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Quality Evaluation of Composite Flours and Cookies Produced from High-Quality Cassava and Unripe Plantain Peel Flours

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ABSTRACT
Cassava (Manihot esculenta crantz) and Unripe Plantain (Musa paradisiaca) peels were processed into flours and used to substitute wheat flour for preparation of cookies. Five blends were prepared: 5C5P (50:50), 6C4P (60:40), 4C6P (40:60), 3C7P (30:70), 7C3P (70:30), along with 100C (100% cassava) and 100P (100% plantain peel). Cookies were produced from the formulated blends and also from 100% wheat flour which served as the control. The proximate and functional properties of the composite flours were assessed, and sensory evaluations of the cookies were conducted using standard techniques. Data was expressed as mean ± SD at P<0.05. Moisture content ranged from 1.93–2.93%, crude fiber 0.75–9.0%, crude fat 1.25–2.75%, and crude ash 0.5–9.0%. Water absorption capacity (WAC) varied from 1.56–3.27 g/g, oil absorption capacity (OAC) from 1.56–2.19 g/g, and bulk density from 0.44–0.58 g/ml. Cookies made from 100P were darker with less favorable texture and aroma compared to other blends. Increasing the proportion of plantain peel raised the moisture, crude fiber, ash, and fat contents, while 100C and blends with more cassava showed lower nutrient content. The 5C5P blend had a balance of nutrients and received high sensory acceptance. Therefore, this study exposed the importance of utilizing purported waste in baked product enrichment.
Keywords: *Composite flour, Cassava, Unripe plantain peel, Cookies, Sensory evaluation*

1.0 Introduction

Cookies are affordable, ready-to-eat, high-energy snacks popular across all age groups due to their long shelf life (Bala *et al*., 2015). Typically made from wheat flour, fat, sugar, and water, along with optional ingredients like milk and flavoring agents (Ikechukwu *et al*., 2017), cookies provide a rich source of fat, protein, and carbohydrates (Olaoye & Ndukwe, 2016). In Nigeria, cookie consumption is rising, but reliance on imported wheat due to unsuitable local climate burdens the economy (Inyang & Elijah, 2020). Additionally, wheat-based cookies contain gluten, unsuitable for celiac disease sufferers, who must follow a lifelong gluten-free diet (Lu *et al*., 2020). While gluten contributes to the sensory and structural qualities of baked goods, it is less critical in cookies than in bread, fueling interest in gluten-free cookie alternatives (Kurniadi *et al*., 2019; Lu *et al.,* 2020).

Cassava (Manihot esculenta) is a vital starch resource that thrives under harsh climatic conditions and is cultivated in tropical and subtropical regions as a staple due to its high starch content (Kusumayanti *et al*., 2015; Dudu *et al*., 2019). Cassava roots offer high carbohydrate yields, surpassing rice and corn by 40% and 20%, respectively (Bala *et al.,* 2015). Despite its nutritional benefits, unprocessed cassava contains cyanogenic glycosides that release toxic hydrocyanic acid if damaged, reducing its edibility (Ahaotu *et al*., 2017). Traditional preparation involves peeling, soaking, sun-drying, and grinding to detoxify. Cassava is used in foods such as bread and cakes in South America and in fermented snacks in Southeast Asia. It is suitable for partial or full substitution of wheat flour due to its high yield, cost-efficiency, and unique functional properties (Akingbala *et* *al*., 2011; Gyedu-Akoto & Laryea, 2013). Edible-grade cassava flour is nutrient-rich and produced by cleaning, detoxifying, drying, and grinding fresh cassava (Adesina & Bolaji, 2013). Its use as a wheat flour substitute is popular for bakery applications (Lu *et al*., 2020), offering similar starch composition and water absorption capacity but lacking gluten and sulfur-containing amino acids. Studies by Jensen *et al*. (2015) and Ekunseitan *et al.* (2017) highlighted the sensory, nutritional, and functional properties of cassava-based flours, proving it to be an excellent gluten-free alternative for cookie production.

Plantain (*Musa paradisiaca*) is a major starchy food in Nigeria and over 2.1 million metric tons are produced annually, which contributes substantially to the nutritional needs of the rural populace (Akinsanmi *et al*., 2015). Plantain is rich in carbohydrate, minerals, vitamins, dietary fibre and resistant starch (RS) (Arun *et al*., 2015). As a climacteric fruit, it is usually harvested at mature green stage to reduce postharvest losses. The unripe fruits are usually peeled and the pulp processed into flour while the peels which constitute about 40% of the total weight of the fruit (Akinsanmi *et al*., 2015), are thrown away as waste that contributes to environmental pollution or occasionally used as animal feed. Analysis of unripe plantain peels showed that the peels are rich in antioxidant, dietary fibre, minerals and vitamins (Akinsanmi *et al*., 2015; Arun *et al*., 2015). Adamu *et al*. (2017) reported that unripe plantain peels had higher Ca, Mg, Mn and Fe than the pulp and recommended that the peels should be ground into flour and used to fortify plantain pulp flour to increase the nutritional value. Garcia-Valle *et al*. (2019) reported that the resistant starch content in whole plantain flour (4.8–5.8%) was higher than dietary fibre associated starch in conventional food items such as whole wheat bread (1.7– 2.8%). Ighodaro (2012) reported that unripe plantain peels also contain substantial levels of bioactive compounds including flavonoids, alkaloids, tannins, phlobatannins and terpenoids. The presence of these compounds is a strong indication that the peels possess valuable medicinal properties which are yet to be explored. Based on the above documented information on mature green plantain, the use of both the peel and the pulp as well cassava flour as functional food ingredient in a variety of food products including cakes and cookies have been proposed (Akinsanmi *et al*., 2015; Arun *et al*., 2015; Agama-Acevedo *et al*., 2016).

Composite flours are mixtures of two or more plant flours, rich in starch, protein, and/or other nutrients (Olaoye & Ade-Omowaye, 2011) and in this present study, cassava flour and unripe plantain peel flour was made into a composite flour. The practice of using composite flours in the production of baked products may therefore be an interesting option for the management of costs associated with importation of wheat flour in developing countries where wheat is not cultivated for climatic reasons (Olaoye & Ndukwe, 2016). Therefore, this study was aimed at evaluating the quality of cookies produced from high quality cassava flour and plantain peel flour. Production of cookies from these fibre rich and high bioactive raw materials will increase fibre yield, prevent waste generation and maximize the use of nutrients and health promoting constituents upon consumption.

2.0 Materials and Methods

2.1. *Raw materials procurement*

Mature green plantain fruits, salt, sugar, baking fat, baking powder and eggs were purchased from Marian Market in Calabar, Cross River State, Nigeria. High quality cassava roots were obtained from Cross-River Agricultural Development Program (ADP) Cross-River State, Calabar, Nigeria. All other reagents, materials and equipment used during proximate analysis and functional properties were obtained from the Department of Food Science and Technology Laboratory University of Calabar.

2.2. *Sample Preparation*

The freshly obtained cassava roots were processed into flour without fermentation to achieve high-quality cassava flour as shown in Figure 1. The mature green plantain fruits were carefully peeled using a kitchen knife and were processed into flour as shown in Figure 2. This followed the method earlier reported by Isaac & Titilope, (2017).

2.3. *Blend Formation*

Various percentages of the flour produced from unripe plantain peel and cassava were mixed in different ratios as shown in Table 1.

Table 1: Formulation of blends

Sample codes	Description
5C5P	50%Cassava flour + 50%Plantain peel flour
6C4P	60%Cassava flour + 40%Plantain peel flour
7C3P	70%Cassava flour + 30%Plantain peel flour
4C6P	40%Cassava flour + 60%Plantain peel flour
3C7P	30%Cassava flour + 70%Plantain peel flour
100C	100%Cassava flour
100P	100%Plantain peel flour
100W(control)	100%Wheat flour

2.4. *Preparation of cookies*

The cookies were produced using the procedures stated by Adekunle and Mary (2014). The recipe for formulated cookies were developed using different ingredients such as high-quality cassava flour, plantain peel flour, sugar, baking fat, salt, baking powder and eggs w ere weighed appropriately. The quantity of ingredients was the same for all proportions. After weighing, the fat was manually mixed vigorously in a large bowl, sugar was added and mixed for 10 minutes to from cream. Eggs were added to the mixture one at a time, beating after each addition to incorporate, flour was also added and beat to incorporate. The flour was added with other ingredients such as baking powder and salt with continuous mixing for 15 minutes until a smooth dough was obtained. A piece of this dough was cut, placed on a clean platform then rolled out using a rolling pan until the desired uniform texture and thickness was obtained. A heart-shaped mold was used to cut the firm dough into heart shapes, these were transferred to a greased (with margarine) baking tray. The baking was done at 180°C and baked for 20 minutes. After baking, the hot cookies were removed and allowed to cool before packaging in sealed bags for further analysis. The ingredient and quantity used are shown in Table 2.

Table 2: Ingredient and quantity used in preparation of the cookies

Ingredient	Quantity
Flour (g)	200
Salt (g)	2.0
Sugar (g)	100
Baking fat (g)	100
Egg	1
Baking powder (g)	2.0

2.5. Quality Evaluation

2.5.1. *Proximate Composition*

The proximate content of the composite blends was investigated using the procedure of Association of Official Analytical Chemist (2000). The methods were used in analyzing for - moisture, crude protein, crude fat, ash, crude fibre and carbohydrate by difference.

2.5.2. *Functional properties determination*

The bulk density, water absorption capacity (WAC), oil absorption capacity (OAC) and wettability of each composite blends were determined using the method of Onwuka (2005).

Bulk density was determined by filling a 50 mL graduated cylinder with 30 g of flour, gently tapping it to remove air pockets, and weighing the flour. The bulk density was calculated as the ratio of the weight of the flour to the volume (g/mL).

Water Absorption Capacity (WAC) was measured by mixing 5 g of flour with 50 mL of distilled water, allowing it to stand for 30 minutes, and then centrifuging at 3,000 rpm for 10 minutes. The water absorbed by the flour was noted, and WAC was expressed as grams of water absorbed per gram of flour.

Oil Absorption Capacity (OAC) was evaluated by adding 10 mL of vegetable oil to 5 g of flour, mixing it thoroughly, allowing it to rest for 30 minutes, and then centrifuging at 3,000 rpm for 10 minutes. The amount of oil absorbed was recorded and expressed as grams of oil per gram of flour.

Wettability was assessed by sprinkling 1 g of flour on the surface of 100 mL of water at room temperature and recording the time taken for it to become fully wet.

2.5.3. *Sensory Evaluation*

The sensory attributes, including taste, color, aroma, texture, appearance and overall acceptability of the prepared cookies were evaluated by a semi trained 15-member panel, drawn within the University of Calabar, Cross River State using a 9-point Hedonic scale with 1 representing the least score (dislike extremely) and 9 the highest score (like extremely).

2.7 Statistical Analysis

Data was expressed as mean ± SD of three replicate measurements. Statistical Package for Social Sciences (SPSS) version 23 was used to carry out one-way Analysis of Variance (ANOVA). Duncan's Multiple Range Test was used to separate the means, and differences between the means were considered significant at $P<0.05$.

3.0 Results

3.1 *Functional properties*

The results of the functional property evaluation of the flours blends are presented in Table 3.

Table 3: Functional properties of high-quality cassava and plantain peel flour.

Sample Code	Water absorption capacity (g/g)	Oil absorption capacity (g/g)	Bulk density (g/ml)	Wettability (min/sec)

5C5P	$2.33^{c} \pm 0.13$	$2.19^{a} \pm 0.55$	$0.51^{b} \pm 0.01$	$327.33^{e} \pm 2.52$
6C4P	$2.03^{d} \pm 0.03$	$1.63^{b} \pm 0.03$	$0.47^{c} \pm 0.00$	$490.33^{a} \pm 7.51$
7C3P	$1.94^{d} \pm 0.01$	$1.69^{b} \pm 0.01$	$0.51^{b} \pm 0.01$	$442.33^{b} \pm 2.52$
4C6P	$2.49^{b} \pm 0.01$	$1.65^{b} \pm 0.03$	$0.48^{c} \pm 0.02$	$365.33^{c} \pm 2.52$
3C7P	$2.46^{bc} \pm 0.03$	$1.56^{b} \pm 0.03$	$0.52^{b} \pm 0.00$	$349.00^{d} \pm 4.00$
100C	$1.56^{b} \pm 0.03$	$1.56^{b} \pm 0.02$	$0.44^{d} \pm 0.01$	$207.33^{f} \pm 7.51$
100P	$3.27^{a} \pm 0.18$	$1.69^{b} \pm 0.02$	$0.58^{a} \pm 0.00$	$367.00^{c} \pm 2.00$

Values are expressed as mean SD (n=3). *Means with the same superscripts (a, b, c, d) within a column are not significantly (P<0.05) different

KEYS: **5C5P** = 50%Cassava flour + 50%Plantain peel flour; **6C4P** = 60%Cassava flour + 40%Plantain peel flour; **7C3P** = 70%Cassava flour + 30%Plantain peel flour; **4C6P** = 40%Cassava flour + 60%Plantain peel flour; **3C7P** = 30%Cassava flour + 70%Plantain peel flour; **100C** = 100%Cassava flour; **100P** = 100%Plantain peel flour

3.2 *Proximate composition*

The results of proximate content analysis of the flour blends are presented in Table 4.

Table 4: Proximate composition of high-quality cassava and plantain peel flour

Sample Code	Moisture content (%)	Crude protein (%)	Crude fibre (%)	Crude fat (%)	Crude ash (%)	Carbohydrate (%)
5C5P	$2.27^{b} \pm 0.23$	$1.78^{b} \pm 0.12$	$5.5^{b} \pm 0.50$	$2.75^{a} \pm 0.05$	$2.29^{c} \pm 0.72$	$85.39^{d} \pm 1.11$
6C4P	$2.20^{b} \pm 0.00$	$1.23^{b} \pm 0.01$	$3.11^{d} \pm 0.13$	$2.50^{ab} \pm 0.50$	$1.00^{de} \pm 0.00$	$89.95^{b} \pm 0.44$
7C3P	$2.27^{b} \pm 0.23$	$1.37^{b} \pm 0.06$	$4.00^{c} \pm 0.25$	$1.63^{cd} \pm 0.34$	$0.50^{e} \pm 0.00$	$90.21^{b} \pm 0.68$
4C6P	$2.67^{a} \pm 0.31$	$1.77^{a} \pm 0.01$	$2.08^{e} \pm 0.14$	$2.00^{bc} \pm 0.50$	$2.00^{bc} \pm 0.50$	$89.48^{bc} \pm 0.35$
3C7P	$2.20^{b} \pm 0.00$	$2.23^{b} \pm 0.01$	$2.25^{e} \pm 0.66$	$1.73^{cd} \pm 0.46$	$3.98^{b} \pm 0.86$	$87.66^{c} \pm 1.20$
100C	$1.93^{b} \pm 0.30$	$2.19^{b} \pm 0.01$	$0.75^{f} \pm 0.25$	$1.25^{d} \pm 0.25$	$1.00^{de} \pm 0.50$	$92.88^{a} \pm 1.10$
100P	$2.93^{a} \pm 0.12$	$1.56^{a} \pm 0.01$	$9.00^{a} \pm 0.50$	$2.23^{abc} \pm 0.23$	$9.00^{a} \pm 1.00$	$75.25^{e} \pm 1.75$

Values are expressed as mean SD (n=3). *Means with the same superscripts (a, b, c, d) within a column are not significantly (P<0.05) different

KEYS: **5C5P** = 50%Cassava flour + 50%Plantain peel flour; **6C4P** = 60%Cassava flour + 40%Plantain peel flour; **7C3P** = 70%Cassava flour + 30%Plantain peel flour; **4C6P** = 40%Cassava flour + 60%Plantain peel flour; **3C7P** = 30%Cassava flour + 70%Plantain peel flour; **100C** = 100%Cassava flour; **100P** = 100%Plantain peel flour

3.3 *Sensory evaluation*

The mean sensory scores for the cookies produced from the resulting flour blends are presented in Table 5.

Table 5: Sensory evaluation of cookies made from high quality cassava flour and plantain peel flour

Sample Code	Colour	Taste	Aroma	Texture	Overall Acceptability
5C5P	$4.00^{cd} \pm 1.56$	$4.60^{de} \pm 1.55$	$4.67^{bc} \pm 1.29$	$5.00^{bc} \pm 1.85$	$5.80^{ab} \pm 2.43$
6C4P	$4.67^{bc} \pm 1.95$	$5.00^{cd} \pm 1.65$	$4.93^{bc} \pm 1.49$	$5.33^{b} \pm 1.99$	$5.27^{ab} \pm 2.01$
7C3P	$5.93^{b} \pm 1.39$	$6.13^{bc} \pm 1.46$	$5.80^{b} \pm 1.61$	$5.73^{b} \pm 1.71$	$6.47^{ab} \pm 1.77$
4C6P	$5.13^{bc} \pm 1.64$	$5.27^{cd} \pm 1.83$	$5.20^{b} \pm 1.57$	$4.47^{bc} \pm 1.36$	$5.60^{ab} \pm 1.81$
3C7P	$3.13^{d} \pm 2.33$	$3.33^{e} \pm 1.68$	$3.87^{c} \pm 2.13$	$3.93^{c} \pm 1.79$	$4.73^{b} \pm 1.91$
100C.	$8.20^{a} \pm 0.86$	$6.80^{b} \pm 1.97$	$7.60^{a} \pm 1.68$	$7.93^{a} \pm 1.22$	$6.40^{ab} \pm 2.59$
100P	$2.93^{d} \pm 2.34$	$4.07^{de} \pm 2.79$	$3.80^{c} \pm 1.78$	$3.87^{c} \pm 1.85$	$5.20^{ab} \pm 2.86$
100W	$8.47^{a} \pm 0.74$	$8.33^{a} \pm 0.98$	$8.07^{a} \pm 0.96$	$8.40^{a} \pm 0.91$	$7.07^{a} \pm 2.40$

Values are expressed as mean SD (n=3). *Means with the same superscripts (a, b, c, d) within a column are not significantly (P<0.05) different

KEYS: **5C5P** = 50%Cassava flour + 50%Plantain peel flour; **6C4P** = 60%Cassava flour + 40%Plantain peel flour; **7C3P** = 70%Cassava flour + 30%Plantain peel flour; **4C6P** = 40%Cassava flour + 60%Plantain peel flour; **3C7P** = 30%Cassava flour + 70%Plantain peel flour; **100C** = 100%Cassava flour; **100P** = 100%Plantain peel flour, **100W** = 100% Wheat flour (Control)

4.0. Discussion

4.1. *Functional properties of composite flour blends*

From Table 3, the water absorption capacities of the flours tend to increase with increase in the unripe plantain peel flour content. The 100P (100% plantain peel flour) sample had the highest water absorption capacity of (3.27g/g), followed by the 4C6P, 3C7P and 5C5P samples with a score of (2.49g/g), (2.46g/g) and (2.33g/g) respectively. This signified that an increase in the content of plantain peel flour increases the water absorption capacity of the composite flour samples.

There was no significant ($P<0.05$) difference in the oil absorption capacities of the composite flour samples except for the 5C5P (50% cassava & 50% plantain flour blend) sample which showed a higher degree of oil absorption with a value of 2.19g/g. This signified that the 5C5P flour blend will be useful in bakery products, doughnuts and pancakes where oil absorption properties are of prime importance.

Bulk density is significant in the package design, storage and transport of foodstuff. Bulk density values as shown in Table 3, ranged from 0.44g/ml to 0.58g/ml, with whole cassava flour (100C) having the lowest value (0.44g/ml). The incorporation of plantain peel flour increased the bulk density values of the composite flour samples, with the 100P flour sample having the highest value of 0.58g/ml. The results were within the reported values for starchy foodstuffs (Onuh & Abdulsalam, 2009). Low bulk density of the blends could be an advantage in the formulation of baby foods where high nutrient density to low bulk is desired.

There were significant ($P<0.05$) differences in the wettability of the sample flours. The results showed a high wettability level in the composite flour blend samples when compared with the whole cassava flour sample. The wettability of the samples tends to increase in the mixture of the two-flour blend (especially with an increase in the content of cassava flour), although the 100P flour sample showed a high degree of wettability. The 6C4P flour blend sample had the highest wettability profile of 490.33g/sec.

4.2. *Proximate composition of composite flour blends*

From Table 4, the moisture content ranged from 1% to approximately 3% among the blends, which were within the acceptable limits for flours. The 100C (100% cassava flour) sample had the lowest percentage of moisture content (1.93%), while the 100P (100% plantain peel flour) sample had the highest percentage of 2.93%. Generally, all the sample flours (including the flour blends) were below the 10% moisture content level recommended for safekeeping flour samples (SON, 2007). According to Nnam (2002), the lower the moisture content of a product, the longer the shelf life. This implies that the 100C sample can stay longer than the other samples.

The results also showed that an increase in the level of cassava flour contents in the composite flour blends resulted in a decrease in the protein content progressively, this could be attributed to the low protein content in the cassava flour that dilutes the protein content in the plantain flour. This can be seen in the 5C5P, 4C6P, 7C3P and 6C4P flour blends (with a progressive decrease in protein content of 1.78%, 1.77%, 1.37% and 1.23% respectively). The 100C and 100P flour samples however showed a contrasting result in their protein contents with a 2.19% and 1.53%

respectively. This signified that the 100C sample had a higher protein content among the flour samples.

The carbohydrate content was significantly highest (92.88%) in the 100C (100% cassava flour) sample, while the 100P sample had the lowest at 75.25%. This could be attributed to the high carbohydrate levels in cassava. From the result, it was also observed that an increase in the cassava flour content led to a higher carbohydrate level in the composite flour blends.

The results of crude fiber content showed that the 100P sample had the highest percentage of crude fibre (7%) which could be attributed to the high fibre in plantains. Also, the composite flour blend of 50% cassava and 50% plantain peel flour (5C5P) showed a high level of crude fibre content (5.5%). The 100C flour sample exhibited the lowest fibre content of 0.75%. A high fibre content in food samples is very important and necessary for digestion and bulk movement in humans after consumption (Dhingra *et al*., 2012).

There were significant (P<0.05) differences in the crude fat content of the flour samples. The result indicated that an increase in the plantain peel flour content increased the crude fat levels of the flour samples. It was also observed that a blend of the two flour samples increases the fat content of the composite samples, which can be clearly seen in the 5C5P sample with a fat content of 2.75%.

The crude ash content of the samples ranged from 1% in the 100C sample to 9% in the 100P flour sample. The result indicated that a higher concentration of the plantain peel flour in the flour blend samples increased the crude ash content of the composite flour samples, as seen in the 5C5P sample (2.29%), 3C7P sample (3.98%) and 4C6P sample (2%). Ash content is an indication of mineral content; hence samples with a high ash content are expected to have a relatively high mineral content.

4.3. *Sensory evaluation score of cookies produced from the resulting blends*

The brown colour resulting from maillard reaction is always associated with baked goods. The cookies produced from all composite flour samples and individual sample flours were significantly (P<0.05) different in terms of colour, except for the cookies made from the control sample (100% wheat flour) and 100C (100% cassava flour) which had scores of 8.47 and 8.20 respectively.

Taste is an important sensory attribute of any food because of its influence on acceptability. There was a significant (P<0.05) difference among the cookie samples. Cookies produced from the control sample (100% wheat flour) scored highest (8.33), this signified a high degree of acceptability in its taste. Cookies produced from the 100C (100% cassava flour) sample followed closely, this could be attributed to the rich sugar content in carbohydrate foods which enhances the taste. Cookies from the 100P (100% plantain peel flour) sample scored lowest (4.07) which was understandably so due to the taste of unripe plantain peel. Cookies made from the 7C3P (70% cassava & 30% plantain flour blend) sample also showed a high degree of acceptance in taste with a score of 6.13.

Aroma is another attribute that influences the acceptance of baked goods even before they are tasted (Ubbor, et. al, 2022). Substitution of wheat flour with cassava flour did not significantly (P<0.05) affect the sensory score of aroma. Cookies made from 100P (100% plantain peel flour) had the least score of 3.80. The result signified that an increase in the plantain peel flour concentration had a negative influence in the aroma score.

Furthermore, there were significant (P<0.05) differences among the sample means for texture scores in comparison with the control sample (100% wheat flour). The cookies produced from the

100C (100% cassava flour) sample showed a high level of texture (7.93) as compared with the other samples. Also, it was observed that an increase in the amount of cassava flour increased the texture score, while the reverse was the case for plantain peel flour.

Generally, cookies from 100C (100% cassava flour), 100P (100% plantain peel flour), 7C3P (70% cassava & 30% plantain peel flour blend), 5C5P (50% cassava & 50% plantain peel flour blend), 6C4P (60% cassava & 40% plantain peel flour blend) and 4C6P (40% cassava & 60% plantain peel flour blend) were not significantly different from each other in terms of overall acceptability, but were significantly ($P<0.05$) different from the control sample in overall acceptability. The cookie made from 3C7P (30% cassava & 70% plantain peel flour blend) had the lowest overall acceptability score of 4.73.

5.0 Conclusion

This study was conducted to ascertain the proximate composition and functional properties of composite flours produced from a blend of high-quality cassava flour and unripe plantain peel flour and also to investigate the sensory characteristics of cookies produced from the resulting flour blends. Results of the study indicated that every formulation involving the two components of cassava and unripe plantain peels could last longer due to the low moisture contents found and also that increasing the levels of unripe plantain peels, gave rise to more moisture, crude fibre, ash and even fat contents. On the other hand, 100C and blends that had more of the cassava showed less nutrient content in comparison with those of the unripe plantain peel. However, the 5C5P (50% cassava 50% plantain peel flour) blend proved to be more suitable as it showed appreciable levels of nutrients and cookies produced from it were generally accepted by the sensory evaluation panelist. In lieu of this, evaluation of the cyanogenic contents of the composite flours and resultant cookies, toxicity studies of the flour samples using biological models is recommended. Furthermore, food industries can take a cue from this study and invest more in this field.

Declarations

Author's contribution

A. S. Henshaw contributed to the writing of the paper. Nyong M. contributed to the methodology, laboratory analyses and data collection. C. A. Ikpeme-Emmanuel contributed to the conceptualization of the research, validation and supervision of the research. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare no conflict of interest.

Data availability

All data generated or analyzed during this study are included in this published article.

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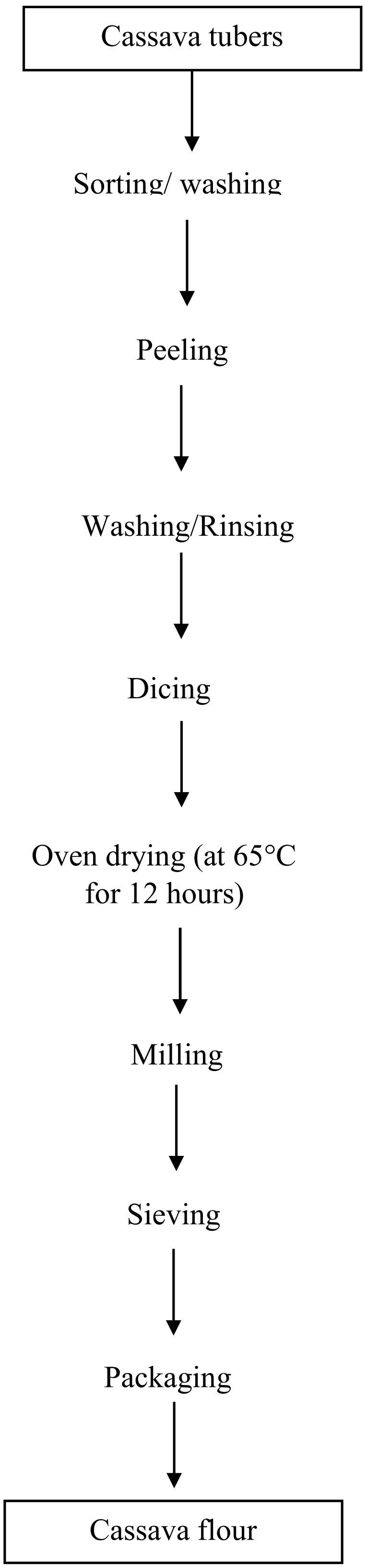
Cassava tubers
Sorting/ washing
Peeling
Washing/Rinsing
Dicing
Oven drying (at 65°C for 12 hours)
Milling
Sieving
Packaging
Cassava flour

Figure 1: Flow chart for the production of high-quality cassava flour

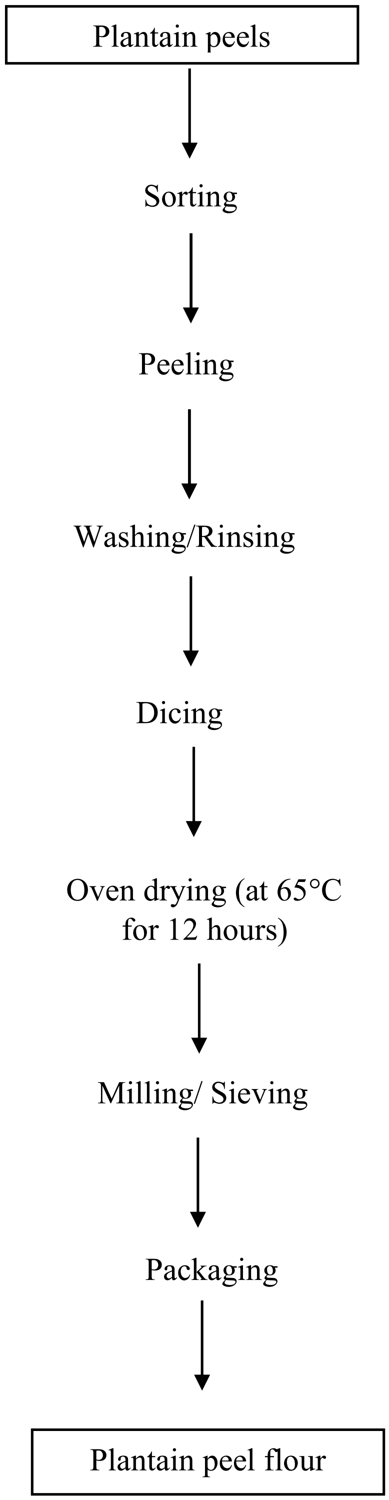

Figure 2: Flow chart for the production of plantain peel flour