to form a smooth consistency (Fetuga et al., 2014). It is a common meal among the vulnerable groups and the convalescents, who need adequate intake of protein. It is therefore desirable to improve the protein content of *amala* with available, acceptable and affordable protein source such as cowpea. There are research reports (Akissoe et al., 2001; Mestres et al., 2004; Babajide et al., 2006) on the processing variables, chemical and sensory attributes of fermented flour from yam. Information is however scanty on the performance of cocoyam-cowpea flour blends in *amala*. This study therefore evaluated the nutrient composition and functional properties of cocoyam-cowpea flour blends, and the sensory attributes of *amala* obtained from the blends.

2. MATERIAL AND METHODS

Materials

Cocoyam (Colocasia esculenta) cormels and cowpea (Vigna unguiculata) grains were purchased from Osiele market, Abeokuta, Ogun State, Nigeria.

Preparation of fermented cocoyam flour (FCF)

The method described by Obadina et al. (2016) was used. The cocoyam cormels were sorted, washed with water, peeled and sliced to about 1 cm thickness using a manual kitchen slicer. The slices were transferred into a stainless pot, covered with water, and parboiled at 50 ^{o}C for 3 h. The pot with its content was removed from the fire and left for about 24 h at ambient temperature of about 28 ºC.

The slices were dried in a Genlab drying cabinet (Model: DC 500; Serial number: 12B154) at 65 °C for 48 h and milled in a laboratory hammer mill (Fritsch, D-55743, Idar-oberstein-Germany). The milled sample was sieved using 250 µm screen and stored in air-tight polyethylene bags until further analysis.

Preparation of cowpea flour (CWF)

Cowpea flour was also processed according to the method described by Olayiwola et al. (2012). Cowpea seeds were cleaned, soaked for 5 min in cold water and decorticated. The bean seeds were manually separated from seed coat.
The decorticated seeds were then dried and milled, as described for FCF.

Blending of flour

Six composite flour samples were prepared by substituting CWF for FCF at 0 (control), 10, 20, 30, 40 and 50% levels. The flours were blended using a Kenwood mixer (Model HC 750D, Kenwood, UK) to produce FCF-CWF blends. Each blend was prepared in three replicates for proximate composition, functional and pasting characteristics determinations.

Proximate composition of cocoyam-cowpea flour blends

The moisture, crude fat, crude protein, ash, crude fibre of the flour blends were analysed according to the methods of AOAC (2005). The carbohydrate contents of the flour samples were calculated by difference (James, 1995).

Mineral analysis of FCF-CWF blends

The mineral content of the flour blends was determined using the methods of AOAC (2005). The ash obtained during proximate analysis was used in the determination of the minerals. The ash was placed in porcelain crucibles, and then few drops of distilled water were added, followed by 2 mL of concentrated hydrochloric acid. About 10 mL of 20% HNO_3 was added and heated over a hot plate. The samples were filtered through Whatman filter paper No 4 into 100 mL- volumetric flask. The mineral elements (calcium sodium and potassium) were determined using Jenway digital flame photometer (PFP7 Model). Magnesium was determined by atomic absorbance spectrophotometer (AA800 Perkin-Elmer, Germany). The phosphorus in the sample filtrate was determined by colorimetry using Spectronic 20 spectrophotometer at a wavelength of 470 nm.

Functional properties of FCF-CWF blends

The bulk density, water absorption capacity, swelling power of the flour blends were determined according to the methods described by Wang and Kinsella (1976), Beuchat (1977) and Takashi and Siebel (1988), respectively.

Pasting characteristics of cocoyam-cowpea flour blends

The pasting characteristics of the composite flour samples were analysed using a Rapid Visco- Analyzer (RVA TECMASTER, Perten instrument-2122833, Australia). About 3 g of sample were weighed into a dried empty canister, and then 25 mL of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed so that no lumps were obtained and the canister was fitted into the rapid visco analyzer. A paddle was then placed into the canister. The measurement cycle was initiated by depressing the motor tower of the instrument. Samples were pasted according to a programmed heating and cooling cycle. The dispersions were heated from 50 to 95 ºC with constant stirring at 2.67 Hz and were held at 95 ºC for 2.5 min (breakdown). Then the block temperature was cooled to 50 ºC and held for 2 min. The total cycle was 13 min. Parameters estimated were peak viscosity, setback viscosity, final viscosity, trough, breakdown viscosity, pasting temperature and time to reach peak viscosity (IITA, 2001).

Preparation of *amala*

Amala was prepared from cocoyam-cowpea flour blends using the method described by Awoyale et al. (2010). About 50 g of cocoyam-cowpea flour blend was added to 200 mL of boiling water in a stainless pot. The paste was stirred manually with a wooden spoon over a low flame until a smooth consistency was attained.

Sensory evaluation of *amala*

The method described by Iwe (2002) was used. The sensory panel consisted of 50 consumers of *amala* who were asked to rate the colour, aroma, texture, taste and overall acceptability of the product using a 9-point hedonic scale (1=dislike extremely, 5= neither like nor dislike, 9= like extremely).

Statistical Analysis

Data obtained were subjected to statistical analysis using SPSS version 21.0. The means were separated, where differences were observed, using Duncan's multiple range test at $p<0.05$.

3. RESULTS AND DISCUSSION

Proximate composition of FCF-CWF blends

Table 1 shows the proximate composition of cocoyam-cowpea flour blends. Significant ($p<0.05$) differences were observed in the proximate composition of the blends. The moisture content of the composite flour samples ranged from 8.88 to 9.40%. Moisture content of flour is indicative of dry matter of the flour. The low moisture content of the flour blends may indicate the efficiency of the drying method, and good storage stability of the flour samples (Sanni et al., 2006). The moisture content of FCF-CWF blends was within the acceptable limit of not more than 10% suggested for long term storage of flour (Onimawo and Akubor, 2012).

Table 1: Proximate Composition of cocoyam-cowpea flour blends

FCF:CWF	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
100:0	9.40^{d}	6.05^{a}	0.72^{a}	3.20^{a}	1.86^{a}	77.7^{f}
90: 10	9.30^{d}	7.67^{c}	0.93^{b}	3.24^{ab}	1.98^{b}	76.3^{d}
80:20	9.20^{bcd}	9.30^{e}	1.14^{c}	3.30^{ab}	2.10^{c}	74.8^{b}
70:30	9.09^{abc}	10.9^{b}	1.34^{d}	3.34^{ab}	2.22^{d}	73.3^{e}
60:40	8.99^{ab}	12.5^{d}	1.55^{e}	3.40^{ab}	2.34^{e}	71.8^{c}
50:50	8.88^{a}	14.2^{f}	1.76^{f}	3.44^{b}	2.46^{f}	70.3^{a}

Mean values with different superscripts within the same column are significantly different ($p <0.05$)
FCF: Cocoyam flour, CWF: Cowpea flour

The low moisture content of FCF-CWF blends observed in this study would enhance its storage stability by avoiding mould growth and other biochemical reactions (Onimawo and Akubor, 2012).
The protein content of the blends which ranged from 6.05 to 14.2%, increased with CWF inclusion. This trend may be due to the fact that cowpeas are rich sources of protein when compared with cocoyam (Olayiwola et al., 2012). Proteins are increasingly being utilised to perform functional roles in food formulations, hence therefore, the protein content of the flour samples in this study suggests that, they may be useful in food formulation such as cooked paste (*amala*).
The fat content of the flour blends ranged from 0.72% in control sample to 1.76% in FCF substituted with CWF at 50% level. The fat content of the blends was lower than the findings of Abulude and Ojediran (2006).
The flour blends would serve the special dietary needs of people who are obese. The ash content which is a measure of the total mineral content ranged between 3.20 and 3.44% with 50:50 (FCF:CWF) having the highest while the control had the lowest. This may mean that the higher the CWF, the richer the flour blends in terms of mineral content. The crude fibre composition, which ranged from 1.86 to 2.46%, also followed the same trend as observed in the ash content. Significant ($p<0.05$) difference was observed in the crude fibre content of FCF-CWF blends. Fibre has been reported to aid digestion, lower plasma cholesterol level in the body, soften stools and prevent several diseases such as irritable colon, cancer and diabetes (Norman and Joseph, 1995; Slavin, 2005; Elleuch et al., 2011).
All the flour blends were high in carbohydrate, which ranged from 70.3% in 50:50 (FCF:CWF) to 77.7% in the control sample. The carbohydrate contents of the blends are similar to the report of Amandikwa (2012). Carbohydrate supplies energy to cells such as brains, muscles and blood, contributes to fat mechanism, acts as mild natural laxative, and spares proteins as an energy source (Gaman and Sherrington, 1996; Gordon, 2000).

Mineral Composition of FCF-CWF blends

The calcium and sodium contents of the blends increased significantly ($p<0.05$) with increase in CWF from 13.36-104.0 mg/100g and 23.40-56.10 mg/100g, respectively (Table 2). Calcium is necessary for supporting bone formation and growth, muscle contraction and maintenance of healthy blood pressure (Thompson and Manore, 2005). Sodium maintains proper acid-base balance, assists with transmission of nerve signals and absorption of glucose/other nutrients, and aids muscle contraction (Thompson and Manore, 2005).
The range of values for phosphorus and potassium showed no definite trend but varied significantly ($p<0.05$) among the blends. Phosphorus is an essential element which plays an important role in multiple biological processes such as maintenance of cell membrane integrity and nucleic acids, generation of ATP, maintenance of acid-base homeostasis, among others (Penido and Alon, 2012).

Table 2: Mineral composition of cocoyam-cowpea flour blends

FCF: CWF	Calcium (mg/100g)	Sodium (mg/100g)	Phosphorus (mg/100g)	Potassium (mg/100g)	Magnesium (mg/100g)
90:10	31.49^{b}	29.97^{b}	114.0^{d}	1309.0^{cd}	80.50^{b}
80:20	49.60^{c}	36.51^{c}	114.9^{b}	1157.8^{ab}	90.88^{c}
70:30	67.74^{d}	43.05^{d}	158.6^{e}	1384.7^{de}	101.3^{d}
60:40	85.87^{e}	49.59^{e}	129.5^{c}	1233.5^{bc}	111.6^{e}
50:50	104.0^{f}	56.10^{f}	100.4^{a}	1077.9^{a}	122.0^{f}

Mean values with different superscripts within the same column are significantly different ($p <0.05$)
FCF: Cocoyam flour, CWF: Cowpea flour

Table 3: Functional properties of cocoyam-cowpea flour blends

FCF:CWF	Bulk density (g/ml)	Water absorption capacity (%)	Swelling power (g/g)
100:0	0.60[a]	1.16[a]	3.88[a]
90:10	0.61[a]	1.16[a]	3.91[a]
80:20	0.61[a]	1.18[a]	3.94[a]
70: 30	0.60[a]	1.18[a]	3.98[a]
60:40	0.61[a]	1.18[a]	4.27[b]
50:50	0.61[a]	1.90[b]	4.52[b]

Mean values with different superscripts within the same column are significantly different (p <0.05)
FCF: Cocoyam flour, CWF: Cowpea flour

Magnesium is essential for good health because it is necessary for normal muscle and nerve functions, production of ATP, DNA and protein and vitamin D metabolism (Thompson and Manore, 2005).

Functional properties of FCF-CWF blends

Table 3 shows the functional properties of the blends of fermented cocoyam flour and cowpea flour. Functional properties determine the application of food material for various food products. The inclusion of CWF may not affect the packaging requirement of FCF as there was no significant (p>0.05) variation in the bulk density of the blends. This may be due to the fact that the blends were sieved to the same particle size using 250 µm screen since bulk density is influenced by particle size and structure of starch polymers (Plaami, 1997; Adeleke and Odedeji, 2010). The water absorption capacity of the blends which ranged from 1.16 to 1.90% was not significantly (p>0.05) different, except in 50:50 blend (FCF:CWF). The highest water absorption capacity observed for 50:50 (FCF:CWF) blend may be due to the fact that it recorded the lowest moisture content among the blends, and that the hydrophilic constituent (protein) had significant contribution to the water absorption capacity of the blends (Osundahunsi, 2006).
The swelling power ranged from 3.88 g/g in the control sample to 4.52 g/g in 50:50 blend (FCF:CWF). There was however no significant (p>0.05) difference in the swelling power of the control and those of 90:10, 80:20, 70:30 and 60:40 blends. Swelling power is a measure of hydration capacity because the determination is a weight measure of swollen starch granules and their included water (Yellavila et al., 2015). It is an indication of the extent of associative forces within the granule and it is also related to the water absorption index of starch-based flour during heating (Loss et al., 1981; Moorthy and Ramanujan, 1986).

Pasting characteristics of FCF-CWF blends

The pasting characteristics of FCF-CWF blends are presented in Table 4. Pasting properties influence the quality and aesthetic properties of foods since they affect texture, digestibility and end use of starch-based food commodities (Onweluzo and Nnamuchi, 2009). Except for peak, trough and breakdown viscosity there was no significant (p>0.05) difference in the pasting properties of the control sample and blends. Peak viscosity, which is an index of the ability of starch-based foods to swell freely before their physical breakdown (Sanni *et al.*, 2006; Adebowale et al., 2012), ranged from 140.1 to 224.1 RVU. The fact that the peak viscosity of the blends reduced as the level of CWF increased may be indicative of reduced starch content (Osungbaro, 1990).
There was no significant (p>0.05) difference in the peak and trough viscosity of the control sample and 90:10 (FCF:CWF) blend. The relatively low peak viscosity obtained in this work may indicate that the flour blends are suited for products requiring low gel strength and elasticity (Abioye et al., 2011).

Table 4: Pasting characteristics of cocoyam-cowpea blends

FCF:CWF	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final Viscosity (RVU)	Setback viscosity (RVU)	Peak time (min)	Pasting temperature (°C)
100:0	224.1^{b}	206.4^{d}	58.5^{b}	276.4^{a}	90.8^{a}	5.17^{a}	85.2^{a}
90:10	204.9^{b}	199.8^{cd}	56.0^{b}	276.2^{a}	63.3^{a}	4.64^{a}	79.9^{a}
80:20	155.8^{a}	189.3^{c}	56.7^{b}	232.9^{a}	93.6^{a}	5.80^{a}	85.6^{a}
70:30	146.9^{a}	181.7^{c}	43.3^{b}	232.9^{a}	94.5^{a}	5.30^{a}	86.5^{a}
60:40	144.8^{a}	139.7^{b}	47.7^{b}	225.9^{a}	93.3^{a}	5.56^{a}	85.6^{a}
50:50	140.1^{a}	118.2^{a}	21.9^{a}	163.1^{a}	107.3^{a}	5.84^{a}	85.2^{a}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$)
FCF: Cocoyam flour, CWF: Cowpea flour

Low viscosity is desirable in complementary foods due to increase in nutrient and energy densities without excessive increase in viscosity (Ade-Omowaye, 2009). The trough viscosity of the blends ranged between 99.8 and 206.4 RVU. A high trough viscosity gives an indication of high ability of the paste to withstand breakdown during cooling (Adebowale et al., 2008). It therefore follows that the higher the level of CWF, the lower the ability of the pastes (obtained from the blends) to withstand breakdown during cooling. Breakdown viscosity value is an index of the stability of starch (Adebowale et al., 2008). The breakdown viscosity values ranged from 21.9 to 56.7 RVU. The inclusion of CWF may lead to reduced stability of pastes obtained from FCF since there was a reduction in the breakdown viscosity as CWF increased. Oduro et al. (2000) explained that starch with low paste stability or breakdown shows weak cross linking among the granules. However, the reduction in the stability of the paste may not be significant since there was no statistical difference ($p>0.05$) in the breakdown viscosity of the blends, except 50:50 (FCF:CWF) blend. Final viscosity, which is the change in viscosity after holding cooked starch at 50 °C, ranged from 163.1 to 276.4 RVU. The final viscosity decreased with increase in cowpea flour substitution. Cowpea flour therefore hinders the formation of viscous pastes (after cooking and cooling) and resistance of the paste to shear stress during stirring, in FCF-CWF blends (Adebowale et al., 2008). The setback viscosity of the flour blends which was between 63.3 and 107.3 RVU did not vary significantly ($p>0.05$) among the blends. Setback region, the phase where after cooling of the mixture a re–association between starch molecules occurs to a greater or lesser degree, affects retrogradation or re-ordering of the starch molecules and texture of the food products (Michiyo et al., 2004).

The higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the product made from the flour samples (Adebowale et al., 2008).

Peak time is the time at which the peak viscosity occurs in minutes and a measure of the cooking time of the flour (Adebowale et al., 2008). The peak time of the blends ranged between 4.64 and 5.17 min with 50:50 (FCF:CWF) recording the highest and 90:10 (FCF:CWF) having the lowest. The pasting temperature of the blends ranged from 79.9 °C in 90:10 (FCF:CWF) blend to 86.5 °C in 70:30 (FCF:CWF) blend. The pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and other components' stability (Shimelis et al., 2006). A higher pasting temperature implies higher water binding capacity and higher gelatinization (Numfor et al., 1996).

Table 5: **Sensory scores of cooked paste prepared rom cocoyam-cowpea flour blends**

CY:CP	Colour	Aroma	Texture	Taste	Overall acceptability
100:0	7.60^{c}	5.80^{a}	6.37^{b}	6.60^{b}	7.00^{cd}
90:10	6.47^{b}	5.73^{a}	6.53^{bc}	6.07^{ab}	6.83^{cd}
80:20	6.17^{b}	6.13^{a}	6.57^{bc}	6.13^{ab}	6.47^{bc}
70:30	5.70^{ab}	5.43^{a}	6.00^{ab}	5.33^{a}	5.80^{ab}
60:40	5.60^{a}	5.20^{a}	5.50^{a}	5.40^{a}	5.80^{ab}
50:50	4.97^{a}	5.50^{a}	5.97^{ab}	5.72^{a}	5.67^{a}

Mean values with different superscripts within the same column are significantly different ($p <0.05$)
CY: Cocoyam flour, CP: Cowpea flour

Sensory properties of cooked paste (*amala*) prepared from cocoyam-cowpea flour blends

The sensory scores of the cooked paste (*amala*) prepared from cocoyam-cowpea flour blends are shown in Table 5. There were significant differences ($p<0.05$) in all the sensory attributes, except aroma. Except for aroma and texture, there was a decrease in the sensory scores of *amala* as substitution with cowpea increased. Amala prepared from 100% FCF had the highest scores for colour, taste and overall acceptability. Substituting FCF with CWF up to 20% level did not significantly ($p>0.05$) affect the texture, taste and overall acceptability of the paste. The high scores given to *amala* from 100% FCY may be as a result of the familiarity of the panelists to the product.

4. CONCLUSIONS

The study showed that protein, ash and mineral composition of cocoyam flour increased with inclusion of cowpea flour. Blending of cocoyam flour with cowpea flour had significant effect on the functional properties of the flour blends. However, acceptable *amala* could be produced from cocoyam flour substituted with cowpea flour at 20%.

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