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Effect of Cassava Flour on the Physico-chemical and Sensory Properties of Konkonde, a Traditional Dish Prepared from Unripe Plantain Flour

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Abstract Plantain flour is gradually finding applications in weaning food supplementation and composite flour preparations in Cote d'Ivoire. This study therefore aimed at evaluating the effect of cassava flour fortification on physicochemical and sensory properties consumer acceptability of plantain flour. The plantain-cassava mixes were prepared from green plantain and cassava. Substituted plantain flour with cassava flour at varying proportions (100:0; 90:10; 80:20; 70:30; 60:40; 50:50) was evaluated for physicochemical and properties. Reconstituted thick paste konkonde" prepared from all the flour samples were evaluated for consumer acceptability. Substitution of unripe plantain flour with cassava flour up to a level of 20% had no significant (p>0.05) effect on the colour, texture and overall acceptability of the konkonde samples. The swelling power and solubility of the flour samples decreased while the water absorption capacity and bulk density increased on cassava substitution. The pasting viscosity analysis showed that cassava flour addition increased the peak viscosity and breakdown of the flour while the peak time and pasting temperature decreased. The sensory evaluation of the reconstituted plantain thick paste indicated a sharp difference at 5 % probability level in all quality attributes between 30 to 40% substitution, while that 30% cassava flour reconstituted "konkonde" was more preferred.

Keywords: *unripe plantain flour, cassava flour, konkonde, physicochemical properties, sensory attributes*

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1. Introduction

Plantain (Musa AAB) is one of the most important food crops in tropical regions of the world and constitute a valued source of income through local and international trade [1]. The plantain is mainly cultivated for its fruits, which enter the daily diet of many populations, especially African, in many forms. Traditionally produced in forest zone of Côte d'Ivoire, plantain is a dynamic staple food and its consumption increases regularly in various forms, and has been extended to the completely Ivorian people (120 kg/capita/year) both in rural and urban areas [2,3]. Nutritionally, plantains constitute a rich energy source, with carbohydrates accounting for 22 and 32 % of fruit weight for banana and plantain, respectively. It is also rich in vitamins A, B6, C, minerals and dietary fiber [4]. The dense caloric content coupled with nutritional quality makes plantain one of the most important and regularly consumed staple food in Côte d'Ivoire [5]. Plantain production is seasonal and is harvested from October to March. Post-harvest losses estimated at 30 % are recorded during this period [6]. Because of this seasonal production and its perishability, dried plantain flour is then converted for its best use and conservation [7]. Like cassava flour, unripe plantain flour is used in the preparation of a large variety of traditional dishes that include the konkonde [8,9,10]. Konkonde also known as amala in Nigeria and Benin [11] or konkonte in Ghana [12] is prepared from fermented cassava flour or from plantain flour or again yam flour. According to Amani and Kamenan [13], Coulibaly [9] surveys, the konkonde (made from plantain) is less popular in Côte d'Ivoire with an appreciation rate of 5 % against 96.5 % for plantain *futu* (pounded plantain banana) and 91.4 % for *alloco*. It is also little-known Ivorian population (70 % of the population) in these same studies. These facts remain a constraint to the promotion and consumption of this dish. An incorporation of cassava flour into plantain flour could improve the plantain konkonde in terms of texture, colour and taste in order to increase its acceptability to consumption. Thus, plantain can fully play its role in food security in Cote d'Ivoire. This study aims to evaluate the effects of cassava (*Manihot esculenta* Crantz) flour supplementation on physicochemical and sensory properties of plantain konkonde.

2. Material and Methods

2.1. Raw Materials

The plant materials used for this work were unripe plantain (variety *afoto*) and cassava sweet variety (variety bonoua) roots purchased from a local market in Ouragahio town in Cote d'Ivoire and processed into plantain flours and cassava flour respectively.

2.2. Raw Materials Preparation and Flour Processing

Cassava and unripe plantain flours were processed, according to Heny et al. [14]. Fresh cassava roots were washed with tap water to remove dirt and soil. These tubers were peeled and kept in tap wate11r to prevent enzymatic darkening for 30 minutes. Peeled samples were then cut into slices (1 mm thickness) using a slicing machine. The slices were dried using a tray dryer at 45°C for 12 h. The flour was obtained by milling the dried slices using a grinder, and sieved through an 80-mesh screen to obtain cassava flour. The same principle is applied to plantain flour production.

2.3. Proportions of Plantain and Cassava Flour in Konkonde Making

To prepare composite flours, the plantain and cassava flours were blended together on percent dry weight basis into five ratios of 90:10; 80:20; 70:30; 60: 40 and 50:50 % corresponding to sample codes PC1, PC2, PC3, PC4, PC5 and PF respectively, with 100:0 whole cassava flour (CF) serving as the control. A moulinex mixer was used to achieve uniform blending. The blend formulations in this study were produced using the methods described by Babajide and Olowe [15].

2.4. Cassava-Plantain Processing into Konkonde

To prepare konkonde meals, 50 g of Konkonde powder is mixed with 150 ml boiling water. The mixture stirred repeatedly on the fire until it thickens and then it is kneaded against the pot until the water mixes it well, until it is cooked. The konkonde for each sample was then packaged in polyethylene film respectively before sensory evaluation.

2.5. Physico-chemical and Functional Properties Analysis

The swelling power was evaluated according to Leach et al. [16]. 0.1 g of the sample was suspended in distilled water (10.ml) and was heated in water bath (MEMMERT) at 60°C for 30 minutes with intermittent mixing. After heating, the suspension was centrifuged (ALRESA DITACEN II) at 16 rpm for 30 minutes. The sediment was weighted. The swelling power (SP) was calculated as:

$$Swelling\ power = \frac{weight\ of\ sedimental\ paste\ (\text{g})}{weight\ of\ the\ sample\ (\text{dry basis})\ (\text{g})}. \quad (1)$$

The solubility was determined by the method described by Kainuma (1967) [17]. 0.5 g of the sample was mixed with 10 ml distilled and was heated in a water bath at 60°C for 30 minutes without stirring. After heating, the suspension was centrifuged with the same centrifuge at 16 rpm for 10 minutes. The supernatant was separated and weighted.

The solubility (S) was calculated using the formula:

$$\%\ Solubility = \frac{weight\ of\ Soluble\ starch\ (\text{g})}{weight\ of\ the\ sample\ (\text{dry basis})\ (\text{g})} \times 2 \times 100\%. \quad (2)$$

The method described by Philips et al. [18] and Anderson et al. [19] was employed in determining the water absorption capacity of the samples. The bulk density was evaluated using the method of Oladele and Aina [20]. The titratable acidity and the pH of all the samples were determined using the methods described by AOAC [21].

2.6. Determination of Pasting Properties

Pasting properties (peak, holding strength, breakdown, setback, final viscosity, pasting time and pasting temperature) were carried out on the samples using Rapid Visco-Analyzer (RVA model 3D for windows) [22]. Flour suspension was prepared by addition of equivalent weight of 3.0 g dry flour to distilled water to make a total of 28.0 g suspension in the RVA sample canister. This was placed centrally into the paddle coupling and was inserted into the RVA machine. The 12 min profile used was seen as it ran on the monitor of a computer to the instrument. The starting temperature was 50 °C for 1 min and later heated from 50 °C to 95 °C for 3 min. It was held at 95°C for 3 min before the sample was subsequently cooled to 50°C over a period of 4 min. This was followed by a period of 1 min where the temperature was kept constant at 50°C. Pasting properties were carried out in duplicate.

2.7. Sensory Evaluation of the Konkonde

30 g of each konkonde was carried out in a well-lit sensory laboratory for consumer's acceptance and preference using 20-member semi-trained panellist. They were evaluated for palatability, texture, colour, taste and overall acceptability using nine-point hedonic scale (9 = like extremely and 1 = dislike extremely) [23]. The scores obtained were subjected to analysis of variance at 5 % level of significance and means separated using Duncan Multiple Range Test. The panellists were provided with water to rinse their mouths before and after tasting each sample.

2.8. Data Analysis

All data obtained were subjected to one-way analysis of variance (ANOVA) except for sensory analysis which were subjected to two-way ANOVA and means were separated by Duncan Multiple Range Test using SPSS (16.0 version) (SPSS Inc., USA).

3. Results and Discussion

3.1. Functional Properties

The functional properties determine the application and use of food material for various food products. Density of the flour increased with increase in cassava flour substitution. The bulk density values were found to be between 0.49 to 0.69 g/cm^3 (Table 1). These results were similar with the Bulk density values of 0.50-0.62 g/cm^3, which were reported for the flour samples of *D. cayenensis, D. bulbifera* and *D. rotundata* [24]. Increase in bulk density increased the sink ability of powdered particles, which aids wetting by aiding their ability to disperse. The bulk density is generally affected by the particle size and the density of the flour and it is very important in determining the packaging requirement, material handling and application in wet processing in the food industry, indicating a lesser package requirement with increase in cassava flour substitution [25]. Substitution significantly ($p < 0.05$) affected the water absorption capacity of the unripe plantain flour. The water absorption capacity showed an increase within the range 121.5 - 154.3 % for plantain flour and 50 % substitution, while that of cassava flour alone was 162.2 %. Water absorption capacity is the ability of flour to absorb water and swell for improved consistency during food preparation. The increase in water absorption capacity implies the higher digestibility of the starch. Its characteristics the ability of the product to associate with water under condition where it is limiting in order to improve handling [26]. The solubility values of the flour ranged from 7.3 to 6.2 % for plantain flour and 50 % substitution respectively. It was observed that the values decreased with cassava flour substitution. The cassava flour had the lowest value (5.2 %). The swelling power (6.9 to 6.5 g/g) also decreased with cassava flour substitution. Moorthy [27] was reported that swelling power of starch depends on the ability of certain component of starch, especially amylose to solubilize in water, hence, allowing water to attack starch molecules. Thus, this decrease observed in the swelling power could be due to a decrease solubility.

The pH of all the samples was more acidic. This low acidic pH might minimize maillard reactions as opposed to the alkaline pH, which encourages maillard reactions in thermally processed according to Okaka and Okechukwu [28].

Totatal titratable acidity (TTA) of the substituted flours and plantain flour was lower than that cassava flour.

Table 1. Functional properties of cassava plantain mixes

SAMPLE	BD (g/cm^3)	WAC (%°)	pH	TT A (%°)	SP (g/g)	S (%)
PF	0.49^a	121.5^a	5.7^b	0.5^a	6.9^a	7.3^c
PC1	0.51^b	123.4^a	5.5^a	0.6^a	6.7^a	7.1^c
PC2	0.53^b	126.2^a	5.2^a	0.7^a	6.5^a	6.8^b
PC3	0.55^c	133.1^b	5.3^a	0.8^a	7.6^b	6.5^b
PC4	0.56^c	145.1^c	5.1^a	0.7^a	7.8^b	6.3^b
PC5	0.56^c	154.3^d	5.1^a	0.9^b	8.7^c	6.2^b
CF	0.69^d	162.2^e	5.5^a	2.5^c	9.1^d	5.2^a

Mean values followed by the same letter down the column were not significantly different ($p \leq 0.05$). Sample: PF: 100 % plantain flour, PC1: 90 % plantain flour and 10 % cassava flour; PC2: 80 % plantain flour and 20 % cassava flour, PC3: 70 % plantain flour and 30 % cassava flour, PC4: 60 % plantain flour and 40 % cassava flour; CF: 100 % cassava flour; BD: Bulk density; TA: titratable acidity; WAC: water absorption capacity; SP, swelling power; S: solubility.

Table 2. Effect of cassava starch substitution on the pasting properties of plantain flour

Sample	Peak viscosity (RVU)	Holding Strength (RVU)	Breakdown value (RVU)	Final viscosity (RVU)	Setback value (RVU)	Peak time (min)	Pasting temperature (°C)
PF	144.03^a	119.01^a	65.36^a	129.34^a	92.24^e	5.24^c	81.88^d
PC1	148.82^b	115.85^b	69.95^b	136.46^b	89.67^d	5.18^c	79.16^c
PC2	147.06^b	111.73^b	75.33^c	139.23^b	85.47^d	5.00^c	77.07^b
PC3	163.61^c	106.13^a	86.48^d	141.20^b	74.21^c	4.85^b	76.54^b
PC4	168.92^c	125.76^c	91.16^e	155.25^c	73.46^c	4.79^b	75.90^b
PC5	188.33^d	122.39^c	113.94^f	153.65^c	69.08^b	4.34^b	75.42^b
CF	351.22^e	127.17^d	209.15^g	160.42^d	36.08^a	3.80^a	64.20^a

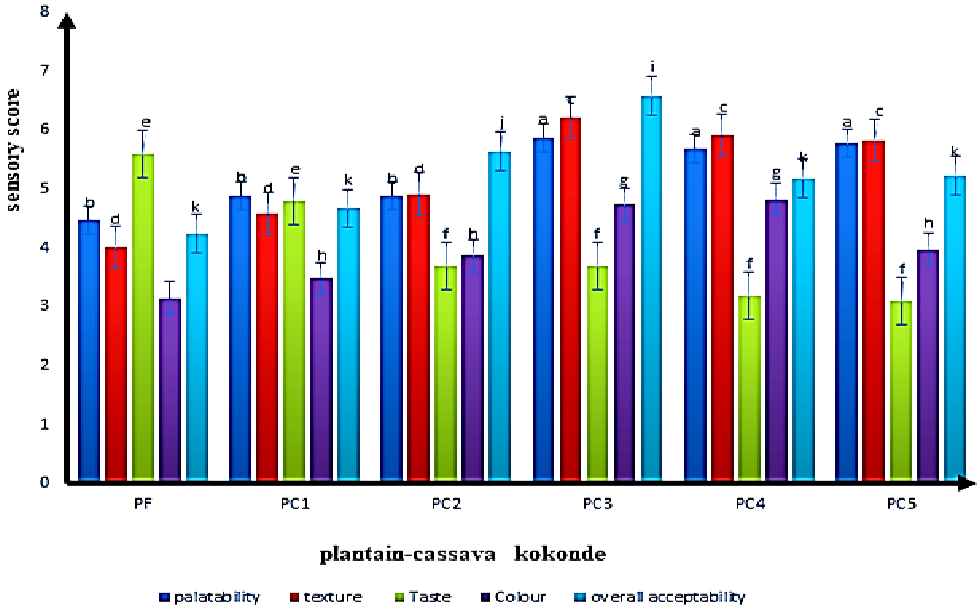
Mean values followed by the same letter down the column were not significantly different ($p \leq 0.05$). Sample: PF: 100 % plantain flour, PC1: 90 % plantain flour and 10 % cassava flour; PC2: 80 % plantain flour and 20 % cassava flour, PC3: 70 % plantain flour and 30 % cassava flour, PC4: 60 % plantain flour and 40 % cassava flour; CF: 100 % cassava flour

3.2. Effect of Cassava Flour Substitution on the Pasting Properties of Plantain Flour

The results of pasting properties of plantain-cassava flour blends are shown in Table 2. The sample with cassava flour alone had the highest peak viscosity (351.22 RVU), holding strength (127.17 RVU), final viscosity (160.42d RVU) and breakdown (209.15 RVU). These were significantly different ($p \leq 0.05$) from all the samples. Peak viscosity, which is the maximum viscosity, developed during or soon after the heating portion of the pasting test ranged between 144.03 to 188.33 RVU for plantain flour (PF) and substituted flour samples. Peak viscosity values increased with increase in cassava flour substitution. This increase may be attributed to different rates of water absorption and swelling of starch granules of these flours during heating according to Ragaee and Addel-Aal [29]. There exists a linear logarithmic correlation between maximum viscosity and starch concentration as observed by Mepha et al. [30]. In addition, the peak viscosity is often correlated with final products quality and it provides of viscous load likely to be encountered during mixing [31]. The Breakdown values ranged between 65.36 to 113.94 RVU for PF and 50 % substitution. For the cassava flour, the value was higher (209.15 g). Therefore the gradually addition of this flour in the plantain flour increased the breakdown. Breakdown is a measure of susceptibility of cooked starch of the flour products [32]. A low breakdown value indicated that the flour products were more stable under hot condition (81.88 °C). This result indicated that the sample PF was more stable than the samples substituted flour samples. The holding strength ranged between to 111.73 and 122.39 R.VU while for the cassava flour, it was 127.17 RVU. The holding strength of sample PF was not significantly different ($p > 0.05$) in values obtained from samples TC1 and TC2 substituted of 10 % and 20 % cassava flour respectively. This could be due to the lowest rate substitution of the cassava flour. The holding strength is the minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling [33]. It is also an indication of breakdown or stability of starch during cooking [34]. The lower value indicated the more stable of the starch gel [35], while the higher holding strength value was generally represented low cooking loss and superior eating quality according to Bhattacharya et al. [36]. The setback or viscosity of cooked is the viscosity after cooling to 50°C and it is a stage where retrogradation or reordering of starch molecules occur. Starch will have tendency to become firmer with increasing resistance enzymatic attack [37]. Setback viscosity increased from 69.08 RVU for 10 % to 89.67 RVU for 50 % substitution with increasing level of substitution, while the values of cassava flour and plantain flour were 92.24 RVU, 36.08 RVU respectively. The higher the setback value means a lower the retrogradation during the cooling and the lower staling rate of the product made from the flour according to Adeyemi and Idowu [38]. The higher setback also means reduced dough digestibility [39]. Final viscosity is the most commonly used parameter to define the quality of a particular starch-based sample, as it indicates the ability of the material to form a viscous paste or gel after cooking and cooling [38]. It ranged between to 129.34a and 160.42d RVU with plantain flour having the lowest value, while the cassava flour having the highest value. Peak time is the measure of cooking time [40]. The peak time decreased from 5.18 min for 10 % to 4.34 min for 50 % substitution. Sample CF had the least value (3.80 min) which was significantly different ($p \leq 0.05$) from plantain (5.24 min) and blended flour samples. Pasting temperature decreased gradually from 79.16 °C for 10 % to 75.42 °C for 50 % substitution; while for plantain, flour alone was 81.88 °C and cassava flour alone was 64.24°C. Pasting temperature is a measure of the minimum temperature required to cook a given food sample (Sandhu et al., 2005) [41]. It affects the stability of other components in the food formula and indicates energy costs [23]. Flour from the plantain was characterized by highly gelatinization due to higher pasting temperature (81.88°C) and its peak time compared to pasting temperature and peak time of the other samples. This reveals lower gelatinization temperature of cassava starch granules, which translates into shorter cooking time and lower paste stability of cassava flour as opposed to the plantain flour [42,43].

3.3. Sensory Evaluation

The results showed how an increased concentration of cassava flour within the same variety affected the rating of the sensory attributes. The samples with 0, 10 and 20 % cassava flour substitution had no significant difference at 5 % probability level while the mixes with 30, 40 and 50 % cassava flour substitution levels had significant difference in all the qualities evaluated but there was a sharp difference between those with 0 to 20 % substitution and 30 to 50 % with 30 % cassava flour yielding product with acceptable sensory characteristics. As shown in this Figure 1, the significant differences ($p < 0.05$) between the samples were on palatability, taste, texture, colour and overall acceptability. Low scores were recorded for palatability, taste, texture, colour and overall acceptability of sample PC1 and PC2 containing 10 % and 20 % cassava flour respectively. Thus, konkonde prepared from unripe plantain-cassava flour was diversely appreciated. It is a clear indication that reconstitution proportion (flour to water ratio) affects all the hedonic appreciations evaluated. The texture of konkonde is one of the main parameters that guide consumer choice as reported by Chilaka et al. [44]. In this study, sample PC3 and sample PC4 have the most appreciated texture. Then, these samples, which differed only on the taste, were satisfactory by the panellists. However, PC3 sample was best preferred. Babajide and Olowe [15] conducted a consumer sensory evaluation of mixed water yam (*D. alata*) and cassava (*M. esculenta*) flour. They reported that konkonde (*amala*) prepared from water yam flour with 30 % cassava flour was highly considered by the consumers in colour, aroma and overall acceptability. It was rated as "like very much" for the colour and "like moderately" for aroma and overall acceptability.



Mean values followed by the same letter down the column were not significantly different ($p \leq 0.05$). Sample: PF: 100% plantain flour, PC1: 90% plantain flour and 10% cassava flour; PC2: 80% plantain flour and 20% cassava flour, PC3: 70% plantain flour and 30% cassava flour, PC4: 60% plantain flour and 40% cassava flour; CF: 100% cassava flour;

Figure 1. Effect of cassava starch substitution on the sensory quality attributes of plantain flour

4. Conclusion

The study has shown substitution of plantain flour with cassava flour at levels of 10 to 50 %. Some of the functional pasting properties of the plantain-cassava mixes obtained could be an advantage in industrial uses, such as the bulk density and water holding capacity. In terms of sensory analysis, the hedonic evaluation indicated that the composite plantain/cassava obtained with 30% of plantain flour as partial substitute of cassava is highly appreciated by consumers. The utilization of cassava flour to improve konkonde plantain could help to use plantain in dried form. This dish could generate more income and contribute to food security in developing countries.

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