Chemical and Functional Properties of Composite Flours Made from Yellow Maize, Soybeans, and Jackfruit Seed

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Abstract: **- Non- wheat composite flour was prepared using yellow maize (YM), soybeans (SB) and jackfruit seed (JF). The ratio of YM:SB:JF was used in the formulation of the flours. The control was 80:20 (sample A), 75:20:5 (sample B), 70:20:10 (sample C), 65:20:15 (sample D), 60:20:20 (sample E), 55:20:25 (sample F). Proximate composition, functional properties, and selected minerals and vitamins, of the flour blends were determined. The proximate composition of flour blends sample showed that the ash content ranged from (1.08-2.05%), moisture (8.89-9.11%), crude fibre (1.10-1.53%) and carbohydrate (69.64-73.72%) respectively. The proximate composition parameters increased significantly (P<0.05) with increasing substitution of the yellow maize flour and soybean flour with jackfruit seed flour with exception of protein content (9.77-7.30%) and fat content (9.52-6.29%) which decreased significantly (P<0.05) with increase in jackfruit seed flour. The functional properties of the flour samples showed that the bulk density varied from 0.57-0.68 g/cm^3, viscosity 97.80- 114.67 mPa.S), swelling capacity (6.05-8.84), water absorption capacity (5.09-9.04g/g) and oil absorption capacity (1.36-2.26g/g) respectively. There were significant differences (p <0.05) in all the values. The result of mineral contents of flour blends showed that iron varied from 0.50-0.65, zinc (1.45-3.55mg/100), calcium (4.13-6.67 mg/100), and phosphorus (4.21-8.01 mg/100. The result of vitamins contents of the flour blends showed that Vitamin A ranged from 12.72-24.30 (mg/100), B$_1$ (10.85-16.81mg/100), B$_2$ (4.51- 7.57mg/100) and Vitamin C (80.43- 113.33mg/100). All the vitamins increased with corresponding increase in the level of yellow maize flour and jackfruit seed flour while the soya bean flour remained constant at 20%. The composite flour produced had increased micronutrients and improved functional properties and could be used in food systems including baked and extruded goods.**

Key Words: **composite flour, yellow maize, jack fruit, soybeans**

I. INTRODUCTION

Composite flour is a mixture of several flours obtained from roots, tubers, cereals and legumes with or without the addition of wheat flour (Elisa *et al;* 2015). Composite flours have been used extensively and successfully in the production of baked foods. Some studies reported that composite flours produced from cereal and leguminous plant protein are good sources of protein that complement each other with respect to their amino acid profile including essential amino acids (Okpala *et al;* 2013, Igbabul *et al*, 2015; Dabel *et al.*, 2016). The nutritional quality of the foods produced from composite flours therefore depend on the proportional composition of the flours (Ikuomola *et al.*, 2017). The composite flour should be one that is readily available, culturally acceptable, affordable and able to replace wheat flour in terms of nutrition and functionality (Igbabul *et al.*, 2015).

Yellow Maize, also known as corn (***Zea mays***) is a common staple tropical crop. The maize grains are rich in carbohydrate and contain significant quantities of other nutrients (Ingbian and Oduyela, 2010, Igbabul *et al*., 2014). The protein quality of maize is however poor in lysine and tryptophan but rich in methionine (FAO 1995, Dabel *et al.,* 2016). Thus, diets that are prepared from maize require complementation from protein rich foods. In Nigeria, yellow maize is widely consumed as roasted fresh maize, pop-corn, fermented meal for Ogi (gruel) or boiled fresh maize. Yellow maize is high in β-carotene, which gives it a yellow or orange colour (Bhaskarachary *et al*., 2008, Umaymah *et al*., 2018), β -carotene in plants that have pleasant yellow-orange color is a major source of vitamin A (Nagarajaiah *et al*., 2015;). Consumption of foods containing β -carotene helps in prevention of eye disorders, cancer, skin diseases, and Vitamin A deficiency (VAD) (Siems *et al*., 2005). Thus, the use of yellow maize could enhance the nutritional quality of the flour.

Soybean *(Glycine max)* an important oil seed belonging to the family leguminosae and sub-family papillionnideae. It is an excellent source of protein (35-40%), carbohydrate (34%), calcium, iron, phosphorus and vitamins. It is also the source of all the essential amino acids (Singh *et al*., 1999; Alabi *et al*., 2001, Ampofo, 2009). Soybeans is used in the dry form as soy-powder, soy milk, soy protein concentrate or isolate and texturized form, soy-ogi and soy-garri (Ampofo, 2009). Soybeans proteins are rich in lysine but deficient in sulphur containing amino acids, whereas cereal proteins are deficient in lysine, but have adequate amount of sulphur amino acids. Addition of soybean flour and cereal based products could be a good option to overcome the world protein calories malnutrition problem (Okpala *et al*.,2011; Igbabul *et* al., 2014).

Jackfruit (*Artocapus heterophilus*) is among the foreign fruits introduced in Nigeria from India which has adapted so well in Nigeria. It is known in the South East of Nigeria among the Igbo speaking populace as *ukwa bekee/ukwa oyibo* (white-man bread fruit) (Shamsudi *et al* 2009). Ripe jackfruit comprises of three parts namely: the skin (fibrous portion), pulp (bulbs) and seed. The pulp has a sweet- aromatic soft tissue and is a good source of vitamins A, B and C. It is mainly eaten fresh or as a preserve in syrups. The seeds of the jackfruit are rich in carbohydrate, fibre, mineral and vitamin and are consumed when roasted, boiled or milled into flour for snacks like bread and cookies (Hosamani *et al*; 2016). In terms of health benefits, fibre helps to form bulk, making it easier to lose weight, and lower the risk of heart disease, high cholesterol, high blood pressure and constipation. It also provided resistance starch which improve blood sugar control and keep gut healthy. It is a good source of thiamin and riboflavin. Both of these B vitamins converts food in the body to energy and keep skin, eyes and hair healthy. Riboflavin also acts as an antioxidant, that helps prevent cell damage from free radical (Wijngaard and Brunton, 2010). Thus, Jackfruit seed flour could be successfully used to enrich bakery products and other foods, giving alternative utilization opportunity to the producers and healthy choice option to the consumer.

The objective of this work is therefore to produce flour blends of jackfruit, soybeans and yellow maize and analyze its chemical and functional properties for the purpose of diversifying its use in food systems.

II. MATERIALS AND METHODS

2.1 Sources of Raw Materials:

Ripe Jackfruit was purchased in a local market in Anambra State, while maize and soybeans were bought in a local market in Benue State, Nigeria. All the chemicals that were used in analyses were of (analytical reagent) AR grade.

2.2 Preparation of Raw Materials

2.2.1 Preparation of Yellow Maize Flour:

The method of modified Igbabul *et al*., (2014) was used to prepare the maize flour. The yellow maize kernels were sorted to remove stones, dirt and other foreign materials. The clean maize was milled in a disc attrition mill and allowed to pass through 250μm mesh. The flour was packaged in cellophane bag until used.

2.2.2 Preparation of Soybean Flour:

The flour was processed by the modified method of Apotiola (2013). Soybean seeds were picked and winnowed to remove unwanted foreign materials such as dust, dirt and immature seeds. The winnowed soybean was washed, soaked for (10-12h), boiled for 20minutes, cooled and oven dried at 60^{o}C for 6hrs. The dried seeds were grounded using disc attrition mill to pass through a sieve of 250μm mesh diameter. The resultant flour was wrapped in black polyethylene bags and stored in air tight containers at room temperature until used.

2.2.3. Preparation of Jackfruit Seed Flour

The flour was processed by the method of Eke- Ejiofor, *et al.*, (2014). The Jackfruit was first washed to remove some extraneous materials. The fruit was cut in half lengthwise, to carve out the core and to scoop out the bulbs. The ends of the bulbs were cut to remove the seeds. The Jackfruit seeds were soaked for 3h, manually peeled, sliced, and oven dried at 60^{0}C and milled to pass through 250μm mesh sieve pore size. Labeled and stored in air tight containers at room temperature until used.

2.3. Formulation of Composite Flour

Composite flour blends of maize, soy beans and jackfruit seed flours were thoroughly mixed using a Kenwood blender to achieve uniform blending with the quantities given in Table 1.

Table 1: Formulation of Composite flours of Yellow Maize, Soy beans and Jackfruit seeds

Sample Code	YMF(g)	SBF (g)	JSF(g)
A	80	20	0
B	75	20	5
C	70	20	10
D	65	20	15
E	60	20	20
F	55	20	25

YMF = Yellow maize flour

SBF = Soybean flour

JSF = Jackfruit seed flour

III. ANALYSES

3.1 Proximate composition Analysis of the flours:

The ash, crude protein, crude fat and moisture content of the samples were determined by using the standard methods of AOAC (2012). Carbohydrate content was determined by difference using the method of Egounlety and Awoh (1990), by subtracting the total sum of the percentage of fat, moisture, ash, crude fibre, and protein content from hundred (100).

Carbohydrate content = 100 – (%protein + % moisture + % fat + % crude fiber + % ash).

3. 2 Determination of Minerals and vitamins of the flours

The mineral content (iron, zinc, calcium, phosphorus) of the flours was determined using the method of AOAC (2005) with the aid of atomic absorption spectrophotometer (AA800 Perkin Elmer, Germany). The pro-vitamin A (Beta-carotene and vitamin B_1, B_2 and C of the flours were also determined by AOAC (2005).

3.3 Functional properties of flours Analysis:

3.3.1 Viscosity: This was determined using the method by Onwuka (2005) using the falling number (FN) formula. Twenty grams of flour in water suspension in a measuring cylinder was immersed in a boiling water bath and stirred for exactly 60 seconds. A plunger (7g mass) was then allowed a fixed distance in the measuring cylinder, and falling times is the time in seconds for a plunger to fall at the fixed distance.

FN = FT + 60 Where, FN = Falling number, FT = Falling time,

60 = a constant added to FT to obtain FN

3.3.2 Water and oil absorption capacity:

Water and oil absorption capacity were determined using a method described by Onwuka (2005). One gram of each sample was weighed in a conical flask and 5mL of distilled water was added, shake thoroughly and allowed to stand for 30 mins at room temperature (30±2 º C) and then transferred into a graduated centrifuge tube, before centrifuging at 3500 rpm for 30 min. The volume of water and oil absorbed (total volume water –Free volume) was multiplied by the density of sample for conversion to gram of sample

$$\text{Water absorbed} = \text{Total Volume of Water} - \text{Free Water}$$

$$\text{WAC} = \frac{\text{Density of Water X Volume absorbed}}{\text{Weight of Sample}}$$

$$\textbf{\textit{Oil absorption capacity}} = \frac{\textit{Density of oil X Volume absorbed}}{\textit{weight of sample}}$$

3.3.3 Swelling Index: This was determined using the method described by Onwuka (2005).Ten grams of the sample was introduced into a graduated cylinder with the dry bulk volume noted. Therefore, 100ml of boiling water was added to the sample in the cylinder and mixed thoroughly. The volume was measured after 10mins and swelling index was calculated as :

$$\text{Swelling index (mL/g)} = \frac{\text{Change in Volume of Sample (mL)}}{\text{Original Weight of Sample}}$$

3.3.4 Bulk density:

This was determined as described by Onwuka (2005). Analysis was performed in triplicates, 2.5g of sample was filled in a 10mL graduated cylinder and its bottom tapped on the laboratory bench until there was no decrease in volume of sample. The volume was recorded.

$$Bulk\ density\ (g/mL) = \frac{\text{Weight of sample (g)}}{Volume\ of\ sample\ (mL)}$$

IV. RESULTS

4.1 Proximate Composition of Composite Flours

The proximate composition of yellow maize flour, soy bean flour, jackfruit seed flour blends are shown in **Table 2.** The protein content of the flour ranged from 9.79 to 7.30%; sample B had the highest protein content (9.79%) while sample F had the lowest (7.30%). The fat content (%) of the flour ranged between 9.52- 6.29%. The control sample A had the highest fat content (9.52%) while the sample F had the least value (6.29%). Ash content of the flour ranged from 1.08 to 2.05%, for the control sample A and sample F respectively. The moisture content (%) of the cookies ranged from 8.89 - 9.11. The control sample A had the least value while cookie sample F had the highest value. The crude fibre content of flour ranged from 1.10 to 1.53%; flour sample F had the highest value (3.09%) while the control sample A had the lowest value (2.42%). Carbohydrate content of the flour ranged between 69.64 and 73.72%. Flour control sample A had the lowest carbohydrate content (69.64%) while the sample F had the highest value (73.72). The moisture, ash, crude fibre, fat, protein, and carbohydrate contents of maize flour, substituted with 5%, 10%, 15%, 20%, and 25% jackfruit seed flour and 20% soybean in each blends were significantly different ($P < 0.05$) in all the parameters examined in the blends. The protein and fat contents of the mixture significantly decreased as the percentage substitution of jackfruit seed flour increased. While the moisture, crude fibre, ash, and carbohydrate contents were significantly increased as the jackfruit seed flour substitution increased. The result showed that the addition of JSF caused significant ($p < 0.05$) decrease in the protein content of the flour. The observed decrease could be attributed to low protein (5.09%) and high carbohydrate content in Jackfruit seed flour. This trend is in line with several workers including Shadab *et al.,* (2015).

The decrease in fat content could be attributed to the low quantity of fat (1.89%) in JSF. Moreover, the incorporation of jackfruit seed flour to deep fat fried products was found to reduce the fat absorption to a remarkable extent (Rajarajeshwari and Jamuna, (1999). The moisture contents for all the flour blends ranged from 8.89 -9.11% and it is within the recommended level for safe keeping of flour samples by the Standards Organisation of Nigeria (SON) and it is an indication of stable shelf life. Moisture content in excess of 14% in flours has greater danger of bacterial action and mould growth which produce undesirable changes in the flour (Dabel *et al.*, 2016). The increase in moisture content was in agreement with the study of Apotiola *et al* (2014) on evaluation of Wheat Flour, Soybean Flour and Cocoyam Flour blends where moisture content increased.

The ash content of the samples (A-F) increased with increase in the substitution of yellow maize- soy flour with jackfruit seed flour (1.08% to 2.05%). The addition of jackfruit seed flour significantly ($p < 0.05$) increased the ash content of the flour gradually. Ash content of a food material is an indication of the mineral content. Thus, soy bean seeds, jackfruit seeds and yellow maize are excellent sources of minerals and vitamins.

Carbohydrate content of the samples (A-F) increased with increased substitution of yellow maize flour with jackfruit seed flour (69.64% to 73.72%). The addition of jackfruit seed flour significantly ($p < 0.05$) increased the carbohydrate content of the flour gradually. Increase in carbohydrate content could be due to the high carbohydrate content of jack seed and maize flour as observed in similar works using jack seed (Apotiola *et al.*, 2014). The total carbohydrate content indicated that these type of flour are classified as food energy supplier of nutritive and economical value which could represent good sources for industrial flour and starch (FAO, 1998).

Table 2. Proximate Composition (%) of yellow maize, soybeans and jackfruit seed flour blends**:**

Sample	Crude protein	Fat	Ash	Moisture	Crude fibre	Carbohydrate
A	$9.77^{b}\pm0.03$	$9.52^{a}\pm0.02$	$1.08^{c}\pm0.01$	$8.89^{a}\pm0.05$	$1.10^{ab}\pm0.01$	$69.64^{a}\pm0.01$
B	$9.79^{a}\pm0.03$	$7.46^{b}\pm0.01$	$1.10^{c}\pm0.03$	$8.91^{a}\pm0.01$	$1.20^{ab}\pm0.01$	$71.54^{a}\pm0.01$
C	$8.73^{c}\pm0.05$	$7.42^{b}\pm0.02$	$1.18^{c}\pm0.02$	$8.93^{a}\pm0.02$	$1.25^{ab}\pm0.01$	$72.49^{a}\pm0.01$
D	$7.62^{d}\pm0.02$	$7.13^{bc}\pm0.02$	$1.23^{c}\pm0.01$	$9.07^{a}\pm0.01$	$1.35^{ab}\pm0.01$	$73.60^{a}\pm0.03$
E	$7.43^{e}\pm0.01$	$6.58^{bcd}\pm0.02$	$1.70^{ab}\pm0.01$	$9.11^{a}\pm0.01$	$1.50^{a}\pm0.01$	$73.68^{a}\pm0.02$
F	$7.30^{f}\pm0.02$	$6.29^{cd}\pm0.01$	$2.05^{a}\pm0.01$	$9.11^{a}\pm0.01$	$1.53^{a}\pm0.02$	$73.72^{a}\pm0.01$
LSD	0.04	0.58	0.41	0.91	0.34	2.99

Values are mean $\pm$ SD of triplicate determinations. Values with similar superscripts in column do not differ significantly at ($p \leq 0.05$);

Key A= 80:20, B= 75:20:5, C= 70:20:10, D= 65:20:15, E= 60:20:2, F= 55:20:25

4.2 The Minerals Content of Composite Flours

Table 3 shows the result obtained from the minerals (Iron, Zinc, Calcium, and Phosphorus) determination of yellow maize-soy and jackfruit seed flour. The nutrients (Iron, Zinc, Calcium, and Phosphorus) significantly increased with corresponding increase in the levels of substitution of yellow maize flour and soybean flour with Jackfruit seed flour. Iron ranged from to 0.50mg/100g to 0.65mg/100g for (samples A-F), values of 1.45mg/100g to 3.55mg/100g were recoded for Zinc (samples A-F), Calcium ranged from 4.13mg/100g (A) to 6.67.mg/100g (F), and Phosphorus ranged from 4.21mg/100g to 8.01 mg/100g for (samples A-F). Addition of Jackfruit seed flour caused significant ($p < 0.05$) increase in the minerals content of the flour. The observed increase could be attributed to the significant quantity of mineral in jackfruit seed flour.

Iron ranged from 0.50mg/100g to 0.65mg/100g for (samples A-F), values of 1.45mg/100g to 3.55mg/100g were recoded for Zinc (samples A-F), Calcium ranged from 4.13mg/100g (A) to 6.67.mg/100g (F), and Phosphorus ranged from 4.21mg/100g to 8.01 mg/100g for (samples A-F). There was significant ($p<0.05$) increase among all the flour samples as JSF flour increases**.**

Table 3. Minerals Content (mg/100g) of Flour blends from Yellow Maize, Soy Bean, and Jackfruit Seed Flour

Sample code	Iron	Zinc	Calcium	Phosphorus
A	$0.50^{bc}\pm0.02$	$1.45^{e}\pm0.04$	$4.13^{e}\pm0\,02$	$4.21^{f}\pm0.01$
B	$0.54^{b}\pm0.01$	$2.75^{d}\pm0.03$	$4.32^{d}\pm0.02$	$4.74^{e}\pm0.01$
C	$0.55^{b}\pm0.02$	$3.13^{bc}\pm0.19$	$5.01^{c}\pm0.05$	$4.97^{d}\pm0.02$
D	$0.63^{a}\pm0.02$	$3.14^{bc}\pm0.12$	$5.02^{c}\pm0.04$	$5.62^{c}\pm0.02$
E	$0.63^{a}\pm0.01$	$3.39^{ab}\pm0.01$	$5.40^{b}\pm0.02$	$6.87^{b}\pm0.02$
F	$0.65^{a}\pm0.02$	$3.55^{a}\pm0.03$	$6.67^{a}\pm0.02$	$8.01^{a}\pm0.01$
LSD	0.04	0.15	0.04	0.03

Values are mean $\pm$ SD of triplicate determinations. Values with similar superscripts in column do not differ significantly at ($p \leq 0.05$);

Key: A= 80:20, B= 75:20:5, C= 70:20:10, D= 65:20:15, E= 60:20:2, F= 55:20:25

4.3 The Vitamins Content of Composite Flours

Table 9.0 shows the result of the vitamins (vitamin A, B_1, B_2 and C) content of yellow maize-soy and jackfruit seed flours. Vitamin A ranged from 6.23mg/100g to 12.56mg/100g (F), Vitamin B_1 ranged from 6.13mg/100g (A) to 9.65mg/100g (F). Vitamin B_2 ranged from 3.07mg/100g (A) to 5.88.mg/100g (F) and Vitamin C ranged from 15.04mg/100g (A) to 70.74.mg/100g (F). The vitamins increased as the levels of substitution of yellow maize-soy flour with jackfruit seed flour increased. Addition of Jackfruit seed flour caused significant ($p < 0.05$) increase in the vitamin contents of the blend flour. The observed increase could be attributed to the significant quantity of vitamins in jackfruit seed flour.

Table 4.0 Vitamins Content (mg/100g) of Composite Flours from Yellow Maize, Soy Bean, and Jackfruit Seed Flour and their blends

Sample code	Vitamin A	Vitamin B_1	Vitamin B_2	Vitamin C
A	$6.23^{f} \pm 0.02$	$6.13^{f} \pm 0.01$	$3.07^{f} \pm 0.01$	$15.04^{f} \pm 0.03$
B	$6.81^{e} \pm 0.01$	$7.66^{e} \pm 0.01$	$3.49^{e} \pm 0.00$	$45.38^{e} \pm 0.32$
C	$7.11^{d} \pm 0.01$	$8.72^{d} \pm 0.01$	$3.90^{d} \pm 0.01$	$51.07^{d} \pm 2.00$
D	$10.73^{c} \pm 0.01$	$9.02^{c} \pm 0.03$	$4.30^{c} \pm 0.01$	$56.35^{c} \pm 0.34^{c}$
E	$11.09^{b} \pm 0.01$	$9.11^{b} \pm 0.01$	$4.58^{b} \pm 0.01$	$62.72^{b} \pm 1.47$
F	$12.56^{a} \pm 0.00$	$9.65^{a} \pm 0.02$	$5.88^{a} \pm 0.01$	$70.74^{a} \pm 0.36$
LSD	0.02	0.02	0.01	1.65

Values are mean $\pm$ SD of triplicate determinations. Values with similar superscripts in column do not differ significantly at ($p < 0.05$);

Key: A= 80:20, B= 75:20:5, C= 70:20:10, D= 65:20:15, E= 60:20:2, F= 55:20:25

4.4 The Functional Properties of Composite Flours

Result of the functional properties of the flour blends are presented in Table 5. There were significant differences ($p < 0.05$) in bulk density, viscosity, swelling index, water and oil absorption capacity. The bulk density ranged from 0.57–0.68g/m^3. The control sample A flour had the lowest bulk density of 0.57 g/m^3 while flour sample F had the highest value of 0.68g/m^3. The highest viscosity value of 114.67 was found in flour sample F while the control sample A flour had the lowest value of 97.80. The swelling capacity of the flour ranged from 6.05 to 8.84 g/g, while F had the highest value of 8.84 g/g. The water absorption capacity ranged from 5.09g/g – 9.04g/g. The sample A Flour had the lowest water absorption capacity of 5.09 g/g while the F had the highest value of 9.09g/g. No significant difference (p>0.05) was found among these flour blends C and D. It was observed that the control (A) was significantly different (p>0.05) from blends samples containing jackfruit seed flour. The oil absorption capacity of the flour samples ranged between 1.36g/g – 2.26g/g. The sample A Flour had the lowest oil absorption capacity of 1.36 g/g while sample F had the highest value of 2.26g/g. No significant difference (p>0.05) was found among the blends containing 5-10% and 15-20% JSF. The bulk density, viscosity, swelling index, water and oil absorption capacity ranged from 0.57– 0.68g/m^3, 105.00%- 116.13%, 6.05 to 8.84 g/g, 5.09g – 9.04g and 1.36g–2.26g respectively.

The addition of JSF caused significant ($p < 0.05$) increase in the bulk density content of the flour. The bulk density of food material is important in relation to its packaging advantage (Lawn 2010). Bulk density gives an indication of the relative volume of packaging material required and high bulk density is a good physical attribute when determining the mixing quality of a particulate matter (Basma., 2003). The density of processed products dictate the characteristics of its container or package product density influences the amount and strength of packaging material, texture or mouth feel (Fola, *et al*, 2011). This study revealed that bulk density depends on the moisture contents of the flours. It is clear that decrease in the proportion of yellow maize increased the bulk density of composite flours. The high bulk densities of flour suggest their use in food preparations since it help to reduce paste thickness which is an important factor in convalescent and child feeding. On contrast, low bulk density would be an advantage in the formulation of complementary foods (Ugwu and Ukpabi, 2002). Similar findings were reported by Eltayeb *et al*.(2011).

Viscosity is a property of flour to resist free flow tendency. It was observed that, the viscosity increased with increase in concentration of the jack seed flour. The addition of JSF caused significant ($p < 0.05$) increase in the viscosity content of the flour. The viscosity is an important determinant of knowing pasting temperature at which the first detectable gelled starch is measured using Brooke field viscometer. This property helps in the food applications.

The swelling capacity of composite flours ranged between 6.05 to 8.84 g/g. From Table5, it is clear that lowest value swelling capacity was observed in A (6.05 g/g) whereas the maximum composite value was in F (8.84 g/g). The addition of jack fruit seed flour caused significant ($p < 0.05$) increase in the Swelling capacity content of the flour. Swelling capacity is the measure of ability of starch to immobile water and swells (Ikegwu et al, 2009). The swelling capacity of flours depends on size of particles, types of variety and types of processing methods used. Thus, it is explicit that the swelling capacity of composite flours was highly affected by the level of yellow maize flour and jackfruit seed flour, because they are rich sources of starch. More so, high swelling capacity has been reported as part of the criteria for a good quality product (Niba et al, 2001).

The water absorption ranged between 5.09g – 9.04g for all flours. F had the highest value of 9.04g and A had the lowest value of 5.09g. The result suggested that the substitution of yellow maize-soybean flour with jackfruit seed flour affected the amount of water absorption. The significance increase in water absorption capacity of flour is attributed to increase in the amylose leaching and solubility and loss of starch crystalline structure. High water absorption capacity of composite flours suggested that the flours can be used in formulation of some foods such as sausage, dough and bakery products. (Butt and Batool 2010, Adebowale et al.,2005). Mcwatters *et al* (2003) reported that lower water absorption is due to less availability of polar amino acids in flour.

The oil absorption capacity of the composite flours (A – F) significantly increased with increase in the proportion of other flours. Similar reports where observed by Kaushal et al. (2012). Oil absorption capacity is the ability of flour protein to physically bind fat by capillary attraction & is potentially useful in structural interaction in food specially in flavor retention, improvement of palatability and extension of shelf life of bakery or meat products, doughnut, baked goods, pancake, and soup mixes where fat absorption is desired, (Iwe, *et al*., 1999, Aremu et al 208).

Table 5. Functional properties of composite flour of yellow maize, soybeans, jackfruit seed and their blends:

Sample	Bulk density (g/cm^3)	Viscosity (Pa·s)	Swelling power (g/g)	Water absorption (g/g)	Oil absorption (g/g)
A	$0.57^{c}\pm0.01$	$97.80^{d}\pm0.13$	$6.05^{e}\pm0.00$	$5.09^{e}\pm0.05$	$1.36^{c}\pm0.12$
B	$0.58^{bc}\pm0.03$	$105.00^{c}\pm1.53$	$6.36^{d}\pm0.01$	$6.02^{d}\pm0.01$	$1.61^{bc}\pm0.05$
C	$0.63^{ab}\pm0.01$	$107.33^{c}\pm0.88$	$7.59^{c}\pm0.01$	$7.10^{c}\pm0.04$	$1.99^{ab}\pm0.10$
D	$0.64^{a}\pm0.02$	$110.00^{b}\pm0.58$	$7.83^{c}\pm0.01$	$8.07^{b}\pm0.04$	$2.03^{ab}\pm0.05$
E	$0.67^{a}\pm0.01$	$112.33^{ab}\pm0.88$	$8.34^{b}\pm0.00$	$9.01^{b}\pm0.02$	$2.23^{a}\pm0.08$
F	$0.68^{a}\pm0.02$	$114.67^{a}\pm1.20$	$8.84^{a}\pm0.00$	$9.04^{a}\pm0.03$	$2.26^{a}\pm0.05$
LSD	0.03	1.40	0.15	0.06	0.35

Values are mean ± SD of triplicate determinations. Values with similar superscripts in column do not differ significantly at ($p < 0.05$);

Key: A= 80:20, B= 75:20:5, C= 70:20:10, D= 65:20:15, E= 60:20:2, F= 55:20:25

V. CONCLUSION

Composite flour of yellow maize, soybeans and jack fruit seed flour was successfully produced. The flour had increased nutrients in minerals, vitamins and improved functional properties. The functional properties have shown that the flour could be used in food systems including baked and extruded goods.

The use of the composite flour would greatly enhance the utilization of these crops in sub-Saharan African countries like Nigeria where the crops has not been optimally utilized. It would encourage farming activities and value addition to the farmers' crops.

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