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SOME QUALITY ATTRIBUTES OF COCOYAM FLOUR SUBSTITUTED WITH MATURE GREEN PLANTAIN FLOUR

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ABSTRACT

This study was carried out to determine the proximate, functional and the sensory properties of the composite flour samples obtained from different ratios of cocoyam and unripe plantain (5 to 20%) flours, with 100% cocoyam flour as the +control. The flour samples had proximate composition ranging from 9.96 to 11.57% moisture, 0.75 to 7.09% ash, 0.49 to 2.39% crude fibre, 0.60 to 2.24% fat, 3.27 to 5.10% protein and 73.23 to 83.33% carbohydrate. The functional properties of the flour samples ranged from 2.31 to 3.02g/ml water absorption capacity, 0.60 to 0.76g/ml bulk density, 3.01 to 3.31g/g swelling power, 5.55 to 12.08g/g solubility and 44.5 to 59.5% dispersability. The results from this study showed that unripe (mature green) plantain flour can be substituted into cocoyam flour up to 20% level to produce acceptable (in terms of sensory attributes) and nutritious (in terms proximate as it increased with substitution level) flour blends for different culinary purposes.

Keywords: Cocoyam, Unripe Plantain Flour, Composite Flour

INTRODUCTION

Taro, cocoyam (Colocasia) and Tannia (Xanthosoma) are the two most important genera of the family Aracea (Ihekoronye and Ngoddy, 1985) and constitute one of the six most important root and tuber crops worldwide (Ekanem and Osuji, 2006). Although, they are less important than other tropical root crops such as yam, cassava and sweet potato, they are still a major staple in some parts of the tropics and sub-tropics (Opara, 2002). Cocoyam is an underexploited tuber crop although the literature is replete with its potential nutritional applications. Annual production of cocoyam in Nigeria is estimated at 26.587 million tonnes (FAO, 2006). Nigeria is the world's largest producer of cocoyam, accounting forabout 37% of total world output (FAO, 2006). In the Eastern part of Nigeria, it serves as staple food and isused as a thickener in food preparations especially the varieties Colocasia esculenta and Xanthosoma cultivar .This is because the starch grain of cocoyam is smalland has improved digestibility which is an importantfactor when selecting a starchy food that will not becumbersome on the digestive system (Ihekoronye and Ngoddy, 1985). Cocoyam is rich in digestive starch, good quality protein, vitamin C, thiamine, riboflavin, niacin and high scores of protein and essential amino acids (Onayemi and Nwigwe, 1987; Lewu et al., 2009).Cocoyam, like other root crops deteriorate few weeksafter harvest due to inadequate post-harvesttechnologies and this makes the crop scarce andexpensive outside the harvesting period. Processing ofcocoyam into flour will automatically extend the shelflife of the commodity thereby making it available foruse all year round. Processing of food commodities into flour involves drying of the food commodity inorder to reduce the moisture content to a minimal levelwhere the food material will be shelf stable and can be used for many culinary purposes.Plantain is a major staple with nutritious appeal in the West and Central Africa, Central Asia, the Caribbean Islands and coastal parts of South America. Plantains are a rich source of energy. Nigeria produces about 20 cultivars of the world's 116 plantain cultivars. They are a great source of vitamin A, B_1, B_2, B_3, B_6 and C. According to FAO (2009), over 2.3 million metric tonnes of plantain are produced in Nigeria annually. However, about 35 to 60% post-harvest losses had been reported and attributed to lack of storage facilities and inappropriate technologies for food processing. Whereas, plantain can be processed into more durable products such as flour that can be safely stored for later use (Dadzie, 1995; Wainwright and Burdan, 1991). It's an inexpensive source of calories, excellent for weight control and slow in the release of β-carotene (pro-vitamin A) (Dadzie, 1995). Starch is the major component of green plantains with a total starch content of 61.3 - 76.8 g/100 g, (Faisant et al. (1995), Juarez-Garcia et al. (2006), Rodriguez-Ambriz et al. (2008)). Green plantain contains a total dietary fibre content of 14.5% (DWB), (Juarez-Garcia et al., 2006). Plantain is low in protein but relatively high in minerals and vitamins (Best et al., 1984). A study of the starch granule structural characteristics and starch degradation patterns of plantain and banana reveals that plantain starch is more resistant to digestive enzymes than banana starch (Soares et al., 2011). Two recent studies (Pelissari et al. (2012) and Ovando-Martinez et al. (2009)) reported a resistant starch (RS2) value of 42.5 ± 0.4 to 50.3 ± 1.0 g/100 g, for raw green plantain flour and starch. Based on all these potentials it will be of great value to health and knowledge to study the effect of plantain flour inclusion into cocoyam flour on some quality properties of the resulting samples.

MATERIALS AND METHODS

Materials collection

Fresh matured green (unripe) plantain (Agbagba) and fresh cocoyam were procured from The Federal Polytechnic, Ilaro agricultural farm, and were identified and biologically dated as follows: Cocoyam (Xanthosoma species) and Plantain (Musa paradisaca, between 2-3 months after flowering). The analytical grade chemicals and reagents used for this research were sourced from the Food Technology laboratories of the Federal Polytechnic Ilaro, Ogun State, Nigeria.

Production of cocoyam flour sample

The cocoyam corms were withdrawn from the stock in storage and sorted to remove unwholesome ones. The corms were then peeled, washed and sliced into chips of 1.5 mm thickness. The slices were blanched in boiling water (100 °C) for two minutes. The blanched slices were dried in a cabinet dryer at 85ºC until they were dry enough to break sharply between hands, with moisture of around 6.5 to 8.2%. The dried samples were milled using an attrition mill to smooth consistency flour which was stored in an air-tight container for product ratio formulations and further analysis.

Production of Plantain Flour sample

The green matured unripe plantains were washed to remove adhering soil particles, weighed and peeled using a stainless knife and weighed again to determine the yield. They were then sliced into thin thickness of 1.5mm using a slicer. The slices were soaked in sodium metabisulphite for 10 minutes, drained and dried in a cabinet dryer at 85ºC for 6-8 hr until it was dry enough to break sharply between hands. The dried samples were milled into smooth consistency flour, stored in air-tight container for product ratio formulations and further analysis.

Composite Flour Samples preparation

The flours of Cocoyam and unripe matured plantain were combined at different ratios as shown in the Table below:

Table 1: Composite Flour Samples Composition (%)

Samples	Cocoyam flour (CF)	Unripe Plantain Flour (UPF)
A	100	0
B	95	5
C	90	10
D	85	15
E	80	20

The chemical composition of samples

The chemical compositions of the samples were determined using the method of AOAC (2012). Protein content was determined on 0.5g sample by the Kjeldahl method. The percentage nitrogen obtained was used to calculate the crude protein by multiplying with a conversion factor of 6.25. Moisture was determined on 5g sample using the gravimetric method of AOAC (2012) at 105°C for 3hours. Ash content of the samples was determined on 5g sample by incinerating in a muffle furnace at 550 °C for 4 hours.The ash was cooled in a desiccator and weighed. This was determined on 5g sample by dilute acid and alkali hydrolysis. Fat content was determined on 5g sample using the Soxhlet solvent extraction method. The carbohydrate content was calculated by difference.

Determination of functional properties

The method of Onwuka (2005) was used for the determination of functional properties. The functional properties determined included water absorption capacities (1g sample); bulk density (5g sample); swelling index (3g sample), solubility and dispersability (1g sample).

Sensory Evaluation of Enriched Cookies

Sensory evaluation of composite flour samples were carried out after making a stiff paste using the method described by Giami and Barber (2004) for fluted pumpkin cookies. The sensory attribute which included taste, appearance, texture, colour, and overall acceptability were evaluated using a 9 – point hedonic scale with 1 representing the least score (dislike extremely) and 9, the highest score (like extremely) as described by Iwe, (2010).

Statistical Analysis

The data obtained were analysed using the analysis of variance (ANOVA) and where means were significant, they were separated using the Duncan multiple range test at the level of $P \leq 0.05$ (Wahwua 1999).

3. RESULTS AND DISCUSSION

Table 2: Mean values of Proximate Composition of cocoyam-plantain composite flour samples

Samples	Moisture Content %	Ash %	Fat %	Fibre %	Protein %	Carbohydrate %
A	11.57 ± 0.02^{bc}	0.75 ± 0.03^{a}	0.6 ± 0.01^{a}	0.49 ± 0.01^{a}	3.27 ± 0.02^{a}	83.33 ± 0.03^{e}
B	11.19 ± 0.01^{b}	4.2 ± 0.02^{b}	1.28 ± 0.03^{b}	1.68 ± 0.03^{b}	3.72 ± 0.01^{a}	77.94 ± 0.07^{d}
C	10.28 ± 0.03^{ab}	6.31 ± 0.03^{c}	1.58 ± 0.02^{b}	1.92 ± 0.02^{b}	4.02 ± 0.01^{b}	75.91 ± 0.01^{c}
D	10.12 ± 0.01^{a}	6.69 ± 0.04^{c}	2.02 ± 0.02^{c}	2.08 ± 0.01^{c}	4.36 ± 0.03^{bc}	74.75 ± 0.06^{b}
E	10.12 ± 0.04^{a}	7.09 ± 0.01^{d}	2.24 ± 0.02^{c}	2.09 ± 0.02^{c}	5.10 ± 0.01^{c}	73.23 ± 0.06^{a}

Values are means of three replicates determination ± standard deviation.
Mean values with different superscripts within the same column are significantly different at 5% level. CF: UPF
CF: A = 100:0% CF, B=95:5%, C=90:10%, D=85:15%, E=80:20%. Where CF= cocoyam flour and UPF= plantain flour which makes up each sample to 100%

Table 3: Mean Values of Functional Properties of cocoyam-plantain compositeflour samples

Samples	BD (g/ml)	WAC (g/ml)	SP (ml/ml)	Sol (%)	Disp (%)
A	0.76 ± 0.0003^{b}	2.31 ± 0.007^{a}	3.31 ± 0.025^{ab}	12.08 ± 0.030^{c}	44.50 ± 0.500^{a}
B	0.70 ± 0.0002^{ab}	2.48 ± 0.010^{a}	3.92 ± 0.010^{b}	13.47 ± 0.030^{d}	48.50 ± 0.500^{b}
C	0.65 ± 0.0001^{a}	2.57 ± 0.010^{ab}	3.38 ± 0.020^{ab}	4.17 ± 0.002^{a}	50.50 ± 0.500^{c}
D	0.61 ± 0.0001^{a}	2.92 ± 0.010^{b}	3.17 ± 0.007^{ab}	8.63 ± 0.030^{b}	55.00 ± 0.500^{d}
E	0.60 ± 0.0001^{a}	3.02 ± 0.010^{c}	3.01 ± 0.010^{a}	5.55 ± 0.050^{a}	59.50 ± 0.500^{e}

Values are means of three replicates determination ± standard deviation.
Mean values with different superscripts within the same column are significantly different at 5% level. CF: UPF
CF: A=100:0%, B=95:5%, C=90:10%, D=85:15%, E=80:20%. Where CF= cocoyam flour and UPF= plantain flour making each sample to 100%
BD= Bulk density, WAC= water absorption capacity, SP= swelling power, Sol= Solubility Index, and Disp= Dispersibility

Table 4: Mean Values of Sensory Evaluation of the reconstituted stiff paste "Amala"

Samples	Taste	Appearance	Texture	Colour	Mouth feel	Overall Acceptability
A	8.00^{c}	7.60^{c}	7.80^{c}	8.00^{d}	8.00^{c}	7.50^{c}
B	7.50^{bc}	6.20^{b}	6.20^{ab}	7.50^{c}	7.60^{bc}	6.90^{b}
C	7.00^{ab}	7.00^{bc}	6.80^{b}	6.90^{b}	7.00^{b}	6.90^{b}
D	7.10^{b}	5.50^{ab}	6.50^{ab}	6.50^{a}	7.20^{b}	5.90^{a}
E	6.80^{a}	5.20^{a}	5.70^{a}	6.50^{a}	6.90^{a}	5.80^{a}

Values are means of three replicates determination ± standard deviation.
Mean values with different superscripts within the same column are significantly different at 5% level. CF: UPF
CF: A=100:0%, B=95:5%, C=90:10%, D=85:15%, E=80:20%. Where CF= cocoyam flour and UPF= plantain flour which makes up each sample to 100%

Crude protein in the composite flour samples increased from 3.27% obtained in sample A (100%, cocoyam) to 5.10% in sample E with 20% plantain flour. The results showed that the unripe plantain flour improved the protein content of the composite flour. This is agreement with the findings of Arisa *et al.*, (2013), who reported a protein content of 4.31 for blended flour and 12.5% wheat flour cookies and Ogunlakin *et al.* (2012) who reported the protein content of cocoyam flour to be between 4.93 to 5.17%. There were significant differences (p<0.05) in moisture content of all the sample (10.12 to 11.57) and it decreased as the level of UPF increased, this could be attributed to the initial moisture content and the hygroscopicity of the cocoyam due to the starch structure of its flour. The ash, fibre and fat contents (0.75 to 7.09, 0.60 to 2.24 and 0.49 to 2.09% respectively) were significantly different across all the samples with an increasing trend as the UPF inclusion level increased. The ash content which is an index of mineral content is higher than that reported by Sefa-Dede and Agyr-Sackey (2004) for cocoyam (1.56 to 2.98%). The fibre content was also observed to increase as the UPF inclusion increased. This increase could be attributed to the richness of fibre in UPF. The fat content is within the range observed by Amandikwa, (2012) (1.7 to 2.6%)who studied the effect of different drying methods on the proximate and functional properties of different varieties of cocoyam flour. Low fat content in flour product is desirable as it reduces the risk of off-flavour development in the product which could be caused by oxidative rancidity. However the observed variations in the results could be attributed to the differences of the species, cultural, climatic and other environmental factors under which the cocoyam and plantains were grown. Asaoka *et al*. (1991) reported that age, variety, growth, season and cultivar's type of tubers affect their physiochemical properties. Maturity at harvest and the length of storage time and elapsed time between harvesting and processing period may also contribute to these variations (Ihekoronye and Ngoddy, 1985). There was a significant difference (p<0.05) in the carbohydrate content of the flour samples as it ranged from (73.23 to 83.33%). It reduced as UPF inclusion increased. The result of this finding agrees with what was reported by Enwere (1998) that in all the solid nutrients in roots and tubers, carbohydrates predominate. The high carbohydrate content indicates that the composite flour is an excellent energy source.

The bulk density of the composite flour samples varied from 0.60 to 0.76g/ml with sample with 100% cocoyam flour having the highest and the sample with 20% UPF having the lowest. There was significant difference in the bulk density of the composite flour samples at p<0.05. The low bulk density exhibited could be as a result of the low moisture they contain. According to Hayata *et al.,* (2006), drying decreases the bulk density of flour. Bulk density givesan indication of the relative volume of packaging material required. Generally, higher bulk density is desirable for greater ease of dispersability and reduction of paste thickness (Padmashree *et al.*, 1987, Udensi and Eke, 2000). Low bulk density of flour aregood physical attributes when determining transportation and storability since the products could be easily transported and distributed to required locations (Agunbiade and Sanni, 2003).Low bulk density is advantageous for the infants as both calorie and nutrient density is enhanced per feed of the child (Onimawo and Egbekun, 1998).High bulk density is a good physical attribute when determining mixing quality of particulate matter (Lewis, 1990).

The water absorption capacity of the composite flour ranged between 2.31 to 3.02 ml/g with 20% UPF inclusion having the highest value and sample with 100% CF having the lowest. There was a significant difference in the values of WAC at p<0.05. The 20% UPF sample had the highest value which might be due to the starch structure and morphology as well as the dryness of the flour, which lead to low moisture content thereby causing the flour to absorb more water. Drying increases the absorption capacity of flour (Hayata, *et al*., 2006). According to Circle and Smith(1972), water absorption capacity is a useful indication of whether flours can be incorporated into aqueousfood formulations especially those involving dough handling. Niba *et al.,* (2001) also stated that water absorption capacity is important in bulking and consistency of products as well as baking applications.

The swelling power of the composite flour samples ranged from 3.01 to 3.92ml/ml with sample B (5% UPF inclusion) having the highest and sample E (20% UPF inclusion) having the least. There was a significant difference among the flour samples at p<0.05. The decrease in the swelling power could be attributed to the looseness and arrangement of the particles of the cocoyam flour used and the packed arrangement of the particles of the UPF. Generally cocoyam samples shows good swelling index when compared to other root crops like cassava (Ojinaka*et al*., 2009). This is because of the type of granules cocoyam starch has and its highly digestible nature. The starch grain of cocoyam is about one tenth of potato starch grain (Akomas*et al*., 1987). The solubility decreased as the UPF inclusion level increased while the dispersability increased as the UPF inclusion increased. Dispersability is a measure of the reconstitution ability of flour or flour blends in water.

The higher the dispersability the better the flour reconstitutes in water (Kulkarni*et al.,* 1991). However, since the dispersability value for all the flour blends are relatively high, it implies that they will reconstitute easily to give a fine consistency dough during mixing as reported by Adebowale *et al.*(2008). The high dispersability values of the flour blends could be due to the flour composition that is, the high percentage of cocoyam flour in the composite flour.

Stiff paste prepared from the composite flour was subjected to sensory evaluation by 30 panelist using a 9-point hedonic scale and the results showed that the samples were generally liked. There were significant differences in all the samples across the attributes evaluated. However sample A (100% CF) had the highest degree of likeness in terms of these attributes while samples B and C (5 and 10% UPF inclusion respectively) were slightly liked and were also accepted in terms of overall acceptability when compared to samples D and E which were neither liked nor disliked.

However, this observation was contrary to the work of Arisa*et al.,* (2013) who reported a significant difference in taste of plantain biscuits compared with 100% wheat biscuit. The texture of the stiff paste decreased from a mean sensory score of 7.60 (sample A) to 5.20 (sample E). Stiff paste prepared from 15% UPF (sample D) and 20% UPF (sample E) were not significantly different ($P > 0.05$) from each other. Ndife*et al.*, (2014) had also reported a score of 8.10 for texture for cookie samples with 30% soy flour substitution with wheat flour. The decrease in the sensory attribute could be linked with the starch morphology and composition with the variety, age and species differences.

CONCLUSION

The results of this research showed that inclusion levels of UPF have a significant effect on the proximate, functional and sensory properties of the composite flours. Depending on the end use of the composite flour different combination ratio could be adopted. However, the results from this study also showed that unripe plantain flour can be substituted with cocoyam flour to produce an acceptable and nutritious flour blends for different culinary purposes.

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