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Evaluation of Physicochemical and Sensory Properties of Composite Flour from Cocoyam and Mungbean and Their Fufu-Like Products

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Abstract:
This study evaluated the physiochemical and sensory properties of composite flour from cocoyam and mungbean and their *fufu*-like products. Cocoyam and mungbean flours were produced and blended into different proportions (100:0, 90:10, 80:20, 70:30, 60:40 and 50:50). Flour made from 100% cocoyam served as the control. The proximate composition, functional, physicochemical and pasting properties of the cocoyam and mungbean composite flour and sensory properties of their *fufu* like products were evaluated using standard procedures. The data generated were statistically analysed by One Way Analysis of Variance (ANOVA) using Statistical Product of Service Solution (Version 22). The result of the functional properties of the flour blends showed that the bulk density ranged from 0.68 to 0.83 g/ml, 1.12 to 1.61 g/ml (water absorption capacity), 0.39 to 0.62 Sec (wettability) and 66.00 to 83.50 °C (gelatinization temperature). The result of the proximate composition showed that the moisture content ranged from ranged from 8.57 to 8.92 %, 7.11 to 15.58 % (crude protein), 1.37 to 1.78 % (fat), 2.96 to 5.05 % (crude fibre), 1.82 to 3.85 % (ash,) 65.18 to 77.90 % (carbohydrate). Physicochemical properties of the flour blends showed that the pH ranged from 6.07 to 6.49, 0.54 to 1.02 g/cm^2 (specific gravity), 0.15 to 0.68 % (total titratable acidity) and 1.66 to 1.72 NTU (turbidity). The sensory properties of the *fufu*-like products made from flour blends of cocoyam and mungbean showed the *fufu*-like products were generally accepted by the panelists. Therefore, flour and *fufu*-like products of acceptable and good quality can be produced from blends of cocoyam and mungbean. This will help increase the utilization of cocoyam and mungbean in food system.

Key words: Cocoyam, Mung Bean, *Fufu*-like, Composite Flour, Functional Properties, Sensory Properties.

1. Introduction

The increasing awareness in health and wellbeing has led to corresponding increase in the demand for nutritious and healthy food products worldwide (Chukwu *et al.*, 2017). *Fufu* is a cream coloured semi-solid fermented food product, originally made from cassava. However, it can also be made from unfermented flours of cereals, legumes and other root and tuber (Odo *et al.*, 2022). It is a common staple in southern, western and eastern Nigeria and some other parts of West Africa (Rosales-soto *et al.*, 2016). In some parts of Nigeria, it is also called *utaraakpu* (Owolarafe *et al.*, 2018). *Fufu* is basically eaten with the fingers, and a small ball of it can be dipped into a soup or sauce. The concept of using composite flour in production of *fufu* has been subject to numerous studies (Olapade *et al.*, 2014; Bamidele *et al.*, 2015). However, in selecting the components to be used in composite flour blends, the materials should preferably be readily available, culturally acceptable and provide increased nutritional potential (Hasmadi *et al.*, 2020).

Cocoyam (*Xanthosoma sagittifolium*), belonging to the *Araceae* family is an under-exploited tropical plant although the literature is abounding with its nutritional and health benefits (Onyeka, 2014; Owusu-Darko *et al.*, 2014). Studies have shown that cocoyam contains thiamin, riboflavin, and niacin (Adeyanju *et* *al*., 2019). The starch granule of cocoyam is small and very easily digestible, making it ideal for it to be a source of carbohydrate for people with digestive problems especially the elderly (Ubalua *et al*., 2016). Cocoyam possesses higher protein content than the major competing staples (yams, cassava and sweet potato) even though it is still low in absolute terms (Ubalua *et al*., 2016). Cocoyam has also been reported in folklore medicine in the management of diabetic mellitus (Eleazu *et al*., 2013). It also traditionally used to prevent and treat bone diseases such as osteoporosis (de Oliveira *et al*., 2012). Owusu-Darko *et al*. (2014) stated that cocoyam can be boiled, roasted, baked, fried in oil, milled and/or pounded into various food products. Production of flour from cocoyam serve as alternative use of cocoyam root which improve the utilization of cocoyam root (Bamidele and Ogundele, 2022).

Mung bean (*Vigna radiate*) is also known as mung, mungo, green gram or golden gram. It is cultivated in many tropical African countries as a principal cash crop (John and Olusegun, 2016). Mung bean is considered a 'green pearl' for its relatively high protein content and nutritional benefits (Brishti *et al*., 2017). For individuals who cannot afford animal proteins or those who are vegetarian, mung bean seed is of a comparatively low-cost and has a good source of protein for them (Yi-Shen *et al*., 2018). Furthermore, mung bean protein is easily digestible, as compared to protein in other legumes (Yi-Shen *et al*., 2018). Mungbean seeds have antidiabetic, antioxidant and antihyperlipidemic effects (Sonali and Rohit, 2020). The immense utilization of cassava root in production of *fufu* results to consumption of product deficient in protein especially when eaten with soup or sauce that does not possess adequate protein.

Protein deficiency is a major public health problem in some parts of the world, including Nigeria and the West Africa sub region. This is because staples in these areas are predominantly starchy foods (Olapade and Aworh, 2012). Mungbean seeds which possess high protein and have the potential to contribute in eradicating protein deficiency is underutilized (Mbaeyi-Nwaoha and Odo, 2018). Cocoyam and mungbean are local staples in Nigeria; therefore their utilization in the production of *fufu*-like products would, boost the nutritional profile of the *fufu* like products, thereby mitigating protein deficiency, increase the economic power of local farmers and enhance food security in developing countries. Increased utilization of cocoyam and mungbean in food system will reduce the reliance on imported flour leading to saving of foreign exchange. This research work will also create awareness of the potentials of cocoyam and mungbean thus, preventing them from going into extinction. Data obtained in this study will be of great benefit to food industries and households that utilize local staples in food production. The main objective of the study was to evaluate the physiochemical and pasting properties of composite flour from cocoyam and mungbean and their *fufu* like products.

2. Research Methods

Material

Cocoyam tubers were procured from Ugworie Market at Ozubulu, Anambra State, Nigeria, whereas mungbean seeds were obtained from the Department of Agronomy, Michael Okpara University of Agriculture Umudike, Nigeria. Reagents and equipment used for analyses were procured from the Biochemistry Laboratory of the National Root Crops Research Institute, Umudike, Nigeria. The cocoyam tubersand mung bean seeds are shown in Figure 1.


Figure 1. Cocoyam tubers (left) and mung bean seeds (right)

Methods

Experimental Design

Completely randomized design was used for this study.

Statistical Analysis

All experiments in this study were reported as mean of duplicate analyses. One way analysis of variance using the Statistical Product of Service Solution version 22.0 was carried out to compare between the means, while treatment means were separated using Duncan multiple range test at 95% confidence level ($p<0.05$).

Research Procedures

Production of Cocoyam Flour

The method described by Ukom and Okerue (2018) was used in production of cocoyam flour. Cocoyam tubers were sorted, manually peeled with stainless steel knife and sliced. Thereafter, they were washed in water and dried (in oven at 55°C for 72 hours), milled (attrition mill) and sieved using 0.4 mm mesh size. The resulting flour was packaged in an airtight polyethylene for further use.

Table 1. Composite flour blends

Samples	Cocoyam flour	Mung bean flour
CMF1	100	0
CMF2	90	10
CMF3	80	20
CMF4	70	30
CMF5	60	40
CMF6	50	50

Production of Fufu-Like Products

The *fufu*-like products were processed using the method described by Gbadegesin *et al.* (2018) as shown in Figure 3. The composite flours were separately poured gradually into boiling water in a cooking pot and stirred continuously using a wooden ladle until stiff dough was obtained. The pot was covered for 3 min so as to cook properly prior to turning until the texture became uniform (see plate 1 to 6).

Determination of Functional Properties of Flour Sampels

The functional properties of the flours were determined according to the method described by Onwuka (2018). These include bulk density, water absorption capacity, wettability, and gelatinization temperature.

Determination of pH

The pH was determined by the method described by Onwuka (2018). Ten grams of the flour sample was dissolved in 100 ml of distilled water. The mixture was allowed to equilibrate for 3 min at room temperature. The pH was then determined by inserting the electrode of the pH meter in the sample then taking the result displayed on the pH meter.

Determination of Turbidity

The turbidity of flour sample was determined using the method described by Perera and Hoover (1999) as cited in Makanjuola and Makanjuola (2018). One (1) percent aqueous suspension of the flour was heated in water bath at 90 ^{o}C for 1 hour with constant stirring. The paste was then cooled for 90 min at 30 ^{o}C. Thereafter, it was stored for 5 days at 4 ^{o}C. The turbidity was determined after 24 h by measuring absorbance at 640 nm against a water blank with spectrophotometer.

Determination of Specific Gravity

Specific gravity of the flour was determined as the ratio of the density of the sample in to the density of water as described by Onwuka (2018).

$$\text{Specific gravity} = \frac{\text{Density of sample}}{\text{Density of water}}$$

Determination of Total Titratable Acidity

Total titratable acidity was determined by the method described by Onwuka (2018). Five grams of the flour sample was dissolved in distilled water and mixed thoroughly. One milliliter (1 ml) of phenolphthalein indicator was introduced into 10 ml of the mixed solution. It was titrated against standard sodium hydroxide solution until pink color persisted for 12 sec for complete neutralization.

Determination of Proximate Composition of Bread Samples

Proximate analyses of the flours were carried out as described by AOAC (2010). These include the moisture content, ash, crude protein, crude fat and crude fibre. Carbohydrate was calculated by difference.

Sensory Evaluation of Fufu-Like Products

Sensory attributes of the *fufu*-like products were assessed according to the method described by Iwe (2014). A panel of 20 members consisting of students in College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike were chosen based on their familiarity with *fufu* for sensory evaluation. The *fufu*-like products were randomly presented to the panelists. The panelists were provided with portable water to rinse their mouth between evaluations. However, a questionnaire describing the quality attributes (appearance, taste, texture, mouldability and general acceptability) of the *fufu*-like products was given to each panelist. The panelist were then asked to score each sample using a 9-point hedonic scale (1 = dislike extremely and 9 = like extremely).

3. Results and Discussion

***Fufu*-Like Products Made From Cocoyam and Mung bean Composite Flour**

The *fufu*-like products made from cocoyam and mung bean composite flour at varying proportions (cocoyam:mung bean) are shown in Figure 2.

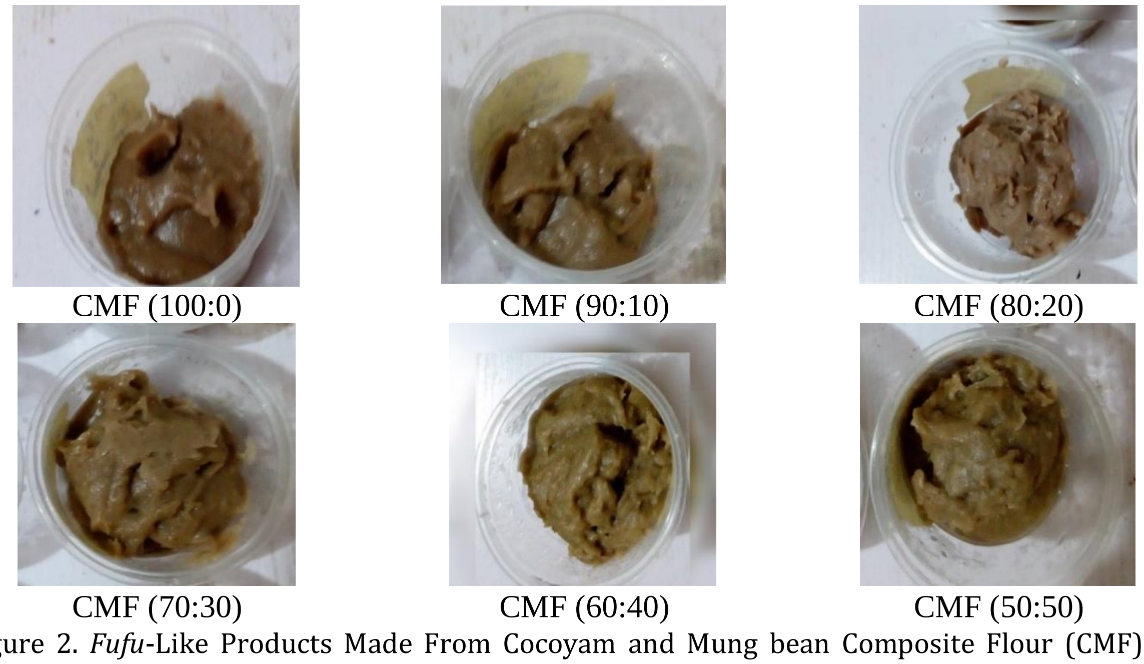

Figure 2. *Fufu*-Like Products Made From Cocoyam and Mung bean Composite Flour (CMF) at varying proportions

Functional Properties of Cocoyam-Mungbean Composite Flour

The functional properties of the cocoyam-mung bean composite flours is presented in Table 2. The bulk density of the flour samples ranged from 0.68 to 0.83 g/ml. There was a slight difference (p<0.05) in the bulk density of the flour samples. Cocoyam:mung bean (50:50) flour sample had the highest value, while (100:0) flour sample had the lowest value. However, cocoyam:mung bean (60:40) and cocoyam:mung bean (50:50) flour samples were not significantly different (p>0.05) from each other. Bulk density, also called apparent density or volumetric density, is the mass of several particles of flour materials per total volume they occupy (Awuchi *et al*., 2019). Variations in bulk density of flours depends on interrelated factors including intensity of attractive inter particle forces, particle size and number of contact points (Chandra *et al*., 2015). The highest bulk density value obtained in cocoyam:mung bean (50:50) flour suggests that its more suitable to be used as thickener in food products (Chandra *et al*., 2015). On contrast, the low bulk density recorded in cocoyam:mung bean (100:0) flour would be an advantage in food formulation especially food with less retrogradation (Oladele and Aina, 2009). The range of bulk density obtained in this study was lower than the range of bulk density (2.05 to 2.58 g/ml) values for composite flour from rice and Bambara groundnut, as reported by Dzandu *et al*. (2023). It was higher the range of bulk density (0.57 to 0.68 g/ml) values for composite flour from yellow maize, soybeans and jackfruit seeds as reported by Meka *et al*. (2019). The variations in bulk density of these flours could be due to the differences in the types of raw materials used in producing the composite flours. The water absorption capacity of the cocoyam-mungbean composite flours ranged from 1.12 to 1.61 g/ml. There was a significant difference (p<0.05) in the water absorption capacity of the flour samples apart from cocoyam:mung bean (60:40) and cocoyam:mung bean (50:50) flour that did not differ significantly (p>0.05) from each other. Cocoyam:mung bean (60:40) had the highest water absorption capacity value, while cocoyam:mung bean (100:0) flour had the lowest water absorption capacity value. Water absorption capacity is the ability of the flour to absorb water and swell for enhanced consistency in food (Offia-Olua, 2014). It measures the water holding ability by the starch after the swelling in excess water, which corresponds to weight of the gel formed, and therefore is an index of degree of starch gelatinization (Awuchi, 2019).

Table 2. Functional properties of cocoyam-mung bean composite flour

Flour sample	Bulk density (g/ml)	Water absorption Capacity (g/ml)	Wettability (Sec)	Gelatinization Temperature (°C)
CMF (100:0)	$0.68^{c}\pm0.01$	$1.12^{e}\pm0.02$	$0.39^{d}\pm0.02$	$83.50^{a}\pm2.12$
CMF (90:10)	$0.71^{c}\pm0.02$	$1.23^{d}\pm0.01$	$0.47^{c}\pm0.01$	$80.00^{b}\pm0.00$
CMF (80:20)	$0.73^{bc}\pm0.02$	$1.34^{c}\pm0.02$	$0.48^{c}\pm0.02$	$78.00^{bc}\pm0.00$
CMF (70:30)	$0.76^{b}\pm0.03$	$1.44^{b}\pm0.01$	$0.53^{b}\pm0.01$	$75.50^{c}\pm0.71$
CMF (60:40)	$0.82^{a}\pm0.02$	$1.61^{a}\pm0.01$	$0.57^{b}\pm0.02$	$71.00^{d}\pm0.00$
CMF (50:50)	$0.83^{a}\pm0.02$	$1.58^{a}\pm0.01$	$0.62^{a}\pm0.01$	$66.00^{e}\pm1.41$

$^{a-e}$: Values are means $\pm$ standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).
Key: CMF(100:0) = 100% cocoyam : 0% mung bean flour, CMF (90:10) = 90% cocoyam : 10% mung bean flour, CMF (80:20) = 80% cocoyam : 20% mung bean flour, CMF (70:30) = 70% cocoyam : 30% mung bean flour, CMF (60:40) = 60% cocoyam : 40% mung bean flour, CMF (50:50) = 50% cocoyam : 50% mung bean flour

Flours with high water absorption capacity are more suitable to be used in formulation of some foods such as sausage, dough, cheese and bakery products (Twinomuhwezi *et al*., 2020). The range of water absorption capacity values obtained in this study was lower than the range of water absorption capacity (1.26 to 1.64 g/ml) values for composite flours from water yam and soybean as reported by Olapade and Akinyanju (2014) but higher than the range of water absorption capacity (1.00 to 1.05 g/ml) acha based flour supplemented with tiger nut flour as reported by Ayo *et al*. (2018). High water absorption capacity in flour does not only aid in bulking application (Niba *et al*., 2011) but is also very useful prevent staling by reducing moisture loss in baked products (Okpala *et al*., 2012).

The wettability of the cocoyam-mung bean flour samples ranged from 0.39 to 0.62 Sec. There was no significant difference (p>0.05) between the wettability of cocoyam:mung bean (90:10) and cocoyam:mung bean (80:20) flour. More so, cocoyam:mung bean (70:30) and (60:40) flours were not significantly different (p>0.05) from each other. The highest value of wettability was obtained in cocoyam:mung bean (50:50) flour while the lowest value of wettability was obtained in cocoyam:mung bean (100:0) flour. Wettability is a function of ease of dispersing flour samples in water and the sample with lowest wettability dissolves fastest in water (Ubbor and Akobundu, 2009). The highest value of wettability recorded in cocoyam:mung bean (50:50) flour could be attributed to high level of crude fibre content of the flour sample. This is in line with the result of Odimegwu *et al.* (2015), who observed an increase in wettability in fibrous materials. The range of wettability obtained in this study was lower than the range of wettability (109.50 to 139.30 Sec) for wheat-cocoyam composite flour as reported by Olakunle and Olalekan (2020), and the range of wettability (14.00 to 48.55 Sec) for composite flour produced from date fruit pulp, toasted watermelon seed and wheat as reported by Peter-Ikechukwu *et al*. (2020). These differences could be attributed to the fact that they were processed using varying raw materials.

The gelatinization temperature of the flour samples ranged from 66.00 to 83.50°C. There was a significant difference (p<0.05) in the gelatinization temperature of flours. Cocoyam:mung bean (100:0) flour had the highest value, while cocoyam:mung bean (50:50) had the lowest value. It was observed that increase in the proportion of mung bean flour resulted to decrease in gelatinization temperature of the flour samples. The variations in gelatinization temperature may be attributed to differences in particle size of starch granules in the flours, and the differences in proportion of their amylose and amylopectin content (Okwunodulu *et al*., 2019). Gelatinization temperature is the temperature at which viscosity of the flour dispersions first increases by at least 24 mPa within a second and could be used to determine the time required for cooking starch based foods (Uzodinma *et al*., 2016). The range of gelatinization temperature obtained in this study was higher than that of Orisa and Udofia (2020), who reported a gelatinization temperature value range of 62.00 to 68.50°C for composite flours from wheat, cowpea, acha and *Moringa oleifera* leaf powder and that of Peter-Ikechukwu *et al*. (2020), who reported a gelatinization temperature value range of 60.66 to 67.55°C for wheat-toasted watermelon seed-date palm composite flour. The high gelatinization temperature obtained in flours analysed in this study especially cocoyam:mung bean (100:0) flour will give a good and easier cooking quality as stated by Etudaiye *et al*. (2015). However, high gelatinization temperature may require more heat energy and costs (Etudaiye *et al*., 2015). This suggests that the flours investigated in this study should be added to a formula where gelling is required within 66.00 to 83.50°C.

Proximate Composition of Cocoyam-Mungbean Composite Flour

The proximate composition of cocoyam-mungbean composite flour is presented in Table 3. The moisture content of cocoyam-mungbean composite flours ranged from 8.57 to 8.92 %. There were significant differences (p<0.05) in the moisture content of the flour samples. Cocoyam:mung bean (90:10) flour sample had the highest value, while cocoyam:mung bean (50:50) flour sample had the lowest value. The result revealed that the moisture content of the flour samples decreased with increase in the proportion of mung bean flour. The least value of moisture obtained in cocoyam:mung bean (50:50) flour sample could be attributed to its highest quantity of mungbean flour. This claim is in accordance with Butt and Batool (2010) who stated that protein binds moisture. Twinomuhwezi *et al.* (2020) also reported that rice based composite flour with the highest quantity of soybean (60 %) had the least moisture content (5.99 %) compared to 6.25 to 8.58 % reported in other flour samples. The range of moisture content obtained in this study was lower than the range of 29.92 to 33.23 % moisture content value of wheat-sweet banana-carrot composite flour as reported by Ewunetu *et al.* (2023). This variation might be as a result of the different individual flours. Flours with moisture content above 14 % are not often stable at room temperature as it facilitates growth of microorganisms thus, producing off flavours (Twinomuhwezi *et al*., 2020). The low moisture content of the cocoyam-mungbean composite flours particularly cocoyam:mung bean (50:50) flour implies that they can be stored at room temperature and less prone to spoilage.

The crude protein content of the cocoyam-mungbean composite flour ranged from 7.11 to 15.58 %. There was a significant difference (p<0.05) in the crude protein content of the flour samples. Cocoyam:mung bean (50:50) flour sample had the highest value, while cocoyam:mung bean (100:0) flour sample had the lowest value. The content of the flour samples was observed to increase with increase in the proportion of mung bean flour. The highest crude protein content obtained in cocoyam:mung bean (50:50) flour sample could be attributed to the fact that it possess the highest quantity of mungbean, a legume. This is in accordance with Enyiukwu *et al.* (2020) who reported that mungbean is a good source of crude protein (26.25 %).More so, Offia-Olua *et al.* (2020) reported that malted maize-mungbean composite flour with the highest quantity of mungbean had the highest crude protein (19.51 %). Bello *et al.* (2019) also reported that wheat-plantain composite flour with the highest proportion of a legume (Pigeon pea flour) had the highest crude protein (16.10 %) compared to 13.25 % obtained in 100 % wheat flour. The least value of crude protein obtained in flour made from cocoyam:mung bean (100:0) could be attributed to the fact that it was made from cocoyam, a root crop known to possess minute protein. Amah *et al.* (2018) affirmed that cocoyam is not a good source of crude protein (3.50 to 4.72 %). Bello *et al.* (2018) reported that food products from plant origin capable of providing more than 12 % of its calorific value from protein are good sources of protein. This implied that cocoyam:mung bean (50:50), (60:40) and (70:30) flour samples will play more roles in growth and replacement of worn out tissues in humans (Onwuka, 2014). The fat content of the composite flour ranged from 1.37 to 1.78 %. There was a significant difference ($p<0.05$) in the fat content of the flour samples except cocoyam:mung bean (60:40) and cocoyam:mung bean (50:50) flours, which did not differ significantly ($p>0.05$) from each other. Cocoyam:mung bean (50:50) flour sample had the highest value of fat, while the lowest fat content was recorded in cocoyam:mung bean (100:0) flour sample. The result revealed that the fat content of the flour samples increased with increase in the proportion of mung bean flour. The highest fat content obtained in cocoyam:mung bean (50:50) flour sample might be due to the fact that it contained highest proportion of mungbean flour; which have more fat than cocoyam. This is in accordance with Dainavizadeh and Mehranzadeh (2013) and Amah *et al.* (2018) who reported respectively the fat content of mungbean (2.05 %) and cocoyam (0.40 to 0.41 %). Similar finding was also reported by Olapade *et al.* (2014); who stated that increase in bambara nut flour resulted to increase in fat content (1.44 to 5.36 %) of fermented cassava from flour. Fat could play a role in determining the shelf-life of food products (Offia-Olua *et al.*, 2020). The low fat content of the flours obtained in this study especially cocoyam:mung bean (100:0) flour could help to prolong their shelf life as the rate of rancidity which could lead to the production of off flavours and odours will be reduced drastically (Talabi *et al.*, 2019). However, the highest fat content obtained in cocoyam:mung bean (50:50) flour is beneficial to human as it suggests they possess higher quantity of fat soluble vitamins (Onwuka, 2014). The crude fibre content of the cocoyam-mung bean composite flours ranged from 2.96 to 5.05 %. Significant differences ($p<0.05$) existed in the crude fibre content of the flour samples. Cocoyam:mung bean (50:50) flour had the highest value of crude fibre (5.05 %), while Cocoyam:mung bean (100:0) flour had the crude fibre content. The significant increase in crude fibre observed as the proportion of mung bean flour increases could probably be that mung bean possess higher crude fibre than cocoyam. This is in accordance with Enyiukwu *et al.* (2020) and Amah *et al.* (2018) who respectively reported the crude fibre content of mung bean is 6.75 % and that of cocoyam ranged from 1.31 to 1.93 %. Moreso, Dainavizadeh and Mehranzadeh (2013) reported that mung bean is a source of crude fibre (6.40 %). The range of crude fibre obtained in this study was lower than the range of crude fibre (3.57 to 11.37%) values, as reported by Offia-Olua (2014), for wheat-walnut flours but higher than the range of crude fibre content (0.02 to 0.32 %) of cassava-bambara nut flour (Olapade *et al.*, 2014). The variations might be due to the differences in individual flour types. Dietary fiber is the indigestible component of plant material (Ogundele, *et al.*, 2015) that has the potential of lowering serum cholesterol, obesity and enhancing intestinal health (Woo *et al*., 2015).

The ash content of the composite flour ranged from 1.82 to 3.85 %. There was a significant difference ($p<0.05$) in the ash content of the flour samples. Cocoyam:mung bean (50:50) flour sample had the highest value, while cocoyam:mung bean (100:0) (1.82 %) flour sample had the lowest value. The variation in the ash content in the flour samples could be attributed to the effect of mungbean incorporation as reduction in the proportion mung bean incorporation resulted to concurrent reduction in the ash content of the flour samples. Offia-Olua *et al.* (2020) reported similar finding for maize-mungbean composite flour, where they stated that the flour sample with highest proportion of fermented mungbean flour had the highest value of ash (5.60 %) compared to ash value of 2.75 % for maize flour without mungbean flour incorporated. Furthermore, range of ash content obtained in this study was higher than the range of ash content values (0.62 to 1.69 %) for wheat-pigeon pea-plantain composite flour as reported by Bello *et al.* (2019). High ash content in foods is crucial as it's an indication of its mineral content (Bello, 2008). This suggests that flour sample investigated in this study especially Cocoyam:mung bean (50:50) flour possess higher tendency to provide essential minerals needed for body development.

The carbohydrate content of the cocoyam-mungbean flour samples ranged from 65.18 to 77.90 %. There was a significant differences ($p<0.05$) in the carbohydrate content of the flour samples. Cocoyam:mung bean (100:0) flour had the highest value, while cocoyam:mung bean (50:50) had the lowest carbohydrate content (65.18 %). The carbohydrate content of the flour samples decreased with increase in the proportion of mung bean flour. The highest carbohydrate content obtained in cocoyam:mung bean (100:0) flour could be attributed to the fact that it was processed from a root crop which is a good source of carbohydrate. This is in accordance with the report of Ubalua *et al*. (2016), who stated that cocoyam is an excellent source of carbohydrate suitable for consumption, especially by people with digestive problems. Bello *et al.* (2019) reported same trend of finding. The researchers revealed that decrease in proportion of pigeon pea flour resulted in increase in carbohydrate content (76.56 to 68.85 %) for wheat-plantain-pigeon pea composite flour. The highest value of carbohydrate recorded in cocoyam:mung bean (100:0) suggests that it can be a good source of energy to the body. Mudambi and Rajagopal (2012) reported that the primary function of carbohydrates in the body is to supply energy. Furthermore, flour blend of cocoyam:mung bean (100:0) would be more suitable in breakfast meals and weaning formula (Twinomuhwezi *et al*., 2020) because of its high carbohydrate content. The least value of carbohydrate obtained in cocoyam:mung bean (50:50) flour would be of immense benefit for diabetic and hypertensive patients requiring low sugar foods.

Table 3. Proximate composition of cocoyam-mung bean composite flour

Flour sample	Moisture content (%)	Crude protein (%)	Fat content (%)	Crude fibre (%)	Ash content (%)	Carbohydrate content (%)
CMF (100:0)	$8.85^{b}\pm0.02$	$7.11^{f}\pm0.01$	$1.37^{e}\pm0.02$	$2.96^{f}\pm0.03$	$1.82^{f}\pm0.01$	$77.90^{a}\pm0.01$
CMF (90:10)	$8.92^{a}\pm0.03$	$8.74^{e}\pm0.02$	$1.45^{d}\pm0.01$	$3.37^{e}\pm0.03$	$2.17^{e}\pm0.01$	$75.36^{b}\pm0.01$
CMF (80:20)	$8.85^{b}\pm0.03$	$10.43^{d}\pm0.01$	$1.53^{c}\pm0.02$	$3.81^{d}\pm0.01$	$2.26^{d}\pm0.03$	$73.13^{c}\pm0.05$
CMF (70:30)	$8.73^{c}\pm0.02$	$12.12^{c}\pm0.02$	$1.66^{b}\pm0.01$	$4.24^{c}\pm0.03$	$2.47^{c}\pm0.02$	$70.80^{d}\pm0.01$
CMF (60:40)	$8.64^{d}\pm0.03$	$13.87^{b}\pm0.01$	$1.75^{a}\pm0.02$	$4.62^{b}\pm0.01$	$2.65^{b}\pm0.02$	$68.49^{e}\pm0.00$
CMF (50:50)	$8.57^{e}\pm0.02$	$15.58^{a}\pm0.02$	$1.78^{a}\pm0.01$	$5.05^{a}\pm0.01$	$3.85^{a}\pm0.03$	$65.18^{f}\pm0.03$

$^{a-f}$: Values are means $\pm$ standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).

Key: CMF(100:0) = 100% cocoyam : 0% mung bean flour, CMF (90:10) = 90% cocoyam : 10% mung bean flour, CMF (80:20) = 80% cocoyam : 20% mung bean flour, CMF (70:30) = 70% cocoyam : 30% mung bean flour, CMF (60:40) = 60% cocoyam : 40% mung bean flour, CMF (50:50) = 50% cocoyam : 50% mung bean flour

Physicochemical Properties of Cocoyam-Mungbean Composite Flour

Table 4 shows the physicochemical properties of the cocoyam-mung bean composite flour. The pH of the flours ranged from 6.07 to 6.49. There was significant differences ($p<0.05$) in the pH values of the flour samples. It was observed that increase in the proportion of mung bean flour caused a significant increase in pH of the flours with cocoyam:mung bean (50:50) flour having the highest value, while cocoyam:mung bean (100:0) had the lowest value. pH is a measure of acidity or alkalinity and it greatly affects the performance of flours in many food processing applications (Tortoe *et al*., 2017). The significant increase in pH in the composite flour with increase in the proportion of mung bean flour could probably be that mung bean used in this study was more acidic than the cocoyam. The range of pH values obtained in this study was higher than the range of pH (5.62 to 5.92) values for wheat-okra composite flour as reported by Akoja and Coker (2018). Food products with low pH is of great importance as acidic food products is associated with the development of a pleasant taste (Ogunjobi and Ogunwolu, 2010), inhibits the growth of microorganisms and as well promotes wound healing by causing oxygen release from haemoglobin (Buba *et al*., 2013).

The total titratable acidity of the cocoyam-mungbean flour samples ranged from 0.15 to 0.68 %. Significant differences ($p<0.05$) existed in the total titratable acidity of the flour samples. Cocoyam:mung bean (100:0) flour had the highest value, while cocoyam:mung bean (100:0) flour had the lowest value. Total titratable acidity measures the total acid concentration in a food (Tyl and Sadler, 2017). It is an indicator of freshness in flours (Tortoe *et al*., 2017). The significant decrease in total titratable acidity with increase in the proportions of mung bean flour could either be that cocoyam possess higher total acid concentration and/or that there was more departure of volatile acidity and organic compounds during processing of mungbean into flour (Akoja and Coker, 2018). The range of total titratable acidity values obtained in this study was higher than the range of total titratable acidity (0.13 to 0.32 %) values obtained in wheat-okra composite flour as reported by Akoja and Coker (2018), and values of total titratable acidity reported for African finger millet (0.038 %) and pearl millet (0.14) (Owheruo *et al*., 2018). Food acids dictate the dominant microflora in foods and to a large extent will determine its shelf stability (Ezeama, 2007). The higher total titratable acidity obtained in this study suggests they are less susceptible to bacterial action but are more susceptible to the action of yeasts and moulds (Jay, 2000).

The turbidity of the cocoyam-mungbean flour samples ranged from 1.66 to 1.72 NTU. There was a significant difference ($p<0.05$) in the turbidity of the flour samples. Cocoyam:mung bean (100:0) flour had the highest value of turbidity while cocoyam:mung bean (50:50) had the lowest value. The variation in turbidity can be attributed to the differences in interaction between leached amylose and amylopectin chains that lead to development of function zones, or scatter a significant amount of light (Pereira and Hoover, 1999). Furthermore, the least value of turbidity recorded in cocoyam:mung bean (50:50) flour could be attributed to its higher protein and fat content. This is in accordance with Eiamwat *et al.* (2016) who stated that the turbidity of a food product is affected by its protein, fat and amylose content. The range of turbidity obtained in this study was lower than the range of turbidity (3.15 to 5.17 NTU) values for three corn starch flours as reported by Makanjuola and Makanjuola (2018). The differences in turbidity of these flours could be ascribed to the fact that they were processed from varying raw materials. Interestingly, the lower the turbidity of a food product the more tendencies it possess to retard activities of pathogens (Pereira and Hoover, 1999).

Table 4. Physicochemical properties of cocoyam-mung bean composite flour

Flour sample	pH	Total titratable acidity (%)	Turbidity (NTU)	Specific gravity (g/cm^2)
CMF (100:0)	$6.07^{f}\pm0.03$	$0.68^{a}\pm0.02$	$1.72^{a}\pm0.00$	$1.02^{a}\pm0.03$
CMF (90:10)	$6.15^{e}\pm0.01$	$0.56^{b}\pm0.01$	$1.71^{b}\pm0.00$	$0.92^{b}\pm0.01$
CMF (80:20)	$6.25^{d}\pm0.01$	$0.46^{c}\pm0.01$	$1.70^{c}\pm0.00$	$0.87^{c}\pm0.02$
CMF (70:30)	$6.36^{c}\pm0.01$	$0.38^{d}\pm0.01$	$1.69^{d}\pm0.00$	$0.75^{d}\pm0.01$
CMF (60:40)	$6.43^{b}\pm0.01$	$0.27^{e}\pm0.02$	$1.67^{e}\pm0.00$	$0.63^{e}\pm0.02$
CMF (50:50)	$6.49^{a}\pm0.02$	$0.15^{f}\pm0.02$	$1.66^{f}\pm0.00$	$0.54^{f}\pm0.01$

$^{a-f}$: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).

Key: CMF(100:0) = 100% cocoyam : 0% mung bean flour, CMF (90:10) = 90% cocoyam : 10% mung bean flour, CMF (80:20) = 80% cocoyam : 20% mung bean flour, CMF (70:30) = 70% cocoyam : 30% mung bean flour, CMF (60:40) = 60% cocoyam : 40% mung bean flour, CMF (50:50) = 50% cocoyam : 50% mung bean flour

The specific gravity of the cocoyam-mungbean flour samples ranged from 0.54 to 1.02 g/cm^2. Significant differences ($p<0.05$) existed in the specific gravity of the flour samples. Cocoyam:mung bean (100:0) flour had the highest value, while cocoyam:mung bean (50:50) flour had the lowest value. Specific gravity is the comparison of the weight of food sample to that of water having the same volume and at a given temperature (Mohammed and Ali, 2015). The highest value of specific gravity obtained in flour with 100% cocoyam suggests that cocoyam flour possess higher molecular weight than mung bean flour (Mohammed and Ali, 2015).

Sensory Properties of Fufu-Like Products Made From Flour Blends of Cocoyam-Mungbean

Table 6 shows the sensory properties of *fufu*-like products made from flour blends of cocoyam-mung bean. The mean of sensory score for appearance of the *fufu*-like products ranged from 6.95 to 8.15. There was a significant difference ($p<0.05$) in the panelists rating for appearance of the *fufu*-like products apart from *fufu*-like products made from cocoyam:mung bean (100:0), (80:20) and (70:30) flours in which there was no significant ($p<0.05$) in their mean scores for appearance. The *fufu*-like product made from cocoyam:mung bean (50:50) flour had the highest mean score, while the least mean score for appearance was obtained in *fufu*-like products made from cocoyam:mung bean (90:10) flour. The result revealed that the appearances of the *fufu*-products were all liked by the panelists and the degree of likeness slightly increased with increase in the percentage of mung bean flour. Appearance determines how fulfilling a food product is before its consumption (Maina, 2018). The highest mean score of appearance obtained in *fufu*-like product made from cocoyam:mung bean (50:50) flour implied that it was liked very much, based on the 9-point hedonic scale and this could be attributed to its lowest carbohydrate content which least affected the appearance of the sample compared to other *fufu*-like products. This is in line with the assertion by Okwunodulu *et al*. (2019) that carbohydrate impact brownish colour in food when heated. The range of mean score for appearance obtained in this study was higher than the range of mean score for appearance (6.54 to 7.25) for *fufu* substituted with cooking banana and African yam bean (Ogbonnaya *et al*., 2018), and the range of mean score for appearance (5.80 to 8.00) for reconstituted cassava-African yam bean seeds *fufu* flour blends as reported by Nwokeke *et al.* (2013). The higher mean scores of appearance obtained in the *fufu*-like product made in this study is of great importance since consumers eat with their eyes and use the appearance of foods to predict quality (Oluwole, 2009).

Table 6. Sensory properties of fufu-like products made from flour blends of cocoyam and mung beans

Samples	Appearance	Taste	Texture	Mouldability	General acceptability
CMF (100:0)	$7.25^{bc}\pm1.64$	$6.65^{bc}\pm1.84$	$6.50^{b}\pm1.61$	$6.75^{bc}\pm1.68$	$6.90^{cd}\pm1.45$
CMF (90:10)	$6.95^{c}\pm1.23$	$6.90^{abc}\pm1.02$	$6.65^{b}\pm1.50$	$6.15^{c}\pm1.63$	$6.65^{d}\pm1.27$
CMF (80:20)	$7.25^{bc}\pm0.91$	$6.45^{c}\pm1.15$	$7.15^{bc}\pm1.09$	$7.05^{ab}\pm1.28$	$7.15^{bcd}\pm1.14$
CMF (70:30)	$7.40^{bc}\pm0.94$	$6.95^{abc}\pm1.00$	$7.30^{bc}\pm0.98$	$7.20^{ab}\pm1.20$	$7.50^{abc}\pm0.89$
CMF (60:40)	$7.70^{ab}\pm0.86$	$7.45^{ab}\pm1.00$	$7.65^{a}\pm1.09$	$7.75^{a}\pm0.72$	$7.75^{ab}\pm0.97$
CMF (50:50)	$8.15^{a}\pm0.67$	$7.55^{a}\pm0.89$	$7.70^{a}\pm0.80$	$7.90^{a}\pm0.79$	$8.05^{a}\pm1.05$

[a-d:] Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).

Key: CMF(100:0) = 100% cocoyam : 0% mung bean flour, CMF (90:10) = 90% cocoyam : 10% mung bean flour, CMF (80:20) = 80% cocoyam : 20% mung bean flour, CMF (70:30) = 70% cocoyam : 30% mung bean flour, CMF (60:40) = 60% cocoyam : 40% mung bean flour, CMF (50:50) = 50% cocoyam : 50% mung bean flour

The mean scores for taste of the *fufu*-like products ranged from 6.45 to 7.55. There was a slight differences ($p<0.05$) among the mean scores for taste, with *fufu*-like products made from cocoyam:mung bean (90:10) and (70:30) flours having the same mean score significantly ($p>0.05$). *Fufu*-like product made from cocoyam:mung bean (50:50) flour had the highest mean score for taste while the least mean score for taste was recorded in *fufu*-like product made from cocoyam:mung bean (90:10) flour. Taste refers to the proximal sense that requires direct contact of food with stimuli on the tongue to determine the quality of the ingested food (Romagny *et al*., 2017). The highest mean score for taste recorded in *fufu*-like product made from cocoyam:mung bean (50:50) flour could be attributed to the fact that it possessed highest fat content. This claim is in line with the report by Rios *et al.* (2014) that in addition to influencing rheological properties of food products, fat positively affects their taste. However, the range of mean score for taste obtained in this study was higher than the range of mean score for taste (6.50 to 7.50) obtained in *fufu* analog produced from cassava and cocoyam flour blends (Bamidele *et al*., 2015), and the range of mean score for taste (4.95 to 7.57) obtained in *fufu* analog produced from sweet cassava and guinea corn flour blends (Awolu *et al*., 2020). These variations in taste could be ascribed to the fact that their raw materials differed. Interestingly, the mean scores for taste in the *fufu*-like product made in this study translates from "liked slightly" to "liked moderately" according to 9-point hedonic scale (Iwe, 2014).

The mean scores for texture of the *fufu*-like products ranged from 6.50 to 7.70. There was no significant difference ($p>0.05$) in the texture of the *fufu*-like products made from cocoyam:mung bean

(100:0) and (90:10) flours, *fufu*-like products made from cocoyam:mung bean (80:20) and (70:30)flours, and *fufu*-like products made from cocoyam:mung bean (60:40) and (50:50) flours. *Fufu*-like product made from cocoyam:mung bean (50:50) flour had the highest mean score for texture while the least mean score for texture was recorded in *fufu*-like product made from cocoyam:mung bean (100:0) flour. Texture is the functional and sensory manifestation of surface, mechanical and structural properties of foods that are detected through kinesthetic, vision, hearing and touch (Tauferova *et al*., 2015). The highest mean score of texture obtained in *fufu*-like products made from cocoyam:mung bean (50:50) flour could be attributed to the effect of highest proportion of mung bean flour and as well possess higher fat content. This is in accordance with the statement that important attributes such as texture are influenced by the droplets of fat, and these characteristics are paramount to the consumer and consequently crucial to the success of the product in the market (Rios *et al.*, 2014). The range of mean scores for texture obtained in this study were higher than the range of mean scores for texture (6.24 to 7.21) obtained in *fufu* substituted with cooking banana and African yam bean as reported by Ogbonnaya *et al*. (2018), and the range of mean scores for texture (5.00 to 7.40) for reconstituted cassava-African yam bean seeds *fufu* flour blends as reported by Nwokeke *et al.* (2013). These notable differences in the panelists rating for texture of the *fufu*-like products could be ascribed to the fact that their raw materials differed. The mean scores for texture of all the *fufu*-like products were rated "liked moderately" to "liked very much" according to 9-point hedonic scale (Iwe, 2014).

The mean scores for mouldability of the *fufu*-like products ranged from 6.15 to 7.90. There was significant difference ($p<0.05$) in the panelists' rating for mouldability of the *fufu*-like products except for samples made from cocoyam:mung bean (80:20) and (70:30) flours, and *fufu*-like products made from cocoyam:mung bean (60:40) and (50:50) flours in which their mean scores for mouldability were not significantly different ($p>0.05$) from each other. *Fufu*-like product made from cocoyam:mung bean (50:50) flour had the highest mean score for mouldability while the least mean score for mouldability was recorded in sample made from cocoyam:mung bean (90:10) flour. Mouldability is one of the quality attributes consumers' look out for in *fufu*, as they desire a product that can be easily reshaped and/or moulded. The highest mean score of mouldability obtained in *fufu*-like products made from cocoyam:mung bean (50:50) flour could be attributed to the positive contribution of its higher fiber content compared to other samples. This correlate with the assertion that fibre content of *fufu* have impact in its mouldability (Chijioke *et al*., 2021). The range of mean score for mouldability (6.19 to 7.57) obtained in *fufu* analog produced from sweet cassava and guinea corn flour blends (Awolu *et al*., 2020) was lower than the values obtained in this study. The differences was expected considering that they were processed from different raw materials. The range of mean score for mouldability obtained in this study translates from "liked slightly" to "liked very much" in accordance with the 9-point hedonic scale (Iwe, 2014).

The *fufu*-like products had their mean scores for general acceptability ranged from 6.65 to 8.05. There was significant difference ($p<0.05$) in the panelists rating for general acceptability of the *fufu*-like products. *Fufu*-like product made from cocoyam:mung bean (50:50) flour had the highest mean score for general acceptability while the lowest mean score for general acceptability was recorded in sample made from cocoyam:mung bean (90:10) flour. The result revealed that the score for general acceptability slightly increased with increase in the proportion of mung bean flour. Food acceptability directly relates to the interaction food has with the consumer at a given moment in time (Maina, 2018). The highest mean score of general acceptability obtained in *fufu*-like product made from cocoyam:mung bean (50:50) flour could be attributed to the fact that it had the highest mean score of appearance, taste, texture and mouldability. This is in accordance with the assertion that the sensory characteristics of food such as taste, texture and appearance have distinct and influential effects on food acceptability (Piqueras-Fiszman, and Spence, 2015). The mean scores for general acceptability obtained in this study was higher than the values (6.50 to 7.43) obtained in *fufu* substituted with cooking banana and African yam bean (Ogbonnaya *et al*., 2018). The panelists rated general acceptability of the samples from "liked moderately" to "liked very much" according to 9-point hedonic scale (Iwe, 2014).

Conclusion

This study showed that flour and *fufu*-like products of enhanced quality can be produced from blends of cocoyam and mungbean seeds. In terms of functional properties, proximate composition and physicochemical properties of the flours, flour produced from cocoyam:mung bean (100:0) had the highest bulk density, gelatinization temperature, carbohydrate, specific gravity, total titratable acidity and turbidity.

Flour produced from cocoyam:mung bean (90:0) had the highest moisture content, while flour produced from cocoyam:mung bean (60:40) had the highest water absorption capacity. The highest value of wettability, crude protein, fat, crude fibre, ash and pH was recorded in flour produced from cocoyam:mung bean (50:50). The result obtained in the sensory evaluation of the *fufu*-like product showed that all the samples were liked by the panelists with *fufu*-like product made from flour blends of cocoyam:mung bean (50:50) having the highest mean scores for appearance, taste, texture, mouldability and general acceptability.

Composite flours from cocoyam and mungbean especially cocoyam:mung (50:50) flour and their *fufu*-like products are highly recommended due to their high enhanced nutrients and acceptability. The developed cocoyam and mungbean composite flour can be incorporated into our diet to prevent protein-energy malnutrition in Nigeria and other African countries where products from root crops such as cocoyam are staples. Further study should be carried out on the antinutrient contents of the *fufu*-like product.

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