Functional and Pasting Properties of Composite Flour from Wheat, Sweet Potato and Soybean

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Abstract— *This work was done to ascertain the functional and pasting properties of wheat-soy-sweet potato composite flour. Wheat flour, sweet potato flour and soybean flour blends were prepared in different proportions with completely randomized design resulting to 7 samples including control which is 100% wheat flour. Functional and pasting properties of the composite flours were determined and compared with wheat flour as control. The bulk densities of the flour blends ranged from 0.717 to 0.809 g/mL, there was a significant difference in the water absorption capacity of the flour blends. Oil absorption capacity (OAC) ranged between 0.623 to 0.759 mL/g, least gelation concentration (LGC) of the flour samples ranged from 2.000% to 12.000% while the swelling capacity of different flour blends at temperature 50^{o}C ranged from 1.32% to 2.006%. Peak viscosity, sample WSO (90% wheat flour: 10% soy bean flour: 0% sweet potato flour) had the highest peak viscosity of 273.075 RVU, sample WOS (90% wheat flour: 0% soy bean flour: 10% sweet potato flour) had the highest trough viscosity (245.915 RVU) while sample WSS (80% wheat flour: 10% soy bean flour: 10% sweet potato flour) had the highest breakdown viscosity value (94.245 RVU) compared to the control sample WOO which had 100% wheat flour. This investigation shows that set back value was highest for sample WSS (80% wheat flour +10% soy bean flour + 10 % sweet potato flour) at 220.325 RVU. Sample SSO (0% Wheat flour: 50% Soybean: 50% Sweet potato flour) had highest pasting temperature of 93.450^{o}C compared to control flour samples.*

Keywords— functional properties, pasting properties, composite flour, wheat flour, soy flour, sweet potato flour.

I. INTRODUCTION

Wheat (*Triticum* spp.) is the most popular cereal grain that is consumed worldwide. It is the most important stable food crop for more than one third of the world population and contributes more calories and proteins to the world diet than any other cereal crops (Shewry *et al.,* 2009). Wheat is the leading crop due to the elastic property of gluten which is essentially used for the production of numerous baked products such as bread, biscuits, cookies, doughnuts and cakes, of which bread is the most common among them (Dewettinck *et al*., 2008). Many people like wheat-based products because of the taste, and particularly the texture. Wheat is unique among cereals because its flour possesses the ability to form a visco-elastic dough when mixed with water

Sweet potato (*Ipomea batatas*), is a root crop that is grown in developing countries especially the tropics and subtropics. It is high yielding, but bulky and perishable because of its moisture content. However, because of its high dry matter yield, it could be an attractive source of flour in many places if efficient, economical methods of drying could be found. Sweet potato is high in carbohydrates, vitamins (A and C), calories, minerals and precursor of vitamin A (Antonio *et al.*, 2011). According to Akoroda (2009), it provides food security and farmers in Africa produce about 7 million tons of sweetpotato each year of which the majority are lost due to improper postharvest handling.

Soybean is a leguminous vegetable of the pea family that grows in tropical, subtropical, and temperate climates. It was domesticated in the 11th century BC around northeast of China. It is believed to have been introduced to Africa in the 19th century by Chinese traders along the east coast of Africa (IITA, 2015). The eastern half of North China in the eleventh century B.C. has been traced to the first domestication of soybean. Islam *et al.* (2007) reported that soybean is one of the most important oil and protein crops of the world of which Serrem *et al.* (2011) also stated that it contains 30 to 45% protein with a good source of all indispensable amino acids. The protein content of soybean is about 2 times of other pulses, 4 times of wheat, 6 times of rice grain, 4 times of egg and 12 times of milk. Soybean has 3% lecithin, which is helpful for brain development. It is also rich in calcium, phosphorous and Vitamins A, B, C and D. It has been referred to as "the protein hope of the future" (Islam *et al.*, 2007).

The growing concern about a healthier life style and healthy foods has necessitated the food industries to utilize indigenous food to create new products. In essence, various processing technologies have helped in transforming food ingredients into healthier products with maximum nutritional value to ensure nutrient security of the population in developing countries (kumar, 2010). Hasmadi *et al.* (2014) stated that composite flour is considered advantageous in developing countries as it reduces the importation of wheat flour and encourages the use of locally grown crops as flour.

Functional properties are the fundamental physico-chemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of food components together with the nature of environment in which these are associated and measured (Siddiq *et al.*, 2009). Functional characteristics are required to evaluate and possibly help to predict how new proteins, fat, fibre and carbohydrates may behave in specific systems as well as demonstrate whether or not such protein can be used to stimulate or replace conventional protein (Siddiq *et al.*, 2009).

The pasting property is one of the important starch physicochemical properties and is affected by multiple factors (Bemiller, 2011). According to Srichwong *et al.* (2005) starch pasting properties are highly influenced by the composition proportion and structure of starch (e.g. total starch as well as amylose and amylopectin content, the ratio of amylose and amylopectin, the proportion of starch granules with distinct size, distribution of chain length).

This work is aimed at studying the functional and pasting properties of composite flours of wheat, sweet potato and soybean.

II. MATERIALS AND METHODS

The sweet potato tubers, soybean grains and wheat flour that are used for this work were bought from Eke-Awka Market in Anambra state, Nigeria. Equipment that were used include flour milling machine, mechanical sieve, oven, desiccators, centrifuge, weighing balance, Rapid Visco Analyzer (RVA) , stirrer, knife, water, pipettes crucibles, bowls and napkin.

2.1 Production of Flours

2.1.1 Production of Sweet Potato Flour

The method described by Adeleke and Odedeji (2010) was used. Sweet potato tubers were thoroughly sorted to remove bad ones, washed to remove adhering soil, dirts and extraneous materials and thereafter peeled and sliced to 2 mm thickness. The sliced tubers were blanched in water at temperature of 60°C for 2 min to inactivate enzymes that may catalyze browning reaction, and drained followed by drying. Following drying, the sliced tubers were milled, sieved with a mesh of 250 µm into fine flour and packaged for use.

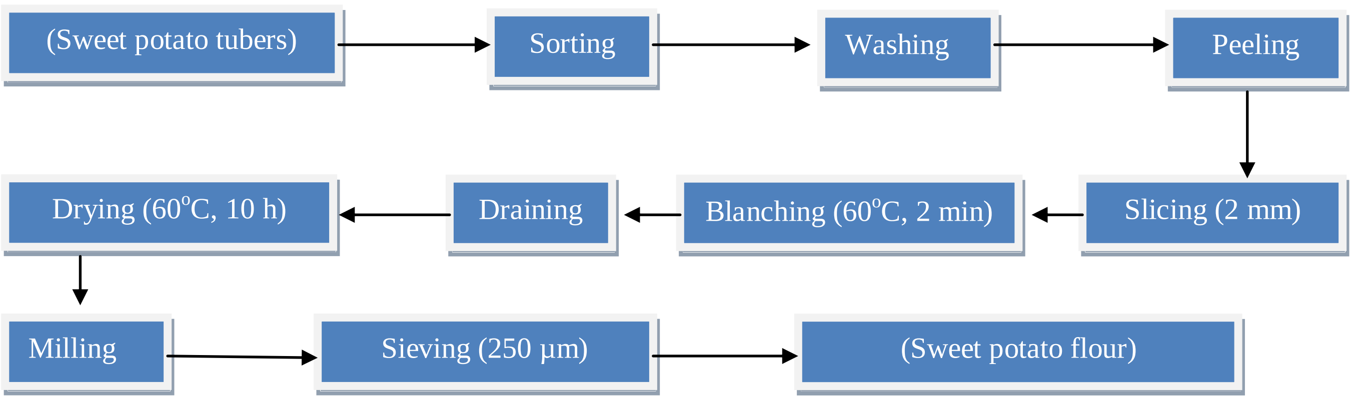

FIGURE 1: flow chart for the production of sweet potato flour

2.1.2 Production of Soybean Flour

The flour was prepared using the method of Bonsi *et al.* (2014) shown in Figure 2. Stones, damaged seeds and other foreign particles were removed from the seeds. The seeds were soaked in portable water for 1 h and the water decanted. The seeds were then boiled in water for 20 min and the water decanted. The seeds were allowed to cool for 10 min and manual decortications by hand. The hulls were separated from the seed by floatation in water. The dehulled seeds were dried in an oven at 60°C to less than 10 % moisture content, milled and sieved with a 250 µm.

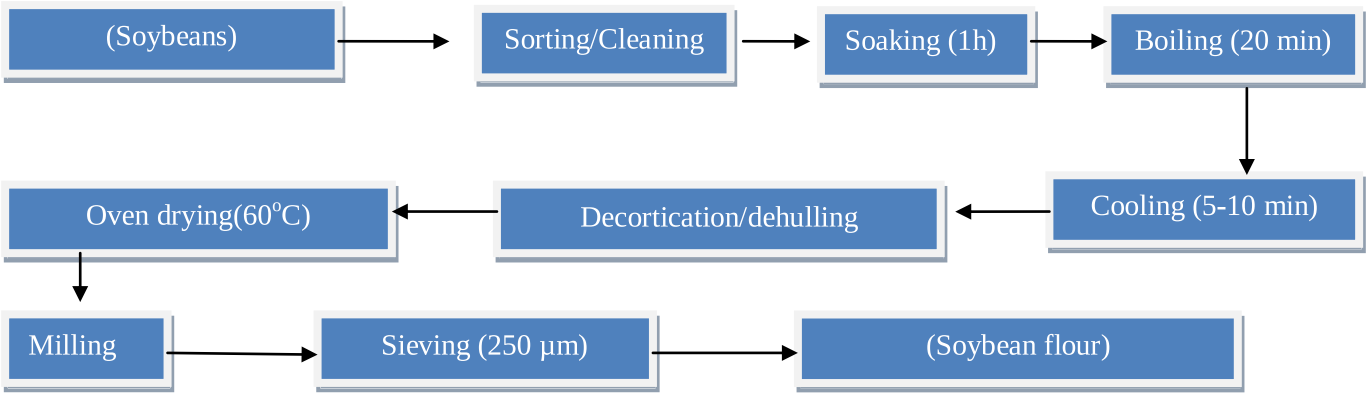

FIGURE 2: Flow chart for the production of soybean flour

TABLE 1
THE FORMULATIONS OF THE FLOUR BLENDS

Code	Wheat (g)	Soybean (g)	Sweet Potato (g)
WOO	100	-	-
WSO	90	10	-
WOS	90	-	10
WSS	80	10	10
$WSS_1$70	10	10	20
$WSS_2$70	20	20	10
SSO	-	50	50

III. METHODS OF ANALYSIS

3.1 Functional Properties

3.1.1 Water Absorption Capacity

The method described by Majzoobi and Abedi (2014) was employed in the determination of the water absorption capacity of the flour samples. One gram of the flour was mixed with 10 ml of water in a centrifuge tube and allowed to stand at room temperature (30 ± 2°C) for 1 h. It was then centrifuged at 5000 rpm for 30 min. The volume of free water was read from the calibrated centrifuge tube. Water absorption capacity was calculated as ml of water absorbed per gram of flour (i.e. the difference in volume of the initial amount of water added to that decanted after centrifugation).

3.1.2 Oil Absorption Capacity

This was determined by the method of Nwosu *et al.* (2010). Exactly 1 g of the sample was measured and 10 mL refined corn oil was measured into a dry, clean centrifuge tube and both weight was noted. Then 10 mL of refined corn oil was poured into the tube and properly mixed with the flour. The suspension was then centrifuged at a speed of 3500 rpm for 15 min. The supernatant thereafter was discarded and the tube content re-weighed. The gain in mass was recorded as the oil absorption capacity of the sample.

3.1.3 Least Gelation Concentration

Least gelation concentration was determined by the method described by Adeleke and Odedeji (2010). Test tubes containing suspensions of 2%, 4%, 6%, 8%,10%, 12%, 14%, 16%, 18%, 20% (w/v) of flours in 5 mL distilled water was heated for 1 h in boiling water bath. This was followed by rapid cooling under cold running tap water. The least gelation concentration (LGC) was taken as that concentration at which the sample in the inverted test tube did not fall down or slip.

3.1.4 Bulk Density

The method described by Heny *et al*. (2015) was used in the determination of bulk density. A 50 g flour sample was put into a 100 mL measuring cylinder. The cylinder was tapped continuously until a constant volume is obtained. The bulk density (g/cm^3) was calculated as weight of flour (g) divided by flour volume (cm^3).

3.1.5 Swelling Power

The swelling powers of the samples was determined with the method described by Heny *et al.* (2015) with slight modification. 1 g of flour sample was mixed with 10 mL of distilled water in a centrifuge tube and heated at 80°C for 30 min in a water bath with continuous shaking during the heating period. After heating, the suspension was centrifuged at 1000 × g for 15 min. The supernatant was decanted and the weight of the paste taken. This was also done at temperatures 50^{o}C, 60^{o}C, 70^{o}C and 90^{o}C.

$$SP = \frac{\text{Weight of paste}}{\text{Weight of dry flour}}$$

3.2 Determination of Pasting Properties

3.2.1 Determination of Pasting Properties

This was determined according to the method described by Efuribe *et al.* (2018) with a Rapid Visco Analyzer (Tecmaster Perten N103802 Australia). Exactly 3.5 g of the samples was weighed into the test canister. Then 25 mL of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister well fitted into the RVA as recommended. The slurry was heated from 50 to 95°C with a holding time of 2 min followed by cooling to 50°C with 2 min holding time. The rate of heating and cooling was at constant rate of 11.25°C/min. Peak, trough, breakdown, final, and setback viscosities, peak time and pasting temperature were read from the pasting profile with the aid of Thermocline for Windows Software connected to a computer.

3.3 Statistical Analysis

The data were subjected to analysis of variance (ANOVA) using Statistical Packaging for Social Science(SPSS) version 20.0 software 2011 to test the level of significance ($p<0.05$). Duncan New Multiple Range Test was used to separate the means where different.

IV. RESULTS AND DISCUSSION

4.1 Functional properties of the flour blends

The functional properties of wheat, soybean and sweet potato composite flours are presented in Table 1. The bulk densities of the flour blends ranged from 0.717 to 0.809 g/mL. From the table, bulk densities of composite flour increased with increase in the level of substitution of wheat flour with sweet potato flour. Sample SSO (0% Wheat flour: 50% Soybean flour: 50% Sweet potato flour) has the lowest bulk density. Formation of an open-bed structure supported by inter-particle forces might have resulted in decreased bulk density of the flours with increased moisture (Fitzpatrick *et al.,* 2004). This decrease occurred mainly because of the increased volume of flours rather than an increase in mass. However, the observed low bulk density of sample SSO (0% Wheat flour: 50%Soybean flour: 50% Sweet potato flour) suggests it's suitability in the formulation of food for babies where high nutrient density to low bulk is desired though such products will not offer packaging advantage compared to wheat flour.

Water absorption capacities (WAC) of the blends increased progressively as the level of sweet potato flour and soy bean increased. However, there was a significant difference ($p\leq0.05$). The increase in WAC of the flour blends may be due to increase in the amylose leaching and solubility and loss of starch crystalline structure (Suresh *et al.,* 2015). Similarly, protein has both hydrophilic and hydrophobic groups and therefore they can interact with water in foods. Thus, the observed variation in different flour blends may be due to different protein concentration, their degree of interaction with water and conformational characteristics (Butt and Batool, 2010).

Water absorption capacity is important with regards to the consistency of product as well as in baking applications. High WAC of composite flours suggests that the flours can be used in formulation of some foods such as sausage, dough and bakery products.

Oil absorption capacity (OAC) ranged between 0.623 to 0.759 g/g among all the flours. The flour sample WOS (90% Wheat flour: 0% Soybean flour: 10% Sweet potato flour) had higher OAC values as compared to sample WOO (100% wheat flour).

Similarly, oil absorption capacity values increased with increased level of sweet potato flour in the mixture. The possible reason for increase in the OAC of composite flours could be variations in the presence of non-polar amino acid side chains of protein which might bind the hydrocarbon side chain of the oil among the flours as reported by Jitngarmkusol *et al*. (2008). This is an indication that the blends would be useful in structural interaction in food especially in flavor retention, improvement of palatability and extension of shelf life particularly in bakery or meat products where oil absorption property is of prime importance. The presence of high-fat content in flours might have affected the oil absorption capacity (OAC) of the composite flours adversely (Chandra *et al*., 2014).

Least gelation concentration (LGC) of the flour samples ranged from 2.000% to 12.000%. The least gelation is defined as the lowest protein concentration at which gel remained in inverted tube. There were no significant difference between the samples . Sample WSO (90% wheat flour: 10% Soybean flour: 0% Sweet potato flour) which has 10% incorporation of soy bean flour has the least level of LGC. Sample WOO (100% wheat flour) and sample WOS (90% wheat flour: 0% Soybean flour: 10% sweet potato flour) formed gel at a significantly low concentration (4.000%) while samples WSS, WSS_1 and WSS_2 formed gel at very high concentration (6.000, 6.000 and 8.000%) respectively. However, sample SSO (50% soybean flour: 50% sweet potato flour) required a significantly higher concentration (12.000%) for gel formation. This is an indication that gelling capacity of wheat flour reduces as the level of other flours increases. The variation in the gelling properties may be ascribed to ratios of the different constituents such as protein, carbohydrates and lipids in different flours, suggesting that interaction between such components may also have a significant role in functional properties (Aremu *et al*., 2007). The lower the LGC, the better the gelling ability of protein ingredient in food formulations. Meanwhile, the observed low gelation concentration of sample WSO (90% wheat flour: 10% Soybean flour: 0% sweet potato flour) as composite flour may be an asset for the formation of curd or as an additive to other gel forming materials in food products.

The swelling capacity of different flour blends at temperature 50^oc ranged from 1.32% to 2.006%. It is worthy to note that swelling capacity is an evidence of non-covalent bonding between molecules within starch granules and also a factor of the ratio of α-amylose and amylopectin ratios. However, the swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations (Suresh *et al.*, 2015).

At 60% the values ranged from 2.213 to 3.617, there was decrease in swelling capacity as the level of incoporation increase. At 70% the values ranged from 3.698 to 5.488 levels ranged from 4.327 to 5.537, there was much increase in samples WSS (80% Wheat flour: 10 % Soybean flour: 10% Sweet potato flour), WSS_1 (70% Wheat flour: 10% Soybean flour: 20% Sweet potato flour) , WSS_2 (70% Wheat flour: 20% Soybean flour: 10% Sweet potato flour) and SSO (0% Wheat flour:50% soybean flour: 50% sweet potato flour) as compared to the control sample WOO (100% Wheat Flour: 0% Soybean flour: 0% Sweet potato flour).At 90% ,the values ranged from 4.916 to 5.637 with sample WSO (90% wheat flour: 10% Soybean flour: 0% sweet potato flour) being the highest.

TABLE 2
FUNCTIONAL PROPERTIES OF THE FLOUR FORMULATIONS

Samples	Bulk Density (g/cm^3)	Water Absorption Capacity (mL/g)	Oil Absorption Capacity (g/g)	LGC (%)	Swelling Power @ 50^oC (g/g)	Swelling Power @ 60^oC (g/g)	Swelling Power @ 70^oC (g/g)	Swelling Power @ 80^oC (g/g)	Swelling Power @ 90^oC (g/g)
WOO	$0.763^{ab} \pm 0.005$	$0.594^a \pm 0.515$	$0.694^{bc} \pm 0.039$	$4.000^a \pm 0.000$	$1.851^f \pm 0.014$	$3.617^f \pm 0.084$	$4.861^a \pm 0.046$	$4.869^c \pm 0.077$	$5.146^b \pm 0.111$
WSO	$0.772^{ab} \pm 0.007$	$0.935^a \pm 0.005$	$0.623^b \pm 0.032$	$2.000^a \pm 0.000$	$1.667^d \pm 0.027$	$3.470^e \pm 0.010$	$4.493^a \pm 0.110$	$4.327^a \pm 0.281$	$5.637^c \pm 0.031$
WOS	$0.809^c \pm 0.002$	$0.960^a \pm 0.040$	$0.759^c \pm 0.013$	$4.000^a \pm 0.000$	$1.621^c \pm 0.013$	$2.867^c \pm 0.062$	$3.903^a \pm 0.042$	$4.617^b \pm 0.016$	$5.204^b \pm 0.084$
WSS	$0.782^b \pm 0.021$	$0.9533^a \pm 0.040$	$0.710^c \pm 0.050$	$6.000^a \pm 0.000$	$1.320^a \pm 0.016$	$3.251^d \pm 0.028$	$3.713^a \pm 0.060$	$5.404^e \pm 0.160$	$5.470^c \pm 0.044$
WSS_1	$0.783^b \pm 0.017$	$0.950^a \pm 0.020$	$0.747^c \pm 0.012$	$6.000^a \pm 0.000$	$1.741^e \pm 0.037$	$3.230^d \pm 0.046$	$3.698^a \pm 0.003$	$5.308^{de} \pm 0.017$	5.469 ± 0.017^c
WSS_2	$0.752^a \pm 0.023$	$0.920^a \pm 0.020$	$0.640^{ab} \pm 0.035$	$8.000^a \pm 0.000$	$1.435^b \pm 0.013$	$2.716^b \pm 0.073$	$4.488^a \pm 0.029$	$5.142^d \pm 0.098$	$4.916^a \pm 0.070$
SSO	$0.71^{7d} \pm 0.011$	$1.648^b \pm 0.143$	$0.726^c \pm 0.049$	$12.000^a \pm 3.138$	$2.006^g \pm 0.021$	$2.213^a \pm 0.037$	$5.488^a \pm 2.884$	$5.537^e \pm 0.023$	$5.447^c \pm 0.237$

Values are Mean ± Standard. Means with the same superscripts (alphabets) along each column are not significantly different whereas different superscript are significantly different (P≤0.05).

WOO = 100% Wheat Flour: 0% Soybean flour: 0% Sweet potato flour

WSO = 90% Wheat flour: 10% Soybean flour: 0% Sweet potato flour

WOS = 90% Wheat flour: 0% Soybean flour: 10% Sweet potato flour

WSS = 80% Wheat flour: 10% Soybean flour: 10% Sweet potato flour

WSS_I = 70% Wheat flour: 10% Soybean flour: 20% Sweet potato flour

WSS_2 = 70% Wheat flour: 20% Soybean flour: 10% Sweet potato flour

SSO = 0% Wheat flour: 50% Soybean flour: 50% Sweet potato flour

4.2 The pasting properties of the flour blends

The pasting properties of the flour blends is shown in Table 2. The peak viscosity ranged from 49.255 to 273.8075 RVU which had sample SSO (0% Wheat flour: 50% Soybean flour: 50% Sweet potato flour) with the lowest value while sample WSO (90% wheat flour: 10% soy bean flour: 0% sweet potato flour) had the highest peak viscosity. High peak viscosity is an index of high starch content. This explains why sample WOO (100% wheat flour) and sample WSO (90% wheat flour: 10% soy bean flour: 0% sweet potato flour) had the highest value indicating high starch content as compared to the other blends. However, incorporation of soybean bean flour and sweet potato flours at different percentages significantly from samples WOS (90% Wheat flour: 0% Soybean flour: 10% Sweet potato flour) to SSO (0% Wheat flour: 50% Soybean flour: 50% Sweet potato flour) decreased the peak viscosity. The relatively low peak is the ability of starch to swell freely before physical breakdown (Sanni *et al*., 2004). The decrease in viscosity could be due to the high fat content. This result is in agreement with Eke *et al*. (2018) on functional and pasting properties of Acha, deffated soybean and groundnut flour blends.

The table revealed that the trough viscosity ranged from sample 5.415 to 245.915 RVU where sample SSO (0% Wheat flour: 50% Soybean flour: 50% Sweet potato flour) had the lowest while sample WOS (90% Wheat flour: 0% Soybean flour: 10% Sweet potato flour) had the highest. Trough viscosity also known as hold period is the point at which viscosity reaches its minimum during either heating or cooling process. The result indicated a decrease in value with an increase in substitution of soybean and sweet potato flour. The values obtained were higher than values (39.60-59.19 RVU) reported for wheat and walnut by ofia-olua (2014) but they are in agreement with Kiin-kabari (2015) on functional and pasting properties of wheat and plantain flours enriched with bambara groundnut protein concentrate.

Breakdown viscosity ranged from 8.245 to 94.245 RVU of which sample WOS (90% Wheat flour: 0% Soybean flour: 10% Sweet potato flour) had the lowest while sample WSS (80% Wheat flour: 10% Soybean flour: 10% Sweet potato flour) had the highest value. The higher the breakdown viscosity, the lower the ability of starch in the flour samples to withstand heating and shear stress while lower breakdown value indicates that the starch in question possess cross-linking properties (Chinma *et al*., 2010). The table showed that there was significant difference (p≥0.05) in the flour blends and this result is in agreement with (Eke *et al*., 2018)

Final viscosity ranged from 118.415 to 377.165 RVU where sample SSO (0% Wheat flour: 50% Soybean flour: 50% Sweet potato flour) had the lowest and WOS (90% wheat flour: 0% Soybean flour: 10% sweet potato flour) had the highest. There were no stability in decrease and increase of values as substitution of soybean and sweetpotato flours increased. There were significant difference (p≥ 0.05) among the samples. The final viscosity is the most commonly used parameters to determine a particular starch-based sample quality. It gives an idea of the ability of a material to gel after cooking. Final viscosities are important in determining the ability of flour to form gel during processing (Liang and King, 2003). The values obtained were above the range reported by Ofia-olua (2014) for wheat and walnut blends (95.51-252) RVU.

Set back viscosity ranged from 69.165 to 220.325 RVU having sample SSO (0% Wheat flour: 50% soybean flour: 50% sweet potato flour) obtaining the least value while WSS (80% wheat flour: 10% soy bean flour: 10 % sweet potato flour) obtained the highest value. Adebowale *et al*. (2005) reported that high set back value is an indication of the propensity of starch molecules to disperse in hot paste and re-associate readily during cooling. Setback viscosity values are reported to correlate with ability of starches to gel into semi solid pastes. This result is slightly higher than that reported by Eke *et al*. (2018) this could be due to the individual flours used.

Peak time ranged from 4.865 to 6.55 min where sample WSS (80% Wheat flour: 10% Soybean flour: 10% Sweet potato flour) obtained the highest value while sample WOS (90% Wheat flour: 0% Soybean flour: 10% Sweet potato flour) obtained the lowest value. The pasting temperature of the flour blends ranged from 80.125 to 93.450 ^{o}C. Sample WOS (90% Wheat flour: 0% Soybean flour: 10% Sweet potato flour) obtained the lowest value while sample SSO (0% Wheat flour: 50% Soybean flour: 50% Sweet potato flour) obtained the highest. This result indicates an increase in peak time and pasting temperature as substitution of soybean and sweet potato flour increased except for sample WOS which obviously decreased. Peak time is a measure of the cooking time while pasting temperature is the temperature at which viscosity starts to raise (Eke *et al*., 2018). Since pasting temperature is a measure of the minimum temperature required to cook a given food sample, flour blends with higher pasting temperature may not be recommended for certain product due to high cost of energy. The values obtained from this study are in agreement with (Eke *et al*., 2018).

TABLE 3
PASTING PROPERTIES AND FALLING NUMBER OF THE FLOUR FORMULATIONS

Samples	Peak 1	Trough 1	Breakdown	Final Visc	Setback	Peak Time	Pasting Temp
WOO	268.165^{a} ± 0.007	205.825^{a} ± 0.007	62.325^{a} ± 0.007	338.915^{a} ± 0.007	133.075^{a} ± 0.007	5.065^{a} ± 0.007	81.415^{a} ± 0.007
WSO	273.075^{b} ± 0.007	228.245^{b} ± 0.007	44.825^{b} ± 0.007	341.495^{b} ± 0.007	113.245^{b} ± 0.007	5.205^{b} ± 0.007	80.655^{b} ± 0.007
WOS	254.165^{c} ± 0.007	245.915^{c} ± 0.007	8.245^{c} ± 0.007	377.165^{c} ± 0.007	131.245^{c} ± 0.007	4.865^{c} ± 0.007	80.125^{c} ± 0.007
WSS	244.925^{d} ± 0.007	150.665^{d} ± 0.007	94.245^{d} ± 0.007	371.005^{d} ± 0.007	220.325^{d} ± 0.007	6.555^{d} ± 0.007	91.845^{d} ± 0.007
WSS$_1$	165.295^{e} ± 0.007	108.075^{e} ± 0.007	57.215^{e} ± 0.007	236.415^{e} ± 0.007	71.115^{e} ± 0.007	6.045^{e} ± 0.007	91.445^{e} ± 0.007
WSS$_2$	161.925^{f} ± 0.007	100.565^{f} ± 0.007	61.345^{f} ± 0.007	232.915^{f} ± 0.007	71.005^{f} ± 0.007	6.365^{f} ± 0.007	90.655^{f} ± 0.007
SSO	49.255^{g} ± 0.007	5.415^{g} ± 0.007	43.825^{g} ± 0.007	118.415^{g} ± 0.007	69.165^{g} ± 0.007	6.365^{f} ± 0.007	93.450^{g} ± 0.014

Values are Mean ± Standard. Means with the same superscripts (alphabets) along each column are not significantly different whereas different superscript are significantly different (P≤0.05).

WOO = 100% Wheat Flour: 0% Soybean flour: 0% Sweet potato flour

WSO = 90% Wheat flour: 10% Soybean flour: 0% Sweet potato flour

WOS = 90% Wheat flour: 0% Soybean flour: 10% Sweet potato flour

WSS = 80% Wheat flour: 10% Soybean flour: 10% Sweet potato flour

WSS$_I$ = 70% Wheat flour: 10% Soybean flour: 20% Sweet potato flour

WSS$_2$ = 70% Wheat flour: 20% Soybean flour: 10% Sweet potato flour

SSO = 0% Wheat flour: 50% Soybean flour: 50% Sweet potato flour

V. CONCLUSION

The study revealed that composite flour with good nutritional value could be produced with wheat flour, sweet potato flour and soybean flour. The functional and pasting properties of the composite flours were determined by the proportion of each constituent flour. There exist variations in the functional and pasting properties of the composite flours which are desirable characteristics for the manufacture of various food products. Sweet potato flour and soybean flour have great potential as a functional ingredient in partial substitution of wheat flour in the diets, particularly in the developing countries. This work recommends the promotion and utilization of wheat-sweet potato-soybean flour. However further research work should be focused on how to improve the sensory quality and hence acceptability.

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