International Journal of Food Science and Nutrition
www.foodsciencejournal.com
ISSN: 2455-4898
Received: 03-04-2023, Accepted: 17-04-2023, Published: 03-05-2023
Volume 8, Issue 2, 2023, Page No. 17-24

Evaluation of the Functional, Proximate and Pasting Properties of Cocoyam *(Xanthosoma sagittifolium)* and Soybean (*Glycine max* L*)* Composite Flour

Patience Chisa Obinna-Echem*, Miracle Ogbuagha
Department of Food Science and Technology, Rivers State University, NKpolu-Oroworukwo, Port Harcourt, Rivers State, Nigeria

Abstract
Functional, proximate and pasting properties of cocoyam (*Xanthosoma sagittifolium*) and soybean (*Glycine max* L) flour blends as ingredients for the production of pancakes was evaluated. Six blends designated as CS1, CS2, CS3, CS4, CS5 and CS6 were prepared by mixing cocoyam and soybean flour in the percentage of 95:5, 90:10, 85:15, 80:20, 75:25 and 70:30 respectively, while 100% wheat (WF) and 100% cocoyam (CF) flours served as the control. Standard analytical methods were used for all analysis. Least gelation capacity, swelling power, water absorption capacity, oil absorption capacity, bulk density and dispersibility of the cocoyam-soybean flour blends ranged respectively, from 5.00 – 9.00 %, 3.50 – 11.00 g/g, 1.85 – 3.20 g/g, 1.64 – 3.05 g/g, 0.71 – 0.87 g/cm^3 and 23.00 – 34.00%. Addition of soybean flour to cocoyam flour led to significant (P<0.05) increase in the contents of protein (13.56 – 20.85%), ash (2.48 – 5.97%), and crude fibre (2.40 – 6.00%); decrease in carbohydrate (52.09 – 70.58%) and energy (372.72 – 386.06 Kcal/100g) while there was no significant (P>0.05) variation in moisture (5.40 – 6.24%) content. Values for the pasting properties ranged from 145.96 - 342.80, 99.25-196.78, 46.71-146.01, 143.88 - 344.00 and 44.68 -147.22 RVU respectively, for peak, trough, breakdown, final and setback viscosities; pasting time and temperature ranged from 4.90 - 5.04 min and 86.56 – 87.78^{o}C respectively. The result revealed that the cocoyam-soybean flour blends had good functional and pasting properties with improved nutrient content. Flour samples with 5 – 20% soybean flour will be able to withstand disintegration during food preparation, which is desirable for pancake making.

Keywords: cocoyam flour, soybean flour, functional properties, proximate composition, pasting properties

Introduction

Cocoyam *(Xanthosoma sagittifolium)* is an edible root crop grown in the tropics of which Nigeria is a major producer (Okpalan and Egwu, 2015) [30]. Cocoyam contributes a significant portion of the carbohydrate content of the diet in many regions in developing countries from its edible starchy corms or cornels (Kabuo *et al*., 2018) [2]. The protein content of cocoyam is more than that of other root and tuber crops and its starch is highly digestible. It is also a reasonable source of vitamins and minerals (Kabuo *et al*., 2018) [2]. Cocoyam is used as subsistence staples in many parts of the tropics and sub-tropics. Almost every part of the cocoyam: the leaves, stalks, corms, cornels is utilized for food. Cocoyam corm can be consumed in various forms. It can be boiled or roasted and eaten with palm oil sauce, fried into chips, cooked and pounded for swallow or used as thickeners for soups. Processing cocoyam into various forms such as flour, chips, sun-dried slices, grits, flakes and beverage powders as reported by Owuamanam *et al*., 2010 [33] will make for a useful ingredient to be used in other food production.

Soybean (*Glycine max* L.) is a leguminous plant widely grown for its edible bean which has numerous uses. It is a good source of vitamins and mineral and an excellent source of protein (about 35 – 45%) with all essential amino acid required for proper growth and maintenance of the body (Zhao *et al.*, 2014; Ojinnaka and Nnorom, 2015) [40, 28]. Soybean is usually processed and used as an essential part of functional foods and for enrichment of product quality (Admad *et al*., 2014) [4]. The main ingredient of many bakery products is wheat, which has deficiency of essential amino acid lysine. Soybean is richer in lysine and can be complemented to wheat or any other flour in bakery products. The addition of soybean flour to cocoyam may improve the protein quality of the flour and make it useful in the production of products such as pancakes with improved nutritional status.

Based on the nutritional advantages, availability and economic value of cocoyam and soybean, in addition to the fact that there is little information on the use of composite flour from cocoyam and soybean, it is therefore important that cocoyam-soybean flour blend be evaluated for use in the production of confectionaries such as pancakes in the food industry. Functional properties of composite flours play essential role in the manufacturing of food products. It determines whether the blends would be useful in bakery products where hydration is needed to improve the handling desired (Mepba *et al*., 2007) [24]. There are studies on the properties of cocoyam flour (Falade and Okafor, 2015; Olagunju *et al*., 2018; Salami *et al*., 2018; Wada *et al*., 2019) [14, 31, 36, 38]. Ojo *et al*., (2022) [29] evaluated the sensory properties of *amala* dumbling from cocoyam (*Colocasia esculenta*) and soybean flour blends. The need for more utilization of different varieties of cocoyam has led to this evaluation of the functional, proximate and pasting properties of cocoyam (*Xanthosoma sagittifolium*) and soybean (*Glycine max*) flour blends as ingredients for the production of pancakes.

Materials and Methods

Samples and Reagents

Cocoyam *(Xanthosoma sagittifolium)* corms and soybean seed (*Glycine max*) were purchased from Mile 1 market in Port Harcourt Rivers State. Chemicals and reagent (sulfuric acid, hydrochloric acid, iodine reagent etc.) were obtained from the Department of Food Science and Technology, Rivers State University, Port Harcourt, Rivers State, and were of analytical grade.

Production of Cocoyam Flour

Cocoyam flour was prepared according to the method described by Kabuo *et. al.*, (2018) [17]. Fresh corms were washed, peeled, rewashed and shredded into thin slices. The slices were blanched with Sodium metabisulphite for 5 min, dried at 70ºC for 10 h and then milled using a disc attrition mill. The flour was sieved using 0.4 mm sieve, packaged in an airtight container and kept in a cool dry place for further use.

Production of Soybean Flour

Soybean flour was prepared according to the method described by Ndife *et. al.,* (2011) [25]. Soybean seeds were sorted, washed, soaked, dehulled manually, oven-dried at 70ºC for 10 h, milled in a disc attrition mill to obtain the flour. The flour was sieved using a 300 μm aperture sieve and kept in an airtight container for further use.

Formulation of Blends

Six blends designated as CS1, CS2, CS3, CS4, CS5 and CS6 were prepared by mixing cocoyam flour and soybean flour using an electric blender in the percentage of 95:5, 90:10, 85:15, 80:20, 75:25 and 70:30 respectively, while hundred percent (100%) wheat (WF) and hundred percent (100%) cocoyam (CF) flours served as the control.

Determination of Functional Properties of Cocoyam-Soybean Flour Blends

Least Gelation Concentration

Least gelation concentration (LGC) of the sample was determined by the method of Abu *et. al., (*2005) [1]**.** Sample suspensions of 2 - 20% (w/w) for each composite flour blend were prepared in distilled water and the dispersion was transferred into a test tube. It was heated in boiling water bath for 1 h and rapidly cooled in a bath of cold water. The test tubes were further cooled at 4ºC, for 2 h. The least gelation concentration is the concentration the sample did not fall down or slip when the test tube was inverted.

Swelling Power

The method described by Ayo *et al*., (2015) [8] was adopted in the determination of the swelling power of the cocoyam-soybean flour blends. The flour (1g) was mixed with 10 ml of distilled water in a centrifuge tube and heated to 80ºC and held for 30 min with continuous shaking. The heated suspension was centrifuged at 1000 x g for 15 min. The weight of the the sediment was taken. Swelling capacity (g/g) was calculated by dividing the sediment weight with the sample weight.

Water and Oil Absorption Capacity

The water and oil absorption capacity was determined according to the method described by Dwiani *et al.,* (2014) [13]. To 1 g of sample (W_0) in a pre-weighed 15 ml centrifuge tubes (W_1), was added 10 ml of distilled water and thoroughly wetted using a vortex for 2 min. After 30 min of standing at room temperature the sample was centrifuged at 3000 rpm for 25 min at 20ºC. The supernatant was decanted and the centrifuge tube containing sediment weighed (W_2). Oil was used in place of water for oil absorption capacity. Water and oil absorption capacity (grams of water or oil per gram of sample) was calculated by dividing the weight of sediment by the sample weight.

Bulk Density

Bulk density was determined according to the standard method of AOAC, (2012) [5]. Briefly, 5 g of the sample was added to a 20 ml graduated measuring cylinder. The cylinder was tapped gently until the samples was closely packed. The volume occupied by the sample was noted and the bulk density (g/ml) was expressed as weight of sample (g) divided by volume of sample (ml).

Dispersibility

Dispersibility was determined using the method described by Onwuka, (2005) [32]. Ten grams (10 g) of each powder was weighed and placed in a 100 ml measuring cylinder followed by the addition of distilled water up to the 100 ml mark. The sample was vigorously stirred, mixed and allowed to settle for 3 h. The volume of the settled particles was recorded and subtracted from 100 to give a difference which is considered as percentage dispersibility.

Proximate Composition of Cocoyam-Soybean Flour Blends

Standard AOAC, (2012) [5] was used in the determination of moisture, protein, fat, ash and crude fibre content of the flours. Briefly, moisture was determined by drying the samples in a hot air oven (DHG 9140A) at 70ºC until a constant weight was obtained. The crude protein content was determined by kjeldahl method and a nitrogen conversion factor of 6.25 was used. Soxhlet extraction method with ethyl ether was used for fat determination. Ash content was determined gravimetrically after the incineration of the samples in a muffle Furnace (Model SXL) at 550ºC for 2 h. Enzymatic gravimetric method was utilized in the determination of crude fibre. Carbohydrate was calculated by difference {100 - (Crude protein + crude fibre + ash + fat)}. Energy values were obtained using Atwater factor of 4 Kcal/g for protein and carbohydrate and 9 Kcal/g for fat.

Pasting Properties of Cocoyam-Soybean Flour Blends

Pasting properties of the cocoyam-soybean flour blends samples was determined using a Rapid Visco Analyzer (Model RVA-4; New Port Scientific Pty. Ltd, Warrie wood, Australia) as described by Obinna-Echem *et al.,* (2019) [27]. Briefly, 3 g of the flour samples were weighed into a dried empty canister; 25 ml of distilled water was dispensed into the canister containing the sample. The mixture was thoroughly stirred and the canister was fitted into the RVA following the manufacturer’s instructions. Measurement cycle was initiated: heating from 50 to 90ºC with a holding time of 2 min followed by cooling to 50ºC with 2 min holding time. The rate of heating and cooling were at a constant rate of 11.25ºC min^{-1}. The pasting parameters: peak viscosity, trough, final viscosity, breakdown and setback viscosities (RVU), peak time (min) and peak temperature (°C) were read from the computer with the aid of Thermo cline for windows software.

Statistical Analysis

Experiments were carried out in duplicates and the means calculated were subjected to analysis of variance (ANOVA) using Minitab (Release 18.0) under the general linear model and turkey pairwise comparison at 95% confidence level.

Results and Discussion

Functional Properties of cocoyam-soybean flour

Functional properties of the composite cocoyam-soybean flour that were evaluated include least gelation capacity (LGC), swelling power (SP), water absorption capacity (WAC), oil absorption capacity (OAC), bulk density and dispersibility as shown in Figure 1, 2 and 3.

Least gelation capacity (Figure 1) ranged from 6 - 10%. There was no significant (P>0.05) difference amongst the samples. LGC, defined as the lowest protein concentration at which gel remained in the inverted tube was used as an index of gelation capacity. It is used to measure the ability of protein to form a gel, whereby a lower least gelation concentration suggests a better gelling capacity [14]. LGC of the flours is an indication of their protein to form gels. The LGC of the flour in this study were low compared to LGC of various legume flours (12 - 14%) reported by Maninder *et al.*, (2007) [20]. The lower the LGC, the better the gelating ability of the protein ingredient.

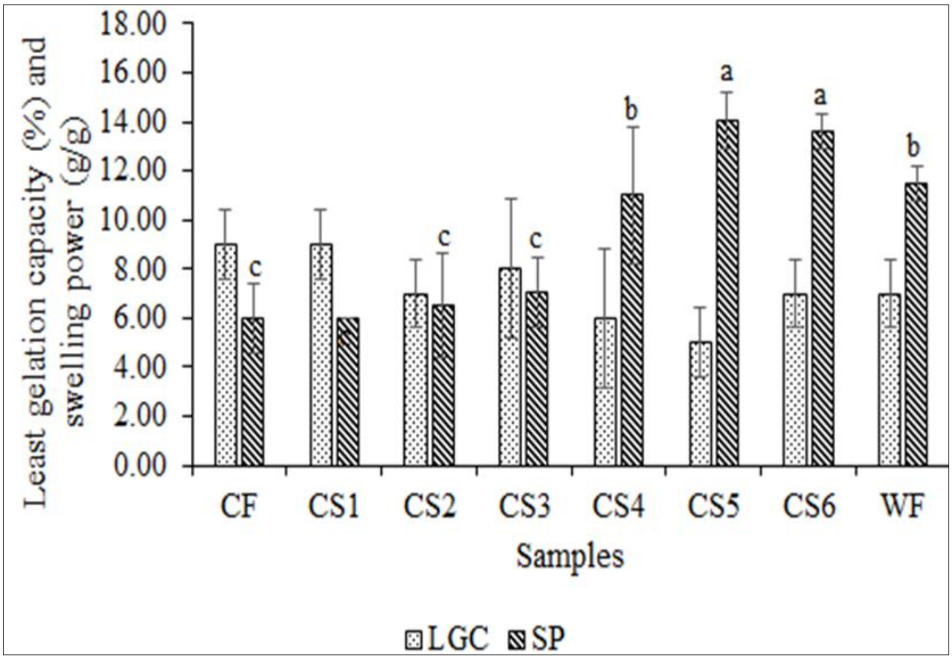

Fig 1: Least Gelation Capacity (%) and Swelling Power (g/g) of the Cocoyam-Soybean Flour Blends

Columns and error bars are means ± standard deviation of duplicate samples.
SP columns with different letters differed significantly (P<0.05) while there was no significant (P>0.05) difference in the LGC.
CF1 = 100% cocoyam flour
CS1 = 95% cocoyam and 5% soybean flour
CS2 = 90% cocoyam and 10% soybean flour
CS3 = 85% cocoyam and 15% soybean flour
CS4 = 80% cocoyam and 20% soybean flour
CS5 = 75% cocoyam and 25% soybean flour
CS6 = 70% cocoyam and 30% soybean flour
WF = 100% wheat flour

Swelling power of the samples ranged from 6.00 - 14.5 g/g (Figure 1). Sample CS1 with 5% soybean flour had significantly (P<0.05) the least value and sample CS5 with the 25% soybean flour had the highest. The swelling power of the cocoyam flour is in the range reported by Falada and Okafor (2018) [14]. Soybean has been reported to have a swelling power of 4.82 g/g by Ratnawati *et al*., (2019) [35]. This could explain the increased in swelling power with increase in soybean addition. Some values for the composite flour reported in this study were higher than values of 9.10 g/g for cocoyam flour reported by Salami *et al.*, (2018) [36]. This indicates that the starch granules of the composite flour have better tendency to swell and soften. Water absorption capacity (WAC) refers to the water retained by a product following filtration and centrifugation (Falada and Okafor 2018; Köhn *et al*., 2015) [14; 18]. WAC of the flour (Figure 2) varied significantly from 1.60 – 3.60 g/g respectively, for sample CF (100% cocoyam flour) and CS3 with 15% soybean flour. WAC of the cocoyam-soybean composite flour was significantly (P<0.05) higher than the controls (100% cocoyam flour and 100% wheat flour). The addition of soybean flour resulted in increase in WAC of the composite flour. Appiah *et al.,* (2011) [6] reported that protein concentration influences the WAC of the flour. The hydrophilic end of protein prevents the loss of water during processing and storage of food (Ratnawati *et al*., 2019) [35]. WAC of legumes such as soybean, mung bean and red bean flour was reported to be 4.07, 3.60 and 4.39 g/g respectively by Ratnawati *et al*., (2019) [35] while that of cocoyam in this study was 1.60 g/g. The increase in WAC of the composite flour could therefore be attributed to the soybean flour and its protein content. High water absorption capacity indicates that such flour will be useful in the formulation of some foods such as pancakes and other bakery products (Chandra *et al*., 2015) [10].

The oil absorption capacity (OAC) of the samples as shown in Figure 2, ranged from sample 1.72 - 3.67 g/g. Sample CS6 with 30% soybean flour had significantly (P<0.05) least OAC while sample CF (100% cocoyam flour) had the highest value. The trend was a decrease in OAC with the addition of soybean flour. The result was comparable with what was reported by Peter-Ikechukwu *et al.*, (2018) [34] for cocoyam soybean flour. OAC is the physical entrapment of oil in the product and indicates the rate at which protein binds to fat in food formulations. This is important in flavour retention, mouth-feel and improvement of palatability Falada and Okafor (2018) [14]. The result of this study implies that the composite flour may not pick up much oil during frying which will be a good attribute for the use of the composite flour in pancake production.

Bulk density of the samples shown in Figure 2, ranged from 0.75 - 0.82 g/cm^3 for sample CS4 with 20% soybean flour and CS1 with 5% soybean flour. This value agrees with the report made by Peter-Ikechukwu *et al.,* (2018) [34] on the bulk density of cocoyam wheat and soybean flour (0.77 - 0.82 g/cm^3) but higher than 0.51 g/cm^3 of soybean flour. Bulk density is a measure of heaviness of solid samples, which is important for determining packaging requirements, material handling and application in the food industry Falada and Okafor (2018) [14]. High bulk density of flour suggests their suitability for use in food preparations and it does not take up too much space when distributing and decreases packaging costs (Chandra *et al*., 2015) [10]. Flour with high bulk densities are used as thickeners in food products while those with low bulk density can be useful in formulation of complementary foods. In Figure 3, dispersibility of the samples varied rom 23 – 35%. Dispersibility of the wheat flour sample significantly (P<0.05) the least and there was no significant P>0.05) variation among the cocoyam flour and the blends. Dispersibility is the measure of reconstitution of flour in water. The higher dispersibility of the cocoyam and the composite flour implies better reconstitution in water. Higher dispersibility will give a fine consistency during mixing (Adebowale *et al*., 2008; Adebowale *et al*., 2012) [3, 2]. This is a desirable quality for a pancake mix.

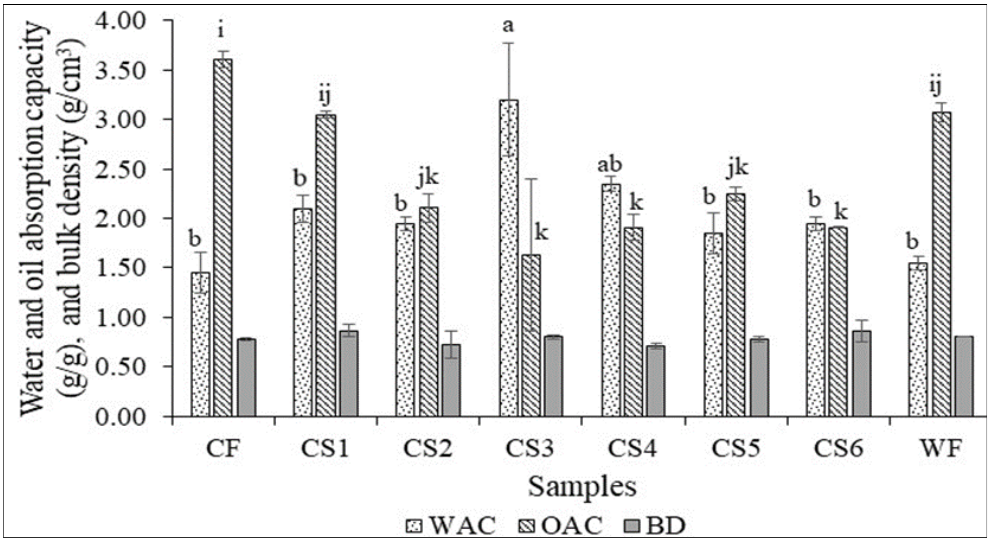

Fig 2: Water Absorption Capacity (g/g), Oil Absorption Capacity (g/g) and Bulk Density (g/cm^3) of the Cocoyam-Soybean Flour Blends

Columns and error bars are means ± standard deviation of duplicate samples. WAC and OAC columns with different letters differed significantly (P<0.05) while there was no significant (P>0.05) difference in the BD.

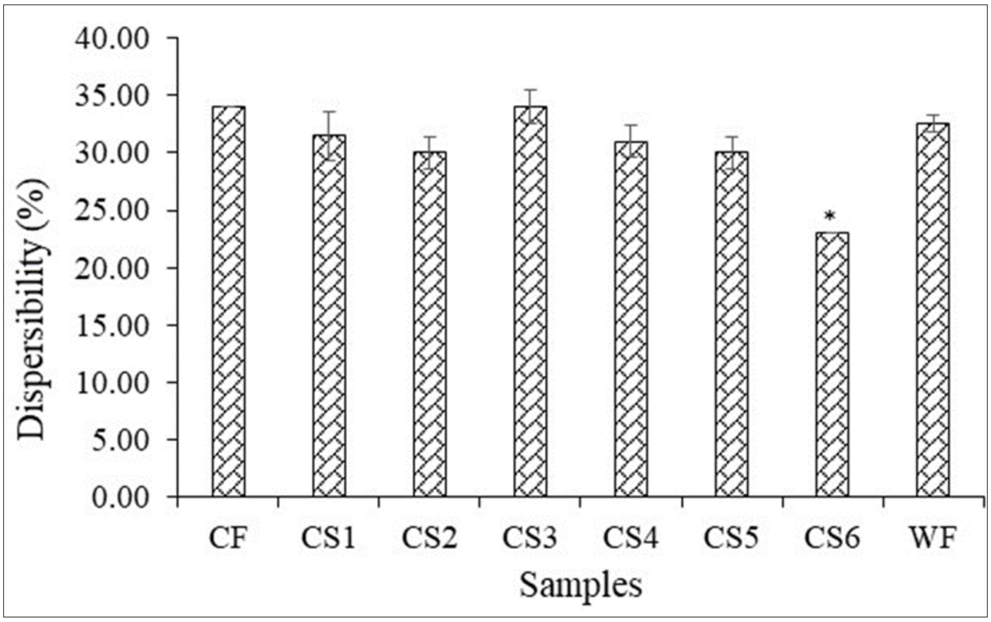

Fig 3: Dispersibility of the Cocoyam-Soybean Flour Blends

Columns and error bars are means ± standard deviation of duplicate samples.
* Sample CS6 is significantly (P<0.05) different from others that did not vary significantly.
CF1 = 100% cocoyam flour
CS1 = 95% cocoyam and 5% soybean flour
CS2 = 90% cocoyam and 10% soybean flour
CS3 = 85% cocoyam and 15% soybean flour
CS4 = 80% cocoyam and 20% soybean flour
CS5 = 75% cocoyam and 25% soybean flour
CS6 = 70% cocoyam and 30% soybean flour
WF = 100% wheat flour

Proximate Composition of Cocoyam-Soybean Flour Blends

Proximate composition of the cocoyam-soybean flour blends is shown in Table 1. The moisture content of the wheat flour (8.25%) was significantly (P<0.05) higher than the test samples. There was no significant (P>0.05) difference in the moisture content of the 100% cocoyam flour (4.75%) and cocoyam–soybean flour blends. The values ranged from 5.46 - 6.10%. This moisture content is below the maximum of 15.5% recommended by CODEX (CS 152-1985) [12], and is an advantage as low moisture content will enhance the shelf life of the flour.

The protein content of the samples ranged from 11.38 - 20.85% for sample CF (100% cocoyam flour) and CS6 with 30% of soybean flour. The protein content of the flour blends increased with increase in soybean flour addition, which is an indication of improved protein value in the blends. Proteins are building blocks and foods that are rich in protein are known to reduce protein energy malnutrition. Protein plays important role in providing structure and texture to food and improves water retention (Jideani 2011) [16]. Flour blends with higher protein content will therefore play a good role in the texture of the product to be made with it.

Table 1: Proximate Composition (%) and Energy Content (Kcal/100g) of the Cocoyam-Soybean Flour Blends

Samples	Moisture	Protein	Fat	Ash	Crude Fiber	Carbohydrate	Energy
CF	4.75^{b}±0.35	11.38^{e}±0.00	4.00^{cd}±0.00	2.49^{d}±0.72	5.40^{ab}±1.41	71.98^{a}±0.34	369.44^{ab}±1.36
CS1	5.46^{b}±0.67	13.56^{de}±1.06	5.50^{bcd}±0.70	2.48^{d}±0.70	2.40^{c}±0.00	70.58^{a}±0.34	386.06^{a}±3.48
CS2	6.24^{b}±0.35	15.75^{cd}±0.00	6.00^{bcd}±0.00	2.50^{d}±0.71	2.90^{bc}±0.71	66.61^{b}±0.37	383.44^{a}±1.47
CS3	5.74^{b}±0.35	16.78^{c}±0.04	6.50^{abc}±.071	3.98^{c}±0.03	3.40^{bc}±1.41	63.61^{c}±0.38	380.04^{ab}±7.69
CS4	5.75^{b}±0.35	17.94^{bc}±1.06	7.50^{ab}±0.71	4.48^{bc}±0.67	4.40^{ab}±0.00	59.94^{d}±1.45	379.00^{ab}±4.81
CS5	6.05^{b}±0.64	20.13^{ab}±0.00	8.00^{ab}±0.00	5.47^{ab}±0.67	4.50^{ab}±0.14	55.86^{e}±0.16	375.94^{ab}±0.66
CS6	6.10^{b}±0.14	20.85^{a}±1.01	9.00^{a}±1.41	5.97^{a}±0.04	6.00^{a}±0.57	52.09^{f}±0.26	372.72^{ab}±9.73
WF	8.25^{a}±0.35	15.75^{cd}±0.00	3.50^{d}±0.71	1.00^{e}±0.00	4.40^{ab}±0.00	67.10^{b}±1.06	362.90^{b}±2.12

Values are means ± standard deviation of duplicate samples. Means with the same superscript along the column are not significantly (P>0.05) different
CF1 = 100% cocoyam flour
CS1 = 95% cocoyam and 5% soybean flour
CS2 = 90% cocoyam and 10% soybean flour
CS3 = 85% cocoyam and 15% soybean flour
CS4 = 80% cocoyam and 20% soybean flour
CS5 = 75% cocoyam and 25% soybean flour
CS6 = 70% cocoyam and 30% soybean flour
WF = 100% wheat flour

There was significant variation in the fat content of the samples. The value ranged from 5.50 – 9.00% for the test samples, where sample CS1 and CS6 had the least and highest values respectively. The cocoyam and wheat flour had fat content of 4.00 and 3.50% respectively. The increase in soybean flour resulted in increase in fat content of the flour. This observation is similar to the observation made by Arukwe, (2020) [7]. This could be attributed to the undefatted soybean flour used. Fat content of 24.9 - 30.31% has been reported for soybean flour (Farzana and Mohajan, 2015; Bayero *et al*., 2019) [15, 19] and 2.38 – 4.90 % was reported for cocoyam flour (Obadina *et al*., 2016; Coronell-Tovar *et al*., 2019) [26, 11]. The increase in fat content of the sample could be an added advantage as fats supplies essential fatty acids and are known to enhance flavour.

Ash content of the cocoyam flour (2.49%) and the test samples CS1 – CS6 (2.48 - 5.97%) where significantly (P<0.05) higher than the wheat flour (1.00%). There was significant (P<0.05) increase in ash content with increase in soybean flour. Ash content is a measure of mineral content of the food and the higher value of the ash in the blends could imply more mineral content which is good for various benefits of mineral to the body.

Crude fibre content of the samples varied significantly (P<0.05) from 2.40 – 6.00%. Sample CS1 with 5% soybean flour had the least and sample CS1 with 30% soy bean flour had the highest value. Consumption of food rich in dietary fibre have been reported to reduce the risk of diabetes mellitus, cancer, cardiovascular diseases, constipation, colon etc. (Yang *et al*., 2012; McRae. 2017; McRae, 2018; Masrul and Nindrea, 2019) [39, 23, 22, [21]. Utilization of the cocoyam-soybean flour will therefore, be good for its dietary fibre content.

Carbohydrate content ranged from 52.09 – 71. 98%. Sample CF (100% cocoyam flour) had significantly (P<0.05) the highest content of carbohydrate and sample CS6 with 30% soybean flour had the least. The increase in addition of soybean flour resulted in decrease in the carbohydrate content. This was expected as cocoyam is a good source of carbohydrate, predominantly starch and are consumed as energy yielding food. Cocoyam contains about 70.24 – 74.23 % of carbohydrate (Obadina *et al*., 2016) [26] as against 5.08% reported for soybean flour Coronell-Tovar *et al*., 2019) [11]. The reduction in the quantity of cocoyam and replacement with soybean resulted in significant (P<0.05) decrease. This would be accepted for low calorie products. There was no significant (P>0.05) difference in the energy content of the samples. The values ranged from 369.44 – 372.72 Kcal/100g for sample CF and CS6 respectively. Wheat flour had energy content of 362.90 Kcal/100g. The energy value of the flour was not just a function of the carbohydrate content but of protein and fat as well. The energy content was comparable to that of cocoyam flour reported by Wada *et al*., (2019) [38].

Table 2: Pasting Properties of the Cocoyam-Soybean Flour Blends

Samples	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (Min)	Peak Temperature (^{0}C)
CF	342.80^a±16.7	196.78^a±8.79	146.01^a±8.71	344.00^a±14.6	147.25^a±0.01	4.97^b±0.05	86.56^b±0.01
CS1	314.94^{ab}±7.27	181.76^{ab}±4.47	133.24^{ab}±2.74	314.70^{ab}±2.70	132.98^{ab}±2.15	4.93^b±0.00	86.98^b±0.53
CS2	271.91^{bc}±10.4	161.13^{bc}±8.16	110.79^{bcd}±1.82	275.34^{bc}±5.50	114.21^{bc}±3.13	5.04^b±0.05	87.38^b±0.03
CS3	242.12^{cd}±1.11	145.82^c±0.10	96.29^d±1.00	241.88^c±1.30	96.05^c±1.23	5.04^b±0.05	87.35^b±0.07
CS4	309.10^{ab}±19.9	179.72^{ab}±7.74	129.41^{abc}±12.1	310.90^{ab}±14.8	131.21^{ab}±7.13	5.04^b±0.00	87.40^b±0.60
CS5	164.69^{ef}±0.55	101.27^d±9.28	63.48^e±8.80	158.38^d±7.71	57.13^d±1.59	4.90^b±0.00	87.78^b±0.56
CS6	145.96^f±4.30	99.25^d±2.47	46.71^e±1.82	143.88^d±7.25	44.63^d±4.77	4.93^b±0.00	87.70^b±0.56
WF	204.40^{de}±23.7	101.17^d±14.4	103.26^{cd}±9.67	234.90^c±2.45	133.71^{ab}±10.4	5.97^a±0.05	94.56^a±0.17

Values are means ± standard deviation of duplicate samples. Means with the same superscript along the column are not significantly (P>0.05) different.
CF1 = 100% cocoyam flour
CS1 = 95% cocoyam and 5% soybean flour
CS2 = 90% cocoyam and 10% soybean flour
CS3 = 85% cocoyam and 15% soybean flour
CS4 = 80% cocoyam and 20% soybean flour
CS5 = 75% cocoyam and 25% soybean flour
CS6 = 70% cocoyam and 30% soybean flour
WF = 100% wheat flour

Pasting Properties of Cocoyam Soybean Flour Blends

Pasting properties of cocoyam-soybean flour blend are shown in Table 2. There was significant (P<0.05) decrease in the peak, trough, breakdown, final viscosity and setback of the samples with increase in soybean addition. The values ranged from 145.96 - 342.80, 99.25-196.78, 46.71-146.01, 143.88 - 344.00 and 44.68 -147.22 RVU respectively, for the peak, trough, breakdown, final viscosity and setback. The pasting time (4.90 - 5.04 min) and temperature (86.56 – 87.78^{o}C) did not vary significantly (P>0.05) amongst the test samples but were significantly (P<0.05) lower than that of wheat flour (5.97 min and 94.56^{o}C).

The pasting properties of a food refer to the changes that occur in the food as a result of application of heat in the presence of water. These changes affect texture, digestibility, and end use of the food product. The decrease in peak viscosity could be related to a decrease in starch content with the increase in soybean flour, as well as interactions between the starch, fat, and protein levels of the blends. Peak viscosity has been linked to starch's water binding capacity, which occurs at a point where swelling causes an increase in viscosity while rupturing and realignment create a decrease Sanni et ai., (2001) [37]. The trough viscosity measures the ability of the paste to withstand breakdown during cooling Obinna-Echem *et al*., (2019) [27]. The cocoyam flour showed ability to withstand breakdown during cooling than the blends with increase in soybean flour. This implies that starch content of the flour blends will easily loss their integrity and rupture on cooling. The breakdown viscosity is actually the difference between the peak viscosity and the trough. It is a measure of paste stability such that the higher the breakdown the higher the resistance to disintegration of the paste Kumar and khatkar, (2017) [19]. The result indicates that 100% cocoyam flour and the samples with 5 – 20% soybean flour will be able to withstand disintegration during the use of the flour blend for food preparation. This is in line with the value of the swelling power (6.00 - 14.5 g/g) that showed higher tendency of flour with high soybean content to swell and soften. Final viscosity marks the ability of the flour to form gel after cooking and cooling, while setback viscosity indicates the viscosity on cooling Obinna-Echem *et al*., (2019) [27]. Glucan chains of starch molecules during cooling, entangled to each other forming a gel and increase in the paste viscosity. The 5 - 20% addition of soybean flour to cocoyam flour had high final and setback viscosities which could imply better gel formation on cooling for a firmer pancake. Pasting temperature is the temperature (^{o}C) at which cooking begins while the pasting time indicates the time (min) at which the viscosity peaks. There was no significant difference in the pasting temperature and time of the flours blends. This implies that regardless of the quantity of soybean flour added they will form gel at the same range of temperature and time. The wheat flour will require higher temperature and time to cook.

Conclusion

The result revealed that the cocoyam-soybean flour blends had the good gelating, swelling and water absorption ability with low oil absorption capability, which is a desirable quality for pancake mix. Addition of soybean flour to cocoyam flour led to significant (P<0.05) increase in the contents of protein, ash, and crude fibre; decrease in carbohydrate and energy while there was no significant (P>0.05) variation in moisture content. The pasting properties of the flour blends showed their ability to withstand application of heat in the presence of water. They were able to form gel at the same range of temperature and time. Significantly, blends with 5 – 20% soybean flour will be able to withstand disintegration during food preparation, which is desirable for pancake making.

Acknowledgements

The authors appreciate the technical assistance of Dr Friday Owuno of the analytical laboratory of Food Science and Technology, Rivers State University, Port Harcourt.

References

1. Abu JO, Muller K, Duodu KG, Minnaar A. Functional properties of cowpea (*Vigna unguiculata* L) flours and pastes as affected by γ irradiation. Food Chemistry,2005:93(1):103-111, https://doi.org/10.1016/j.foodchem.2004.09.010
2. Adebowale A, Adegoke MT, Sanni SA, Adegunwa MO, Fetuga GO. Functional properties and biscuit making potentials of sorghum-wheat flour composite. American Journal of Food Technology,2012:7:372-379
3. Adebowale RA, Sanni SA, Oladapo FO. Chemical, functional and sensory properties of instant yam-breadfruit flour. Nigerian Food Journal,2008:26(1):2-12.
4. Admad AI, Hayat SATM, Nauman K, Anwarr A. Mechanisms involved in therapeutic soybean (Glycine

max). International Journal of Food Properties,2014:17(6):1332-1354.
5. AOAC, Official methods of analysis, 19th ed. Washington D-C, USA: Association of Official Analytical Chemist, 2012.
6. Appiah F, Asibuo JY, Kumah P. Physicochemical and functional properties of bean flours of three cowpea (*Vigna unguiculata* L. Walp) varieties in Ghana. African Journal of Food Science,2011:5(2):100–104.
7. Arukwe DC. Chemical composition, Physical Properties and Sensory Evaluation of Wheat-Cocoyam-Pigeon Pea Biscuits. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT),2020:14(7):47-51.
8. Ayo JA, Adedeji OE, Ishaya G. Phytochemical composition and functional supported by properties of flour produced from two varieties of tigernut (*Cyperus esculentus*). FUW Trends Science and Technology Journal,2015:1(1):261-266.
9. Bayero AS, Datti Y, Abdulhadi M, Yahya AT, Salihu I, Lado UA, Nura T, Imrana A. Proximate Composition and the Mineral Contents of Soya Beans (*Glycine max*) Available in Kano State, Nigeria. Chemical Search Journal,2019:10(2):62–65,
10. Chandra S, Singh S, Kumari D. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. Journal of Food Science and Technology,2015:52(6):3681–3688, DOI 10.1007/s13197-014-1427-2
11. Coronell-Tovar DC, Chávez-Jáuregui RN, Bosques-Vega A, and López-Moreno ML. Characterization of cocoyam (*Xanthosoma* spp.) corm flour from the Nazareno cultivar. Food Science and Technology Campinas,2019:39(2):349-357.
12. CS 152-1985 www.fao.org/input/download/standards/50/CXS_152e, pdt Codex standard for wheat flour Codex Standard 152-1985 date accessed 27/2/23
13. Dwiani A, Yunianta Y, Tati E. Functional properties of winged bean (*Psophocapus tetragonolobus* L.) Seed protein concentrate. International Journal of Chemistry Technology,2014:6(14):5458-5465.
14. Falade KO, Okafor CA. Physical, functional, and pasting properties of flours from corms of two Cocoyam (*Colocasia esculenta* and Xanthosoma sagittifolium) cultivars. Journal of Food Science and Technology,2015:52(6):3440–3448.
15. Farzana T, Mohajan S. Effect of incorporation of soy flour to wheat flouron nutritional and sensory quality of biscuits fortified with mushroom. Food Science and Nutrition,2015:3(5):363–369.doi: 10.1002/fsn3.228
16. Jideani VA. Functional properties of soybean food ingredients in food systems. Soybean-Biochmeistry, Chemistry and Physiology, 2011, 345-366.
17. Kabuo NO, Alagbaoso OS, Omeire GC, Peter-Ikechukwu AI, Akajiaku LO, Obasi AC. Production and Evaluation of Biscuits from Cocoyam (*Xanthosoma Sagittifolium* Cv Okoriko)-Wheat Composite Flour. Research Journal of Food and Nutrition,2018:2(2):53-61.
18. Köhn CR, Fontoura AM, Kempka AP, Demiate IM, Kubota EH, Prestes RC. Assessment of different methods for determining the capacity of water absorption of ingredients and additives used in the meat industry. International Food Research Journal,2015:22(1):356-362.
19. Kumar R, khatkar BS. Thermal pasting and morphological properties of starch granules of wheat (*Triticum aestivum* L.) varieties. Journal of food Science and Technology,2017:54(8):2403–2410. DOI 10.1007/s13197-017-2681-x
20. Maninder K, Kawaljit SS, Narpinder S. Comparative study of functional, thermal and pasting properties of flours from different field pea and pigeon pea cultivars. Food Chemistry,2007:104:259–267.
21. Masrul M, Nindrea RD. Dietary Fibre Protective against Colorectal Cancer Patients in Asia: A Meta-Analysis. Open access Macedonian journal of medical sciences,2019:7(10):1723–1727. https://doi.org/10.3889/oamjms.2019.265
22. McRae MP. "Dietary Fibre intake and type 2 diabetes mellitus:an umbrella review of meta-analses. Journal of chiropractic medicine,2018:17(1):44-53. dio 10.1016/j.jcm.2017.11.002Epub
23. McRae MP. Dietary Fiber Is Beneficial for the Prevention of Cardiovascular Disease: An Umbrella Review of Meta-analyses. Journal of chiropractic medicine,2017:16(4):289–299. https://doi.org/10.1016/j.jcm.2017.05.005
24. Mepba HD, Eboh L, Nwaojigwa SU. Chemical composition, functional and baking properties of wheat-plantain composite flours. African Journal of Food Nutrition,2007:7(1):1-22.
25. Ndife J, Abdulraheem L, Zakari U. Evaluation of the nutritional and sensory quality of functional breads produced from whole wheat and soya bean flour blends. African Journal of Food Science,2011:5(8):466-472.
26. Obadina A, Ashimolowo H, Olotu I. Quality changes in cocoyam flours during storage. Food Science and Nutrition,2016:4(6):818–827. doi: 10.1002/fsn3.347
27. Obinna-Echem PC, Barber LI, Jonah PC. Effect of Germination and Pre-gelatinization on the Proximate Composition and Pasting Properties of Maize Flour a base Ingredient for Cereal-based Infant Complementary Food. International Journal of Biotechnology and Food Science,2019:7(3):30-37,
28. Ojinnaka MC, Nnorom CC. Quality evaluation of wheat-cocoyam-soybean cookies. Nigerian Journal of Agriculture, Food and Environment,2015:11(3):123-129, https://doi.org/10.1016/s0189-7241(15)30084-9.
29. Ojo MA, Ologunde MO, Alabi OD, Ohijeagbon OR, Ojo H. Evaluation of Cocoyam-Soybean Flour Blends and Sensory Properties of the Amala Dumpling. Agriculture and Food Sciences Research,2022:9(1):44-49,
30. Okpalan LC, Egwu PN. Utilisation of broken rice and cocoyam flour blends in the production of biscuits. Nigerian Food Journal,2015:33:8–11. http://dx.doi.org/10.1016/j.nifoj.2015.04.010
31. Olagunju TM, Aregbesola, OA, Akpan GE. Effect of Pre-Treatment and Temperature on the Physical and Functional Properties of Cocoyam Flour. The Proceedings 12th CIGR Section VI International Symposium 22 –25, 2018, 1012-1030.
32. Onwuka GI. Food Analysis and Instrumentation: Theory and Practice. Naphtali Prints, Surulere, Lagos, 2005, 63-75.
33. Owuamanam CI, Ihediohanma NC, Nwanekezi EC. Sorption isotherm, particle size, chemical and physical

properties of cocoyam corm flours. Research,2010:2(8):11–19

34. Peter-Ikechukwu A, Ibeabuchi JC, Eluchie CN, Agunwa IM, Aneke EJ, Chukwu MN, Ogbuagu JC, *et al.* Functional Properties of Sausage Rolls Made from Cocoyam and Wheat Flour Enriched with Soybean Flour. Food Science and Nutrition Studies, 2018, 3(2).
35. Ratnawati L, Desnilasari D, Surahman DN, Kumalasari R. Evaluation of Physicochemical, Functional and Pasting Properties of Soybean, Mung Bean and Red Kidney Bean Flour as Ingredient in Biscuit. 2nd International Conference on Natural Products and Bioresource Sciences–2018. IOP Conference Series: Earth and Environmental Science, 251, 2019. 012026. IOP Publishing doi:10.1088/1755-1315/251/1/0120261
36. Salami LA, Ajibola T, Akinjohnson E. Comparison of Functional and Mineral Characteristics of Yam; Cassava; Cocoyam and Plantain Flour. IOSR Journal of Applied Chemistry, (IOSR-JAC) e-ISSN: 2278-5736,2018:11(5):43-46.
37. Sanni LO, Ikuomola DP, Sanni SA. Effect of length of fermentation and varieties on the qualities of sweet potato gari. Proceeding. 8th triennial Symposium of the International Society for Tropical Root Crops. Africa Branch (ISTRC-AB), Ed. M.O. Akoroda, IITA, Ibadan, Nigeria, 12 -16, 2001, 208-211.
38. Wada E, Feyissa T, Tesfaye K. Proximate, Mineral and Antinutrient Contents of Cocoyam (*Xanthosoma sagittifolium* (L.) Schott) from Ethiopia. Hindawi International Journal of Food Science,2019:1:1-7. doi.org/10.1155/2019/8965476
39. Yang J, Wang HP, Zhou L, Xu CF. Effect of dietary fiber on constipation: a Meta-analysis. World journal of gastroenterology,2012:18(48):7378–7383. https://doi.org/10.3748/wjg.v18.i48.7378
40. Zhao Q, Selomulya C, Xiong H, Chen XD, Li Y, Wang S. Rice Dreg Protein as an alternative to soy protein isolate. Composition of Nutritional Properties, International Journal of Food Properties,2014:17:1791-1804.