Effect of Soybean Flour Addition on the Proximate Composition, Functional and Pasting Properties of Soy-Poundo Yam Flour

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Abstract

The nutrition of the people of developing countries is a major public health problem that has challenged breeders to enhance the nutritional quality of preferred and commonly consumed staple crops such as yam. This study, therefore aimed at evaluating the effect of soybean flour addition on the proximate, functional and pasting properties of soy-poundo yam flours. The yam flour was substituted with soybean flour at varying proportions (100:0, 90:10, 80:20, 70:30, 60:40 and 50:50) and used to produce more nutritionally balanced products (soy-poundo yam flours). The samples of soy-poundo yam flour obtained were evaluated for proximate, functional and pasting properties using standard methods with 100% instant yam used as control. The moisture, crude protein, fat, ash and crude fibre contents of the samples increased significantly ($p<0.05$) with increase in substitution of soybean flour from 7.56 - 8.36%, 4.41 – 21.14%, 4.18- 5.09%, 2.51- 4.16% and 2.76 - 4.06%, respectively, while their carbohydrate and energy contents decreased from 78.74-57.21% and 370.16- 359.15KJ/100g, respectively. The functional properties of the samples also showed that the bulk density, swelling capacity, water absorption capacity, oil absorption capacity, foam and gelation capacities ranged from 4.03–4.94g/ml, 3.77–4.64%, 21.73-101.64ml/g, 1.37-2.35ml/g, 38.76-97.18% and 32.42 -81.65%, respectively. The samples substituted with 50% soybean flour recorded the highest values in all the functional properties evaluated with the exception of bulk density and water absorption capacity which decreased from 4.94-4.03g/ml and 101.64 -21.73ml/g, respectively as the level of substitution of soybean flour increased. The pasting properties also showed that the peak, trough, breakdown, final and setback viscosities as well as the peak time and pasting temperature of the samples increased significantly ($p<0.05$) with increase in substitution of soybean flour from 78.34-112.21 RVU, 48.31- 98.23 RVU, 70.13 – 105.70 RVU, 67.81-107.14 RVU, 56.77 – 95.15RVU, 24.44 – 64.33 min and 55.64 – 90.25^{o}C, respectively. The control sample (100% instant yam flour) and the sample substituted with 50% soybean flour had the least and highest values, respectively. The study, therefore, showed that the enrichment of yam flour with soybean flour at the levels of 10-30% would add value and varieties to poundo yam meal and also reduce the problem of food security especially among children in the sub-Sahara region of Africa where malnutrition due to protein deficiency is prevalent.

Keywords: *Poundo Yam, Soybean Flour, Enrichment, Proximate Composition, Functional Properties, Pasting Properties*

INTRODUCTION

Yam, a member of genus *Dioscorea* is the most important staple food in West Africa after cereals (Ekwu *et al.*, 2005). It is a major staple food for an estimated 60 million people in the region stretching from Ivory Coast to Cameroun, an area commonly referred to as "Yam Zone" of West Africa (Akissoe *et al.*, 2003; IITA, 2009). In West Africa yam zone, which is regarded as the principal producer of yam on global basis, *Dioscorea rotundata*, *Dioscorea alata* and *Dioscorea cayenensis* are the most common species. Yam is an excellent source of carbohydrate and is equally rich in vitamin C and fibre. There are indications that yam has great potential to contribute towards ameliorating the problem of food shortage in Africa in the 21st century, if efforts are made to identify and overcome the constraints to its production (Jude *et al.*, 2020). Yam is consumed in many different forms. It can be boiled, roasted, fried and converted into flour. It is also mashed and pounded into dough after boiling (Omonigho and Ikenebomeh, 2000). Yam belongs to semi perishable class of food due to its relatively high moisture content and vulnerability to gradual physiological deterioration after harvest. However, yam can be traditionally processed into less perishable products such as yam flour through the slicing, drying and milling processes (Jimoh and Olatidoye, 2009). The processing of yam tubers into yam flour is the simplest method of preserving yam product in a storable form so as to make it available during the off- season thereby reducing the storage as well as marketing and transportation cost of the product (Iwuoha, 2004).

Soybean (*Glycine max*) is a herbaceous annual legume with a bushy, erect and leafy plant structure. It was domesticated in the 11th Century BC around North East of China. Soybean was first introduced in Nigeria in 1908 but the first successful cultivation was in 1937 with the Malayan variety, which was found to be more suitable for commercial production in Benue State, North-Central, Nigeria (Maestric *et al.*, 2007). Nigeria has been the largest producer of soybean in sub-Sahara Africa (11TA, 2009). Soybean is valued as a productive and adaptable crop which fits well into the cropping pattern of varying agro-climatic conditions. Soybeans are generally considered as high versatile seeds which have about 365 applications in the formulation of both human foods and other industrial raw materials (Song, 2000). Soybean is a cheap source of quality protein that is superior to the proteins of all other plant foods because it has the protein content and amino acid profile that are fairly close to that of cow's milk (Bolarinwa *et al.*, 2015). The fat obtained from soybean is unsaturated type unlike saturated fat from animal origin which is not good for heart disease patients (Song, 2000). It contains the eight essential amino acids and is also a rich source of polyunsaturated fatty acids (including the Omega-3-fatty acids) which is free from cholesterol (Song, 2000). Soybean seed contains about 40% protein, 30% carbohydrate, 20% oil and 10% minerals (Danshiell, 1993). The beans are highly rich in fibre and could be utilized in the liquid, powdery and curd forms for human consumption and as feed for millions of livestock.

Functional properties connote the physical and chemical characteristics which govern the behaviour of nutrients in food during processing and serve as the basis for product performance. Functional properties which affect food quality, storage and acceptability include bulk density, foam stability, oil absorption capacity, water absorption capacity, emulsification and gelation properties etc. Functional properties are also defined as those intrinsic physicochemical characteristics that may affect the behaviour of food systems during processing, storage and consumption such as solubility, foamability, gelation and emulsification properties (Adebowale *et al.*, 2015). The ultimate success of utilizing plant proteins as functional ingredients in food preparations depend largely upon the beneficial qualities they impact to food which depend largely on their functional properties (Chinma *et al.*, 2019).
The rheological behaviour of food and its associated rheological properties can be measured (Ragaee and Abdel-Aal, 2006). These properties will affect the shelf life, design of food processing plant and other important factors including the sensory properties that appeal to the consumers. The rheology of food involves the study of deformation and flow properties. According to Arukwe *et al.* (2017), food rheology is the study of consistency and flow of food under tightly specified conditions. Therefore, the objective of this study was to determine the effect of soybean flour addition on the proximate composition, functional and pasting properties of soy-poundo yam composte flours.

MATERIALS AND METHODS

Procurement of Raw Materials

The white variety of yam tubers (*Dioscorea rotundata)* and the soybean seeds (*Glycine max*) used for the study were purchased from Abakpa Market, Enugu, Enugu State, Nigeria.

Preparation of Yam Flour

The instant yam flour was prepared according to the method described by FIIRO (2005) with slight modifications. One kilogram (1kg) of the yam tubers were washed with 2.5 litres of potable water to remove dirt and other adhering materials. The cleaned tubers were peeled manually with kitchen knife and sliced into smaller slices of 2cm thickness. The yam slices were dipped in 2 litres of potable water containing 1.5% Sodium metabisulphite so as to prevent the enzyme-induced browning reaction. After that, the yam slices were drained and washed repeatedly for three consecutive times with excess water to remove Sodium metabisuphite. The washed yam slices were boiled with 2.5 litres of potable water in a stainless pot at 100°C for 10 min on a hot plate. The cooked yam slices were drained, rinsed, spread on the trays and dried in a hot air oven (Model Gallenkamp 300 Plus, England) at 60°C for 18 h with occasional stirring of the slices at intervals of 30 min to ensure uniform drying. The dried yam slices were milled in a hammer mill and sieved through a 400 mesh sieve. The instant yam flour produced was packaged in a covered plastic container, labelled and kept in a refrigerator until needed for further use.

Preparation of Soybean Flour

The boiled soybean flour was prepared according to the method described by Jimoh and Olatidoye (2009) with slight modifications. One kilogram (1kg) of soybean seeds were washed with 2 litres of potable water to remove dirt and other foreign materials. The cleaned seeds were soaked in 3 litres of potable water at room temperature (29$\pm$2°C) for 4 h. The soaked seeds were drained and dehulled manually by rubbing them in-between palms to remove the hulls. The dehulled seeds were put into a stainless pot and boiled with 3 litres of potable water at 100°C for 25 min on a hot plate. The boiled seeds were drained, rinsed, spread on the trays and dried in a hot air oven (Model Gallen Kamp 300 Plus, England) at 60°C for 20 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried seeds were milled in a hammer mill and sieved through a 400 mesh sieve. The boiled soybean flour produced was packaged in a covered plastic container, labelled and kept in a refrigerator until needed for further use.

Formulation of Flour Blends

The soy-poundo yam composite blends were formulated according to the method described by Jimoh and Olatidoye (2009) with slight modifications. The instant yam flour was mixed thoroughly with soybean flour in the ratios of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 in a Kenwood blender (Model SE-505R, Philips England) to obtain homogenous soy-poundo yam composite blends. The soy-poundo yam composite flours produced were packaged separately in covered plastic containers, labelled and kept in a refrigerator until needed for analysis.

Proximate Analysis

The moisture, crude protein, ash, fat and crude fibre contents of soy-poundo yam flours were determined on dry weight basis according to the standard analytical methods of AOAC (2010). Carbohydrate was calculated by difference, % Carbohydrate = 100 = % (Moisture + Crude Protein + Fat + Ash + Crude Fibre). The energy content was calculated by multiplying the percentage values of protein, fat and carbohydrate by the Atwater factors of 4, 9 and 4, respectively. All determinations were carried out in triplicate samples.

Evaluation of Functional Properties

The bulk density, swelling and water absorption capacities of soy-poundo yam composite blends were determined on dry weight basis according to the methods of AOAC (2010). The oil absorption, foam and gelation capacities were determined according to the methods described by Iwe *et al.* (2016). All determinations were carried out in triplicate samples.

Evaluation of Pasting Properties

The pasting properties of the soy-poundo yam composite flours were determined using Rapid Visco Analyzer (RVA) (Model Nweport Scientific Pty. Ltd., Warne –Wood NSW 2012, Australia) according to the method of AACC (2000). Three grams (3g) of each sample was weighed into a dried empty canister and 30mL of distilled water was dispensed into each canister containing the sample to form the slurry. The slurry was thoroughly mixed and each canister was fitted into the Rapid Visco Analyzer. The slurry was heated from 50°C 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 a constant rate of 11.25°C per min. The viscosity was expressed in centipoise (cP). The parameters measured (RVA unit) were: Breakdown viscosity (The difference between the peak viscosity and the minimum viscosity at the end of the heating stage). Final viscosity (The viscosity at the end of the heating stage). Peak time (min) (The time taken for the paste to reach the peak viscosity). Pasting temperature (°C) (The temperature at which there is a sharp increase in viscosity of the sample suspension after the commencement of the maximum viscosity during cooling and the minimum viscosity during heating). Trough (The minimum viscosity which measures the ability of the paste to withstand breakdown during cooling).Peak viscosity (The measure of the ability of starch to form paste on cooking) and setback viscocity (The measure of the retrogradation tendency of the paste on cooling).

Statistical Analysis

The data generated were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS, version 20) software. Significant means were separated using Turkey's least significant difference (LSD) test at $p<0.05$.

RESULTS AND DISCUSION

Proximate Composition of Soy–Poundo Yam Flours

The proximate composition of soy–poundo yam flours are presented in Table 1.

The moisture content of the samples varied significantly ($p<0.05$) from each other. The moisture content ranged from 7.56 to 8.36% with the control sample (100% instant your flour) having the least value (7.56%), while the sample substituted with 50% soybean flour had the highest value (8.36%). The moisture content of the composite blends reported in this study were within the moisture contents (7.62 – 8.46%) that are compatible with the proper storage of dried food products reported by Ndife *et al.* (2011). The lower the moisture content of a food product, the longer the shelf stability of that product. The low moisture contents observed generally in the formulated soy-poundo yam flours is a good indicator of their longer shelf life with proper packaging and storage.

The protein content of the samples ranged from 4.41 to 21.14%. The observed increase in the protein content of the sample substituted with 50% soybean flour could be attributed to the addition of high proportion of soybean flour to the blend. The increase in protein content of the sample is in agreement with the report of Oluwamukomi and Adeyemi (2015) for poundo yam enriched with deffated soybean flour. The high protein contents of the soy- poundo yam flours produced in this study would be of great importance in reducing the protein-energy malnutrition resulting from high cost of conventional animal products particularly in less developed and developing countries of the world including Nigeria. The high levels of protein observed in the soy-poundo yam flours produced clearly demonstrates the effect of supplementation of yam flour with soybean in the formulation of soy-poundo yam flours. Protein is also very important for growth and tissue replacement (Okaka *et al.*, 2006).

The fat content of the samples ranged from 4.18 to 5.09%. The fat content of the control sample (100% instant yam flour) was significantly ($p<0.05$) lower than the fat content of the substituted samples. The variation in the fat content could be due to the differences in the raw materials used in the formulation of soy-poundo yam flours. The level of soybean flour in the formulation might be responsible for the slight increase in the fat content of the resultant products because there was an increase in fat content with the addition of soybean flour to the yam flour (Gyoung and

Mebrahtu, 2003). The high fat content of a food product may be desirable to consumers interested in the consumption of high fat food products. This is because fat increases the energy density and also provides essential fatty acids needed in the body for proper development of neurones and other fatty tissues (Okaka *et al.*, 2006). Fat also helps the body to absorb certain nutrients and maintain core body temperature (Okafor, 2011).

The ash content of the samples increase significantly (p< 0.05) with increase in substitution of soybean flour from 2.51 to 4.16% with the control sample (100% instant yam flour) having the least value (2.51%), while the sample substituted 50% soybean flour had the highest value (4 .16%). The increase in ash content might be attributed to the substitution of yam flour with soybean flour as it could be observed that an increase in soybean flour in the formulation led to a similar increase in the ash content of the sample. The values (2.51 – 4.16%) obtained in this study were similar to the ash content (2.49 – 4.12%) of yam flour fortified with soy-pomace reported by Gbenga *et al.* (2019). The ash content of a food material could be used as an index for estimating the mineral constituents of such a food product (Okafor, 2011).

The fibre content of the samples was observed to increase with increase in substitution of soybean flour. The fibre content ranged from 2.76 to 4.06% for control (100% instant yam flour) and the sample substituted with 50% soybean flour, respectively. The increase in crude fibre content with increase in soybean flour substitution is an indication that soybeans are good sources of crude fibre (Iwe, 2003). The values (2.76 – 4 0.6%) obtained in this study were higher than the fibre content (1.65 – 1.59%) of soy-fortified yam flour reported by Jimoh and Olatidoye (2009). Fibre is needed to assist in digestion and in keeping the gastrointestinal track healthy. It also makes the blood sugar to be stable by slowing down the process of glucose digestion (Trindad *et al.,* 2006). The feacal bulking action of insoluble fibre makes it useful in the treatment of constipation and diverticular diseases (Lattimer and Haub, 2010).

The carbohydrate content of the soy-poundo yam flours ranged from 57.21 to 78.74% with the control (100% instant yam flour) having the highest value (78.74), while the sample enriched with 50% soybean flour had the least value (57.21%). The carbohydrate contents of the samples substituted with soybean flour at different graded levels were significantly (p< 0.05) lower than the control. The result showed that an increase in the amount of soybean flour addition led to a corresponding decrease in the carbohydrate content of the blends. Similar decrease in carbohydrate content has been also reported by Gbenga *et al.* (2019) for yam flour fortified with soy-pomace.

The energy content of the samples varied from 359.15 to 370.16KJ/100g with the control sample having the highest value (370.16kg/100g), while the sample substituted with 50% soybean flour had the lowest energy value (350.15KJ/100g). The energy content was observed to decrease with increase in substitution of the soybean flour in the samples. The result is in agreement with the findings of Nwamarah and Uwaegbute (2006) who reported similar decrease in the energy content of soy-fortified yam snacks. Energy content represents the amount of energy in food that can be supplied to the body for the maintenance of basic body functions. Generally, the substitution of yam flour with soybean flour in the preparation of soy-poundo yam flours greatly increased the protein, ash, fat and crude fibre contents of the samples, while their carbohydrate and energy contents were drastically reduced.

Table 1: Proximate composition (%) of soy-poundo yam flours.

Samples	% Substitution IYF: BSF	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate	Energy (KJ/100g)
A	100 : 00	7.56^{f}±0.01	4.41^{f}±0.01	4.18^{f}±0.01	2.51^{f}±0.01	2.76^{f}±0.01	78.74^{a}±0.17	370.16^{a}±0.64
B	90 : 10	7.86^{e}±0.01	7.76^{e}±0.01	4.36^{e}±0.01	2.87^{e}±0.01	3.11^{e}±0.00	74.07^{b}±0.01	366.48^{b}±0.06
C	80 : 20	7.92^{d}±0.01	10.79^{d}±0.01	4.58^{d}±0.01	3.12^{d}±0.01	3.44^{d}±0.01	70.17^{c}±0.01	364.99^{c}±0.04
D	70 : 30	8.11^{c}±0.01	14.21^{c}±0.01	4.74^{c}±0.01	3.56^{c}±0.01	3.76^{c}±0.01	65.63^{d}±0.01	361.94^{d}±0.01
E	60 : 40	8.21^{b}±0.01	17.35^{b}±0.01	4.92^{b}±0.01	3.89^{b}±0.01	3.97^{b}±0.01	61.68^{e}±0.03	360.36^{e}±0.05
F	50 : 50	8.36^{a}±0.01	21.14^{a}±0.01	5.09^{a}±0.01	4.16^{a}±0.01	4.06^{a}±0.01	57.21^{f}±0.00	359.15^{f}±0.15

A – 100% instant yam flour, B – Soy–poundo yam flour made with 90% yam flour and 10% soybean flour, C – Soy-poundo yam flour made with 80% yam flour and 20% soybean flour, D – Soy–poundo yam flour made with 70% yam flour and 30% soybean flour, E- Soy-poundo yam flour made with 60% yam flour and 40% soybean flour, F – Soy-poundo yam flour made with 50% yam flour and 50% soybean flour.
Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($p<0.05$).
IYF – Instant yam flour, BSF – Boiled soybean flour.

Functional Properties of Soy- Poundo Yam Flours

The functional properties of soy- poundo yam flours are presented in Table 2. The swelling, oil absorption, foam and gelation capacities of the samples increased significantly ($p<0.05$) as the level of substitution with soybean flour increased with the exception of bulk density and water absorption capacity which decreased drastically.

The bulk density of the samples ranged from 4.03 to 4.94g/ml with the control sample (100% instant yam flour) having the highest value (4.94g/ml), while the sample substituted with 50% soybean flour had the least value (4.03g/ml). The observed decrease in the bulk density could be attributed to the addition of soybean flour to the sample. High bulk density may be desirable in that it increases the rate of dispersion which is important in the reconstitution of flour with boiling water to produce a stiff dough. Although the low bulk density is undesirable as it will impair the dispersability of food powder, it is also a very important factor in the formulation of complementary foods (Bolarinwa *et al.,* 2015). Nutritionally, low bulk density engenders the consumption of more quantity of lighter food item which will in turn translates into the availability of more nutrients for the consumer. Bulk density is also important in the determination of the packaging requirement, material handling and in the wet processing of food products in the food industry (Malomo *et al.,* 2012; Iwe *et al.,* 2016).

The swelling capacity of the soy- poundo yam flours ranged from 3.37 to 4.64%. The control sample had the least value (3.77%), while the sample substituted with 50% soybean flour had the highest value (4.46%). The values (3.77 – 4.64%) obtained in this study were higher than the swelling capacity (2.83 – 3.86%) reported by Iwuoha and Nnanemere (2003) for yam flours produced from different varieties of yam tubers. High swelling capacity of the soy- poundo yam flours is desirable in that they could be easily used for thickening of soups, sauces and gravies.

The water absorption capacity of the samples decreased significantly ($p<0.05$) from 101.64 to 21.73ml/g with the control (100% instant yam flour) having the highest value (101.64ml/g), while the sample substituted with 50% soybean flour had the least (21.73ml/g) water absorption capacity. The water absorption capacity is the ability of the flour to absorb water and swell so as to improve its consistency (Ekwu *et al.*, 2005). The observed difference in water absorption capacity could be mainly caused by the greater number of hydroxyl group which exists in the fibrous structure, thereby allowing more water interaction through the formation of hydrogen bonding (Nassir *et al.*, 2008). The low water absorption capacity observed in all the soy- poundo yam flours could be attributed to the presence of low level of carbohydrate in the form of starch granules which have little ability to absorb greater amount of water to gelatinize on reconstitution with warm or hot water. Lower water absorption capacity is desirable for making thinner gel or paste that would enhance more intake of nutrients. High water absorption capacity of the samples would be more desirable in the formulation of doughs, sausages, bakery and confectionery products (Kanu *et al.*, 2007).

The oil absorption capacity of the blends ranged from 1.37 to 2.35ml/g for the control and the sample substituted with 50% soybean flour, respectively. The result showed that the oil absorption capacity increased with increase in the addition of soybean flour to the blends. The oil absorption capacity of the flour is very important in monitoring the spoilage as well as the ability of protein to bind fat (Jimoh and Olatidoye, 2009). The high oil absorption capacity of the soy- poundo composite blends showed that they could be generally used in various food formulations where flavour enhancement, improvement of palatability and extension of shelf life are highly needed particularly in bakery and baby foods which require fat absorption (Aremu *et al.*, 2009; Suresh and Samsher, 2013).

The foam capacity of the samples increased significantly ($p<0.05$) as the level of substitution with soybean flour increased from 38.76 to 97.18% with the control (100% instant yam flour) and the sample substituted with 50% soybean flour having the least (38.76%) and highest (97.18%) values, respectively. The observed increase could be attributed to the presence of soluble proteins in the soybean flour which enhanced the foam capacity of the composite blends. Kaur *et al.* (2007) reported that soluble proteins enhance the foam capacity of foods. Foamability is related to the rate of decrease of the surface tension of air-water interface caused by the absorption of protein molecules. It is also a function of the type of protein, pH and processing methods used (Akubor, 2016). Foams are used to improve the texture, consistency and appearance of foods. The high foam capacity of the soy- poundo yam flours suggests that they would be suitable for use in the preparation of bakery and confectionery products. They would be also used as whipping and binding agents in the preparation of whipped cream, sour cream and ice-cream (El-Adawy, 2001).

The gelation capacity of the soy-poundo yam flours which ranged from 32.42 to 81.65% increased significantly ($p<0.05$) with increase in substitution of soybean flour in the blends. The result showed that the native proteins that are soluble in water are very active in the soy- poundo composite blends compared to the control (100% instant yam flour). Starch gelatinization is a process in which the intermolecular bonds of starch molecules are broken down in the presence of water and heat with the formation of hydrogen bonds which tend to attract more water. A gel represents a transitional phase between solid and liquid states. In food system, it could consists of protein, polysaccharides or a mixture of both, while the liquid is usually water. The gelation capacity is usually influenced by ionic strength, pH and the presence of non-protein component (Chou *et al.*, 2006). The result showed a gradual increase in gelation capacity with increase in substitution of yam flour with soybean flour in the samples. The variation in the gelling properties of different flours could be associated with the relative ratios of different constituents such as protein, carbohydrate and fat that make up the flours (Oluwamukomi and Jolayemi, 2012). The high gelation capacity of the composite blends suggests that they would be useful in food systems such as puddings and snacks where thickening and gelling are needed. Generally, the addition of soybean flour to yam flour in the formulation of soy- poundo yam flour blends increased the swelling, oil absorption, foam and gelation capacities of the samples with the exception of bulk density and water absorption capacity which decreased as the level of substitution increased in the blends.

Table 2: Functional properties of soy- poundo yam flours.

Samples	% Substitution IYF : BSF	Bulk Density (g/ml)	Swelling Capacity (%)	Water absorption Capacity (ml/g)	Oil Absorption Capacity (ml/g)	Foam Capacity (%)	Gelation Capacity (GC) (%)
A	100 : 00	$4.94^{a} \pm 0.02$	$3.77^{f} \pm 0.01$	$101.64^{a} \pm 0.69$	$1.37^{f} \pm 0.03$	$38.76^{f} \pm 0.01$	$32.42^{f} \pm 0.08$
B	90 : 10	$4.87^{b} \pm 0.01$	$3.96^{e} \pm 0.01$	$98.06^{b} \pm 0.68$	$1.67^{e} \pm 0.02$	$47.72^{e} \pm 1.46$	$46.19^{e} \pm 0.70$
C	80 : 20	$4.75^{c} \pm 0.01$	$4.01^{d} \pm 0.01$	$72.76^{c} \pm 0.01$	$1.89^{d} \pm 0.01$	$61.38^{d} \pm 1.28$	$57.51^{d} \pm 1.09$
D	70 : 30	$4.43^{d} \pm 0.01$	$4.25^{c} \pm 0.01$	$55.49^{d} \pm 1.36$	$2.02^{c} \pm 0.01$	$75.33^{c} \pm 0.62$	$61.99^{c} \pm 0.49$
E	60 : 40	$4.16^{e} \pm 0.01$	$4.43^{b} \pm 0.01$	$37.34^{e} \pm 0.64$	$2.20^{b} \pm 0.03$	$86.71^{b} \pm 1.32$	$73.90^{b} \pm 0.74$
F	50 : 50	$4.03^{f} \pm 0.01$	$4.64^{a} \pm 0.02$	$21.73^{f} \pm 1.35$	$2.35^{a} \pm 0.01$	$97.18^{a} \pm 1.83$	$81.65^{a} \pm 1.24$

A – 100% instant yam flour, B – Soy- poundo yam flour made with 90% yam flour and 10% soybean flour, C – Soy- poundo yam flour made with 80% yam flour and 20% soybean flour, D – Soy- poundo yam flour made with 70% yam flour and 30% soybean flour, E- Soy- poundo yam flour made with 60% yam flour and 40% soybean flour, F – Soy- poundo yam flour made with 50% yam flour and 50% soybean flour. Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($p<0.05$).
IYF – Instant yam flour, BSF – Boiled soybean flour.

Pasting Properties of Soy- Poundo Yam Flours

The pasting properties of soy- poundo yam composite blends are presented in Table 3. The pasting properties of soy- poundo yam flours evaluated in this study were generally increased with increase in substitution of soybean flour in the blends.

The peak viscosity of the samples increased significantly ($p<0.05$) from 78.34 to 112.21 RVU with increase in the addition of soybean flour in the blends. The control sample (100% instant yam flour) had the least peak viscosity (78.34RVU), while the sample substituted with 50% soybean flour had the highest value (112.21 RVU). The increase in peak viscosity could be due to the addition of soybean flour which increased the protein content of the formulation with subsequent reduction in starch content. Peak viscosity is an indication of water holding capacity of starch and is often correlated with the final product quality (Bamigbola *et al.*, 2016). The peak viscosity has been reported to be closely associated with the degree of starch damage. High starch damage results in high peak viscosity (Shimelis *et al.*, 2006). The high peak viscosity of the soy- poundo yam flours is not nutritionally beneficial in infant food formulation. However, they could be utilized in the preparation of snacks and bakery products where gelling and thickening are needed.

The trough viscosity of the samples ranged from 48.31 to 98.23 RVU with the control and the sample substituted with 50% soybean flour having the least (48.31RVU) and highest (98.23RVU) values, respectively. Trough viscosity is the minimum viscosity which measures the ability of paste to withstand breakdown during cooling (Bolarinwa *et al.*, 2015). Trough viscosity is the point at which the viscosity reaches its minimum during either heating or cooling process. It is the minimum viscosity value in the constant temperature phase of the RVA profile. Trough viscosity is regarded as the measure of paste stability (Oluwamukomi and Jolayemi, 2012). It gives an indication of hot paste stability and the smaller the value, the higher the stability. The flours with low trough viscosity values could be said to have hot paste stability and could be useful in processes that require stable paste and low retrogradation, such as filler in meat canning industry. However, the high trough viscosity of the soy- poundo yam flours produced in this study is an indication that they did not have hot paste stability and hence, they would have high retrogradation tendency.

The breakdown viscosity of the samples varied from 70.13 to 105.70 RVU. The control sample had the least value (70.13 RVU), while the sample substituted with 50% soybean flour had the highest (105.70 RVU) breakdown viscosity. The values (70.13–105.70 RVU) obtained in this study were higher than the breakdown viscosity (69.1–56.4 RVU) reported by Oluwamukomi and Adeyemi(2015) for poundo yam enriched with defatted soybean flour. Breakdown viscosity is a measure of the degree of paste stability or starch granule disintegration during heating (Usman *et al.*, 2016). It is the measure of the susceptibility of the cooked starch sample to disintegration. At breakdown, the swollen starch granules disrupt further and amylose molecules generally leach out into the solution (Shimelis *et al.*, 2006). Higher values of breakdown viscosity in foods are associated with high peak viscosities which are equally related to the degree of swelling of the starch granules. Starch with lower breakdown viscosity had been reported to possess high capacity to withstand heating and shearing during cooking (Kiin-Kabari *et al.*, 2015).

The final viscosity of the samples ranged from 67.81 to 107.14 RVU. The control sample (100% instant yam flour) had the least final viscosity (67.81 RVU), while the sample substituted with 50% soybean flour had the highest value (107.14 RVU). The observed increase in final viscosity could be attributed to the high level of protein contained in the soybean flour used for the formulation of the samples. The final viscosity is an indication of the ability of the starch-based food to form a viscous paste or gel after cooking and cooling (Oluwalana *et al.*, 2011). The result showed that the soy- poundo yam flours produced had higher final viscosity than the control (100% instant yam flour). This implies that the composite blends with high final viscosity values would be less stable after cooling, while the 100% instant yam flour (control) that had the lowest final viscosity would be more stable after cooling.

The setback viscosity of the blends ranged from 56.77 to 95.15 RVU with the control having the least (56.77 RVU) value, while the sample substituted with 50% soybean flour had the highest value (95.15 RVU). There were significant ($p < 0.05$) differences in setback viscosity among the soy- poundo yam flours formulated. Higher setback viscosity value is closely associated with reduced dough digestibility (Arukwe *et al.*, 2017), while lower setback viscosity during the cooling of the paste is an indication of lower tendency to retrogradation as well as increase in dough digestibility. Setback viscosity has been correlated with the texture of the food products (Achi, 2003; Sandhu and Singh, 2007).

The peak time of soy- poundo yam composite blends also varied from 24.44 to 64.33min with the control (100% instant yam flour) and the sample substituted with 50% soybean flour having the least (24.44min) and highest (64.33min) values, respectively. Peak time is a measure of the cooking time (Adebowale *et al.*, 2005)[a]. It is also regarded as the total time taken by each sample to attain its respective peak viscosity (Zhou *et al.*, 2007). Peak time is an indication of the minimum time required to cook the flour sample. The peak time (24.44 – 64.33min) obtained in this study were relatively higher than the peak time (15.13 – 26.30min) reported by Kiin-kabari *et al.* (2015) for wheat/plantain flours enriched with bambara groundnut and protein concentrates. High peak time values of the samples showed that they would not cook faster and hence, they would require more heating to form paste. The lower the peak time, the faster the cooking and the lesser the heat that would be required to form paste during cooking.

The pasting temperature of the blends increased significantly ($p<0.05$) with increase in substitution with soybean flour. The pasting temperature of the samples ranged from 55.64 to 90.25^oC with the control (100% instant yam flour) and the sample substituted with 50% soybean flour having the least (55.64^oC) and highest (90.25^oC) values, respectively. The increase in the pasting temperature of the soy- poundo yam flours could be due to their high fat contents which exerted buffering effect on the starch thereby interfering with the gelatinization process during cooking (Adebowale *et al.*, 2005)[b]. The values (55.64 – 90.25^oC) obtained in this study were lower than the pasting temperature (64.85 – 94.85^oC) reported by Oluwamukomi and Adeyemi (2015) for poundo yam enriched with defatted soybean flour. The pasting temperature is a measure of the minimum temperature required to cook a given food sample (Sandhu and Singh, 2007). The higher the pasting temperature, the higher the gelatinization tendency with reduction in the swelling capacity due to the high associative forces between the starch granules. Pasting temperature is one of the properties that provides an indication of the minimum temperature required for cooking a food product. It also provides an indication of the energy cost involved and the stability of other components. Flours with high pasting temperature may not be recommended for use in the production of certain food products due to the fact that they would not cook faster and as such more energy (fuel) would be required. However, flours with low pasting temperature would generally cook faster and reasonable amount of energy would be also saved during cooking. Ideally, the substitution of yam flour with soybean flour in the formulation of soy- poundo yam flours generally increased the peak, trough, breakdown, final and setback viscosities as well as the peak time and pasting temperature of the samples.

Table 3: Pasting properties of soy- poundo yam flours

Samples	% Substitution IYF : BSF	Peak Viscosity (RVU)	Trough (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak time (Min)	Pasting Temperature (^oC)
A	100 : 00	$78.34^f±0.70$	$48.31^f±0.01$	$70.13^f±0.01$	$67.81^f±0.01$	$56.77^f±0.01$	$24.44^f±0.01$	$55.64^f±0.01$
B	90 : 00	$83.16^e±0.02$	$57.65^e±0.01$	$76.23^e±0.01$	$74.16^e±0.01$	$61.16^e±0.02$	$30.99^e±0.63$	$62.17^e±0.01$
C	80 : 20	$88.22^d±0.68$	$61.15^d±0.04$	$85.11^d±0.01$	$84.26^d±0.76$	$70.21^d±0.02$	$38.92^d±0.52$	$68.98^d±0.31$
D	70 : 30	$98.36^c±0.01$	$72.29^c±0.01$	$90.44^c±0.01$	$93.16^c±0.03$	$79.85^c±0.01$	$46.36^c±0.01$	$78.35^c±0.04$
E	60 : 40	$103.10^b±0.48$	$88.32^b±0.61$	$98.56^b±0.01$	$98.62^b±0.64$	$86.56^b±0.01$	$52.58^b±0.02$	$84.31^b±0.01$
F	50 : 50	$112.21^a±0.03$	$98.23^a±0.01$	$105.70^a±0.50$	$107.14^a±0.06$	$95.15^a±0.01$	$64.33^a±0.02$	$90.25^a±0.01$

A – 100% instant yam flour, B – Soy- poundo yam flour made with 90% yam flour and 10% soybean flour, C – Soy- poundo yam flour made with 80% yam flour and 20% soybean flour, D – Soy- poundo yam flour made with 70% yam flour and 30% soybean flour, E- Soy- poundo yam flour made with 60% yam flour and 40% soybean flour, F – Soy- poundo yam flour made with 50% yam flour and 50% soybean flour.
Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($p<0.05$).
IYF – Instant yam flour, BSF – Boiled soybean flour.

CONCLUSION

The study showed that the enrichment of yam flour with various proportions of soybean flour significantly enhanced the proximate composition, functional and pasting properties of soy- poundo yam composite blends. The results showed that the increase in the addition of soybean flour resulted to corresponding increase in protein, fat, ash and crude fibre with slight decrease in their carbohydrate and energy contents. It was observed from the study that the addition of soybean flour to yam flour generally increased the oil absorption, swelling, foam and gelation capacities of the samples, while the bulk density and water absorption capacity were drastically reduced. This implies that the soy- poundo yam flours have good functional properties and, hence, they could be used in food systems like bread, cake and biscuit products. The pasting properties (peak, trough, breakdown, setback and final viscosities) were also increased with increase in the addition of soybean flour. This implies that the flour samples are not beneficial for use in the preparation of foods required for the feeding of infants and children but rather they could be used for adult food formulations. Also, the high pasting temperature and peak time of the samples are clear indication that they would not cook faster and more fuel (energy) should be needed when reconstituting them into pastes or adult foods.

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