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QUALITY ATTRIBUTES OF STIFF DOUGH (AMALA) FROM YELLOW YAM-JACKBEAN COMPOSITE FLOUR

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ABSTRACT

Yams (Dioscorea spp) as an indigenous starchy food crop are majorly consumed as yam flour when processed into stiff dough, most especially in the South-western region of Nigeria. This study was carried out to investigate the quality attributes of stiff dough (Amala) from yellow yam (YYF)-jackbean composite flour (JBF). The yellow yam tubers and jackbean seeds were processed into flour, blended and substituted in the ratios of 100:0, 95:5, 90:10, 85:15, 80:20, 75:25, 70:30, 65:35 and 0:100, respectively. The nutritional components, functional and pasting properties were assessed. The stiff dough was analyzed for colour properties and browning index. The sensory attributes were also determined.The nutritional composition of yellow yam (YYF)-jackbean composite flour (JBF) all showed significant differences except for the starch content. The bulk density ranged between 0.76 and 0.88g.ml-1. Peak viscosity and final viscosity range was 217 to 2537 and 199 to 3392RVU, respectively while dispersibility ranged between 60.39 and 76.86%. Water absorption capacity and swelling power ranged from 148.82 to 172.45% and12.23 to 14.23%, respectively while solubility index ranged between 1.13 and 1.44%. Breakdown viscosity and setback viscosity of the composite flour ranged from 53 to 220RVU and 50 to 775.0 RVU, respectively. The colour properties, browning index and sensory attributes of the stiff dough varied significantly. Stiff dough prepared from 100% yellow flour had the highest overall acceptability but comparable stiff dough (Amala)could be produced from yellow flour substituted with jackbean flour at 5%, thus reducing the protein-energy malnutrition in developing countries.

Keywords: Yellow yam flour, jackbean flour, stiff dough..

INTRODUCTION

Yam is a member of genus Dioscorea which give rise to consumable starchy storage rhizomes. Yams rank third amongst the most significant sultry root crops in Africa, following cassava and sweet potatoes, with Nigeria being the leading grower of the crops (Ferraro et al. 2016). The nutritional composition of yam chiefly includes starch, with minimal quantity of proteins, lipids, vitamins including vitamins B, E and K, together with beta-carotene, potassium and sodium, which have elevated values (Okoro and Ajieh, 2014). Amongst the more than

600 recognized varieties of yam, only seven are majorly eaten (Jayakody et al., 2007). These include Dioscorea rotundata Poir (White yam), Dioscorea alata(Water yam), Dioscorea bulbifera (Aerial yam), Dioscorea esculenta (Chinese yam) and Dioscorea dumetorum (Bitter yam) and Dioscorea cayenensis(Yellow yam) (Otegbayo et al., 2001).Yellow yam (Dioscorea cayenensis) is a significant variety of grown yam due to its importance in the diet of multifarious individuals in the coast of West Africa, some Eastern and Central African countries as well as the Caribbean region. It is famous for its carotenoids which depict the widest category of pigments occurring naturally (Akin-Idowu et al., 2009). Yellow yam has been reported to be a great source of carotenoids such as α-carotene, β-carotene and zeaxanthin which could help in fighting micronutrient deficiency (Ukom et al., 2014).

In Nigeria, among the under-utilized peas which could alleviate the deficiency of protein in human nutrition especially in developing countries is the Jackbean (Canavalia ensiformis) (Doss et al., 2011). Jackbean is a chief source of nutrients which arevaluable but not completely balance protein with the exception of sulphur amino acids (methionine and cystine)most especially in the diets of vegetarians (Eddy and Allen, 2007). It is an excellent source of protein (23% to 34%), carbohydrate (55%) and minerals such as calcium, zinc, phosphorus, magnesium, copper and nickel (Asirvatham et al., 2011).

Amala is a collective name in Nigeria which describes stiff dough made from yam, cocoyam, cassava or unripe plantain flour that is stirred in hot water to produce a lump-free consistency (Fetuga et al., 2014). In Nigeria, especially the South West locality, root and tuber crops like yam and cassava are normally processed into powdered form referred to as “elubo” which is prepared by the conventional method of simmering in water or drenching before drying. This is done to control the easy spoilage of the raw forms and the periodic nature of their production. The conventional flour, “elubo” is made into a stiff dough meal called “Amala” (Abiodun and Akinoso, 2014). “Amala” according to Fetuga et al.(2014) is described as a regular food among the vulnerable groups and the recuperating individuals who require sufficient protein intake, hence, the need to enhance the protein content with an accessible, tolerable and economical source of protein such as jackbean(Arisa and Aworh, 2007). The quality pointers of interest by the consumers in evaluating the acceptability of “Amala” comprise the texture (elasticity and non-stickiness), colour (brownish) and taste (Akissoe et al., 2001; Chilaka et al., 2002). There have been numerous reports on the production of Amala from blends of root crops and legumes. Fetuga et al. (2014) reported on “Amala” produced from sweet potato flour as having higher acceptability by consumers due to its pleasant taste. Idowu et al. (2017) on cocoyam-cowpea flour blends reported that the protein content, ash content and functional properties of cocoyam flour increases with addition of cowpea flour as well as in the cooked paste. Awoyale et al. (2020) reported on cooked paste from unripe plantain powder and their sensory properties relating to packaging material and storability.

However, there is dearth of information on the performance of yellow yam-jackbean flour for the production of stiff dough (Amala). The use of yellow yam with jackbean as a composite flour for the production of stiff dough will increase their food application most especially in household cooking. Therefore,the objective of the study was to assess the quality attributes of yellow yam-jackbean composite flour blends and its stiff dough, to determine the optimum composite ratio.

MATERIALS AND METHODS

Materials

Matured yam tubers (Dioscorea cayenensis) were obtained from Olodo market in Abeokuta, Ogun State, Nigeria and were identified at the Plant Physiology and Crop Production Department while Jackbean was obtained from the Department of Plant Physiology and Crop Production (PPCP), Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

Methods

Production of yellow yam flour

Yellow yam flour was prepared using the method elucidated by Babajide et al. (2006). Distilled water was used to wash the yam tuber to remove dirt and other undesirable materials. The yellow yam was peeled manually with the aid of kitchen knives and sliced into portions of 2-3cm thickness. The portioned yellow yam slices were simmered in water at 50°C for 30minutes after which the yellow yam was removed. The simmered yellow yam was soaked in water for 24 hours to soften the slices. The soaked yellow yam was drained and taken into the cabinet dryer to dry at 60°C for 72hours. A laboratory hammer mill (Fritsch, D-55743, Idar-Oberstein-Germany) was used to mill the dried yellow yam slices, screened through a 250μm sieve to obtain a smooth flour. The resultant yellow yam flour was packed and sealed in a polythene bag for further analysis.

Production of jackbean flour

Jackbean flour was prepared using the method described by Oke et al. (2020). The jackbean was weighed and boiled in water at 100°C for 10 minutes. The boiled seeds were rinsed with clean water, de-hulled and dried in a cabinet dryer at 60°C for 72 hours. Laboratory hammer mill (Fritsch, D-55743, Idar-Oberstein-Germany) was used to mill the dried-boiled seeds and a sieve of screen 250μm used to sieve out the milled sample to obtain the fine flour. The jackbean flour was packagedin apolythene bag for further analysis.

Formulation of yellow yam-jackbean composite flour

The method described by Awoyale et al. (2015) was adopted in formulating the yellow yam and jackbean flour blends which were 100:0, 95:5,90:10, 85:15, 80:20, 75:25, 70:30, 65:35and 0:100, respectively. The flours were blended using a Kenwood mixer (Model HC 750D, Kenwood, UK), packaged in a polythene bag until required.

Nutrient composition of yellow yam-jackbean composite flour

Method by AOAC (2010) was used to determine the moisture content, total ash, crude fat, crude fibre, crude protein while carbohydrate was determined by difference (Rampersad et al., 2003).

$$\text{Carbohydrate} = 100 - (\%\text{moisture} + \%\text{total ash} + \%\text{crude fat} + \%\text{crude fibre} + \%\text{crude protein})$$

Determination of starch content of yellow yam-jackbean composite flour

The starch content of the composite flour was determined using the method described by Dubois et al. (1956) as modified by AOAC (2010). Starch was extracted using hot ethanol from the yam and jackbean flour sample. The supernatant (extract) and digest (from the residue) was measured calorimetrically for starch, using phenol-sulphuric acid as the colour developing reagent; and absorbance read at 490 nm wave length. 20mg of the flour sample was measured and emptied into a centrifuge tube and moistened with 1 ml 95% ethanol. 2 ml distilled water was included; thereafter, 10 ml of hot 95% ethanol was added. The content was vortexed and centrifuged (GALLENKOMP Centrifuge Model 90 - 1, USA) at 2000 rpm for 10 min. The supernatant was drained while the residue was hydrolyzed with perchloric acid and used to evaluate starch content. The absorbance was read with a spectrophotometer (Milton Spectronic 601, USA) at 490 nm

$$\%Starch = \frac{(\mathrm{Absorbance} - 0.0044)4}{sample\ wt.\ \mathrm{X}\ 0.55}$$

Determination of amylose and amylopectin content of yellow yam-jackbean composite flour

The iodine colorimetric method of Williams et al. (1958) as described by Addy et al. (2014) was adopted in determining the amylose content of the yam starch. 0.1 g of the starch sample was solubilized with 1 ml 95% ethanol and 9 ml 1N NaOH, and steamed in a boiling water bath for 10 min; 1 ml of the extract was filled up to 10 ml with distilled water. 0.1 ml IN acetic acid and 0.2 ml Iodine solution (0.2 g I2+2.0 g KI in 100 ml of distilled water) was added to 0.5 ml of the diluted extract to bring out a dark blue colour. The coloured solution was made up to 10 ml with distilled water and kept for 20 min for the colour to be more pronounced. The solution was whirled and its absorbance read on a spectrophotometer at 620 nm. The absorbance of standard corn amylose with known amylose concentration was used to estimate the amylose content.

$$\%\ Amylose = \frac{\mathrm{Amylose\ of\ standard\ x\ absorbance\ of\ sample}}{absorbanceofstandard}$$

%Amylopectin= 100- Amylose content

Determination of total carotenoid content of yellow yam flour- jackbean composite flour

Total carotenoid content of the composite flour was determined using a spectrophotometer as described in the Harvest Plus Handbook for Carotenoid Analysis and using slight modifications of the methods described by Lee (2001). During the extraction process, some precautions were taken, like working in a reduced luminosity room. This was determined using spectrophotometric measurements using T60 UV Visible spectrophotometer at 450 nm. Six millilitre of n-hexane, 3 ml acetone and 3 ml ethanol ((hexane: acetone: ethanol, 2:1:1) containing 0.05% butylated hydroxytoluene (BHT) was added to 2 g of flour samples. The sample was centrifuged. The top layer of hexane containing the color was recovered and transferred to a cuvette. For total carotenoid, the absorbance of the hexane extract was read at 450 nm.

$$\text{Formula } \mu g/g \text{ Carotenoid } = \frac{A \times VOL \times 10}{2505 \times W}$$

Where,
A= absorbance, W= weight of sample
VOL= volume of hexane used

Determination of functional properties of yellow yam flour- jackbean composite flour

Bulk density determination was carried out using the method described by Wang and Kinsella (1976); Water absorption capacity (Beuchat, 1977; Onwuka, 2005), Dispersibility (Kulkarni et al., 1991; Adebowale et al., 2012), Swelling power and solubility index (Takashi and Seib, 1988; Adebowale et al., 2012).

Pasting properties of yellow yam-jackbean composite flour

A Rapid Visco Analyzer (RVA TECMASTER, perten instrument-2122833, Australia) was used to evaluate the pasting properties. Into a dried empty container was measured 3g of sample and to it was poured 25ml of dis-tilled water. The suspension was vigorously mixed to dissolve the lumps and the container was fixed into the rapid visco analyzer. A paddle was put into the container and analysed instantly which automatically plots the characteristic curve. Parameters estimated included: peak viscosity, setback viscosity, final viscosity, trough, break-down viscosity, pasting temperature and time taken to reach peak viscosity.

Colour properties ofstiff dough prepared from yellow yam-jackbean composite flour

Colour properties were determined using the method described by Feili et al. (2013). Minolta chromameter was used to get the values of L *, a *, and b *. After calibrating the instrument by covering a zero-calibrating mask followed by white calibration plate, the stiff dough was analysed by placing it on the petri dish, and the image was captured on the samples. The colour attributes of L*(lightness), a* (redness) and b* (yellowness) were recorded. The browning index was calculated as: 100-L* as described by Akissoeet al. (2004).

Sensory qualities of stiff dough from yellow yam-jackbean composite flour

Sensory evaluation was carried out on the stiff dough using the method described by-Iwe, (2002). 50 panelists were engaged to evaluate the stiff doughin termsof colour, aroma, texture, mouldability, smoothness, and overall acceptability of the stiff dough using a nine-point hedonic scale (1=dislike extremely, 5= neither like nor dislike, 9= like extremely).

Statistical analysis

All experimental data obtained were subjected to statistical analysis. Analysis of variance was determined using SPSS version 21.0. Differences between the mean values wereseparated at $p<0.05$ using Duncan multiple range test.

RESULTS AND DISCUSSION

Nutrient composition of yellow yam-jackbean composite flour

Significant differences were observed between the moisture content of the yellow yam-jackbean flour (Table 1). The moisture of the flour ranged from 5.88 to 9.40%. Moisture content is an important factor in flour which significantly affects the shelf stability of food products (Adebowale et al., 2005).Hence, the reduced moisture content of the yellow yam-jackbean flour shown in this study would improve its storability by eschewing mould growth and other biochemical reactions (Onimawo and Akubor, 2012).

The crude fat content of the flour ranged from 0.15 to 0.25%, with 15%jackbean flour substitution having the least crude fat content while20%substitution had the highest crude fat content (Table 1).However, the values from yellow yam substituted with jackbean at 25-30% and 100% jackbean were comparable with each other. The crude fat content obtained in this study was lower than the result of Affandi et al. (2017) which ranged from 1.14 to 2.22% using greater yam flour (Dioscorea alata) and jackbean flour. The remarkably reduced fat content in the composite flour blends indicates their suitability as raw materials in formulating diverse food products (Ohizua et al., 2017).

Total ash content is a measure of the total mineral content in foods (Idowu et al., 2017). The total ash content for the yellow yam–jackbean flour ranged from 0.89 to 1.15% (Table 1).The values of 1.07 and 1.09% from yellow yam substituted with jackbean at 20-25% were comparable with each other. Total ash content obtained in this study was lower than value of 2.40-3.50% reported by Awoyale et al. (2015) on water yam and distillers spent grain flour blends and this indicated that the flour blends in this study are poor in minerals

Elleuch et al.(2011) reported that fibre helps increase bowel movement thereby aiding digestion ;reduces blood cholesterol levels; eases stools and prevents many diseases such as irritable colon, cancer and diabetes. The crude fibre composition ranged from 3.88 to 4.96%, with yellow yam flour substituted with 30% jackbean flour having the lowest crude fibre content while yellow yam flour substituted with10% jackbean flour having the highest crude fibre content. However, values of 3.97, 4.06 and 4.01% from 5, 10 and 15% substitutions, respectively were comparable with each other,showing that the flour blends are excellent sources of fibre and can be useful in the processing of functional foods (Ohizua et al., 2017).

The crude protein content ranged from 11.79 to 12.52%with yellow yam flour substituted with jackbean at 5% having the lowest protein content while yellow yam flour substituted with 10% jackbean flour had the highest protein content (Table 1). Significant differences were observed within the crude protein contents of the yellow yam-jackbean composite flour. The values of 12.34, 12.21, 12.44, 12.29% from 20, 25, 35% substitutions and 100% jackbean, respectively were comparable with each other. The crude protein content obtained in this study were within the range value of 9.97 to 16.72% reported by Oke et al. (2020) on yellow yam-jackbean flour.The high protein in yellow yam-jackbean composite in this study could be due to the inclusion of jackbean flour having high protein content.Proteins are consistently being used to render functional roles in food formulations such as Amala stiff dough (Idowu et al., 2017).

Carbohydrates perform the major role of supplying energy to the brain, muscle and blood cells; contribute to mechanism of fat, act as mild natural laxative, and spares proteins as an energy source (Gordon, 2000). Carbohydrate content ranged from 73.28 to

76.19% but still comparable with the range value from 73.76 to 76.19% for 10-20% substitution, 74.13 to 73.74% for 100% yellow yam and 5% substitution and 73.28 to 75.02 %for 100% jackbean and 35% substitutions, respectively(Table 1). The values from this study were close to the value of 68.77 to 74.69% reported by Affandi et al. (2017) for greater yam and jackbean flour. This could be due to the flour blends containing high sugar and starch contents (Saeed et al., 2012).

According to Baah (2009), starch accounts for 80% of yam carbohydrate (on a dry weight basis), and it is a major factor in determining the physicochemical, rheological and textural characteristics of yam food products. The starch content ranged from 74.99 to 79.64%,with yellow yam flour substituted with jackbean flour at 30% having the lowest starch content, while yellow yam flour substituted with jackbean flour at 35% had the highest value for starch (Table 1). Results obtained in this study were comparable with all the values of starch content of yellow yam-jackbean flour blends but still lower than the value of 79.38 to 80.07% reported by Oke et al. (2020) on blend formulations with jackbean flour at 5.00, 6.25, 7.50, 8.75 and 10.00% replacement levels for yellow yam flour.This could be as a result of the inclusion of the jackbean flour and the processing method employed for the yellow yam flour.

Zhenghong et al. (2003) reported that amylose is a major factor of starch which influences pasting and retro-gradation behaviour. Significant differences were observed in the amylose content of the yellow yam-jackbean flour blends.The values for amylose content ranged from 28.75% to 38.05%. Yellow yam flour substituted with 10%jackbean flour had the lowest amylose content; while yellow yam flour substituted with 25% jackbean flour had the highest value for amylose.Amylopectin content gives a precise feature and viability to starch by evaluating the texture and nature of their product (Ezeocha et al., 2014). The values for amylopectin content in this study ranged from 61.95 to71.26%with yellow yam flour at 25% jackbean having the lowest content while yellow yam flour with 10% jackbean substitution had the highest amylopectin content. The value for amylose obtained in this study was higher, while the values for amylopectin content(61.95 to 71.26%)was lower than the value of 70.13 to 74.65% reported by Oke et al. (2020) for yellow yam-jackbean flour. This implies that increased pasting consistency as well as viscosity is obtained when the amylopectin component of a food product is more than that of its amylose component (Zhou et al., 2002).

Total carotenoids content ranged from 2.41 to 4.41µg.g-1;with yellow yam flour substituted with 15% jackbean flour having the highest while yellow yam flour substituted with 35%jackbean flour had the lowest. However the value of 3.45 and 3.28 µg.g-1 from 100% yellow yam flour and5% substitution were comparable with each other. The results from this study were significantly lower than values of5.24 and 6.65µg.g-1reported by Oke et al. (2020) on blend formulations with jackbean flour at 5.00, 6.25, 7.50, 8.75 and 10.00% replacement levels for yellow yam flour. This might be due to the drying conditions, heat, and temperature employed during processing (Oliveira et al., 2010).Carotenoids are mainly plant sources and beta-carotene which is more prevalent (Akin-Idowu et al., 2009), is a significant food nutrient because it is a principal antecedent of vitamin A.

Functional properties of yellow yam-jackbean composite flour

The functional properties of a certain food depict the physical and chemical characteristics that show the behavioral pattern of the protein in food systems during processing, cooking, storage, and consumption (Mahajan and Dua, 2002).The values of bulk density of the yellow yam-jackbean flour ranged from 0.76 to 0.88g.ml^{-1} (Table 2).Significant differences were observed within the bulk density of the yellow yam-jackbean flour. Values of 0.81, 0.83 and 0.81 g.ml^{-1} from 15-25% substitution were comparable with each other. The bulk density is very germane to assess flour-based products as regards the weight, handling conditions, and suitability of packaging materials for storage and transportation of the food materials (Ohizua et al., 2017). The bulk density of this study was higher than 0.56 to 0.84 g.ml^{-1} reported by Malomo et al. (2012) for yam-soybean flour blend and 0.62 to 0.73g.ml^{-1} reported by Oke et al. (2020) for yellow yam-jackbean flour blends. This may be as a result of the composition of flour used in substitution. Bulk density is generally affected by particle size and the density of the flour and is important in determining the packaging requirement and material handling (Adebowale et al., 2008; Adegunwa et al., 2015).

Water absorption capacity (WAC) is the bonding ability of a product with water under conditions where the water is insufficient (Singh, 2001). The WAC values ranged from 148.82 to 172.45%,with jackbean flour at 100% having the lowest water absorption capacity, and yellow yam flour substituted with jackbean flour at 5% having the highest water absorption capacity (Table 2). The elevated water absorption capacity is as a result of the slack structure of the starch polymers while the reduced value shows the tightness of the molecular structure (Khuthadzo et al., 2019). The variation in high value of water absorption capacity obtained in this study could be due to the protein and carbohydrate contents of yellow yam and jackbean flour. Flour blend with high water absorption capacity have been reported by Fekria et al.(2012) and Okorie et al.(2016) to have more hydrophilic polysaccharide and protein constituents. The results obtained in this study were also in agreement with the report of Omoniyi et al. (2016) for sweetpotato-soybean flour and Otunola and Afolayan (2018) for water yam-cowpea flour blends.

Swelling power is an estimate of hydration ability because the evaluation is a measure of the weight of swollen starch granules and the water content (Yellavila et al., 2015). Values for swelling power ranged from 12.23 to 14.33%,with jackbean flour at 100% having the lowest value for swelling power and yellow yam flour with 25% substitution having the highest value swelling power (Table 2). The high value for swelling power is an implication of the high starch content in yellow yam-jackbean flour. However, Singh (2001) reported that swelling capacity is determined by amylose content. High amylose content in a food product connotes increased hydrophilic groups such that more water is bound and swelling power increases. Some of the factors that affect the swelling power include the temperature, availability of water, species of starch and other carbohydrates and proteins (Ezema, 1989; Oppong, 2015). The high swelling power obtained in this study suggests that yellow yam-jackbean composite flour could be utilized in food applications where swelling is required.

Solubility is the ability of water to penetrate into the starch granules of flours (Ikegwu et al., 2009; Oppong, 2015).The solubility index values ranged from 1.13 to 1.44% (Table 2).Values of 1.19 and 1.22% from 15 -25% were comparable with each other. The values of solubility obtained in this study were low; this could be due to protein-amylose complex formation. However, Kumar and Khatkar (2017); Awoyale et al. (2020) reported that solubility index could be due to leaching out of amylose of starch granules during swelling and affected by intermolecular forces and the presence of surfactants and other associated substances. Solubility index of flour granules could be influenced by certain factors such as characteristics of the flour granules, amylose and amylopectin ratio, mineral content and existence of other constituents (Singh et al., 2003).

Dispersibility is the degree of the ability of a flour product to reconstitute in water. The higher the dispersibility value of yellow yam -jackbean flour, the better the flour reconstitute (Kulkarni et al., 1991). Dispersibility values ranged from 60.39 to 76.86%with yellow yam flour at 100% having the lowest dispersibility value and yellow yam flour substituted with 35% jackbean flour having the highest value (Table 2). The high dispersibility values obtained for yellow yam-jackbean flour blend is an indication that the flour blends will enhance the reconstitution capacity and textural features of dough obtained from yellow yam-jackbean flour during mixing as reported by Babajide and Olowe (2013).

Pasting properties of yellow yam-jackbean composite flour

The pasting properties of flours are used in assessing the suitability of its application as a viable component in food and other industrial products (Oluwalana et al., 2011) and it also influences the sensory acceptability of the cooked starchy products (Adebayo-Oyetoro et al., 2016). Peak values ranged from 217 to 2537RVU with 100% jackbean flour having the least peak value while 100% yellow yam flour had the highest peak value (Table 3). The high peak viscosity depicts the water holding ability of the starch, which is usually connected to the final product quality and indicates the viscous load likely to be experienced during mixing (Maziya-Dixon et al., 2007).The relatively high peak viscosity implies that the flour blend from yellow yam -jackbean could be suitable for product with increasing gel strength and elasticity such as cooked paste.

The trough viscosity of the blends ranged from 149 to 2368RVU (Table 3). Significantdifferences were observed within the trough viscosity values of the yellow yam-jackbean flour. High trough viscosity gives a guide to increased capability of the paste to hold-up with breakdown during temperature drop (Adebowale et al., 2008). Breakdown viscosity explains the power of the flour product to endure heating and shear stress during cooking, and high breakdown viscosity is related to a reduced capability of starch to resist heating and shear tress (Ohizua et al., 2017).

The breakdown viscosity of the blends ranged from 53 to 220RVU with yellow yam flour substituted with 25% jackbean flour having the lowest breakdown viscosity and yellow yam flour substituted with 15% jackbean flour having the most elevated breakdown viscosity. The result obtained from this study for yellow yam-jackbean flour blends suggest that they might endure heating and shear processes without major change in consistency.

The final viscosity is the most regularly utilized variable to determine the strength of starch-based materials to form a sticky paste or gel after cooking and subsequent cooling as well as the resistance of the paste to shear force during stirring (Sanni et al., 2015). The values for final viscosity of the yellow yam-jackbean ranged from 199 to 3392RVU (Table 3).In this study, final viscosity decreased with increase in substitution of jackbean flour; showing that jackbean flour hinders formation of viscous paste and resistance of the paste to shear stress during stirring(Sanni et al., 2015).

The setback viscosity gives a hint on the tendency of the starch in the flour sample to retrograde after 50°C (Ohizua et al., 2017).Significantdifferences were also observed within the setback viscosity values of the yellow yam-jackbean flour blends (Table 3). The setback viscosity of the yellow yam-jackbean ranged from 50RVU with 100% jackbean flour to 775.0RVU withyellow yam flour substituted with jackbean at 5%.This implies that the more the setback value is on an upward trend, the lower the retro-gradation during cooling and the more the staling rate of the product made from the flour samples reduces (Adeyemi and Idowu 1990; Adebowale et al., 2008).

Peak time is the time at which the peak viscosity occurs (in minutes). It is a measure of the cooking time of the flour (Adebowale et al., 2008; Oke et al., 2016).The peak time of the yellow yam-jackbean ranged from 4.68 to 6.02mins with 100% yellow yam flour having the highest peak time which suggest more cooking time for 100% yellow yam flour and 100% jack bean flour having the lowest peak time (Table 3). Significant differences were observed within the peak time values of the yellow yam-jackbean flour blends.

Pasting temperature is the temperature at which the first noticeable rise in viscosity is measured and which indicates the first change as a result of swelling of starch (Chinma et al., 2013). The pasting temperature of the yellow yam-jackbean ranged from 85.66 to 88.76°Cwith yellow yam flour substituted with 5% jackbean flour having the lowest pasting temperature and 100% jackbean flour having the highest pasting temperatures (Table 3). Significant differences were observed within the pasting temperatures of the yellow yam-jackbean flour blends, but yellow yam flour substituted with jackbean flour from 10-15% had comparable values with each other.

Colour properties and browning index of stiff dough prepared from yellow yam-jackbean composite flour

Significant differences were observed between the lightness, redness, yellowness and browning index (Table 4). Colour is a significant quality index both in the food and bioprocess industries, and it determines consumer's choice and preferences (Pathare et al., 2013; Oke et al., 2021).The lightness (L*) and redness (a*) of the stiff dough ranged from 44.93 to 52.01 and 1.25 to 2.13, respectively while the yellowness of the stiff dough ranged between 7.05 and 7.78 (Table 4).The lightness value of 51.7, 52.01, 50.99 and 51.94 of stiff dough prepared from substitutions of 10-35% were comparable with each other while the redness of stiff dough prepared from substation of 100% yellow yam, 5% and 15-35% were comparable with each other. The yellowness of stiff dough prepared from substitutions of 10-35% were comparable with each other. Fetuga et al.

(2014) on sweet potato reported that the brown index was the most representative colour index because of the high significant correlation between the brown index of yam flour and that of the Amala. Browning index (BI) of stiff dough from yellow yam and jackbean flour blends ranged from 47.99 to 55.07 with stiff dough from yellow yam flour substituted with jackbean flour at 15% having the lowest browning index value while stiff dough from 100% yellow yam flour had the highest value. Browning index values of 48.43, 47.99, 49.02 and 48.06 of stiff dough prepared from substitutions of 10, 15, 30 and 35%, respectively were comparable with each other. This might be based on the partial enzymatic browning in the yellow yam slices during drying process and non-enzymatic reaction in the flour. However, the browning colour formation in the stiff dough could be caused by a combined interaction of water, flour and heating during processing (Bolade, 2017).

Sensory qualities of stiff dough prepared from yellow yam –jackbean composite flour
All the values obtained for the sensory attributes of stiff dough prepared from yellow yam –jackbean composite flour were comparable with each other (Table 5).Colour and aroma of the stiff dough ranged from 6.68 to 7.74 and 6.70 to 7.44, respectively while texture of the stiff dough ranged between 6.62 and 7.82.However, stiff dough prepared from 100% yellow yam flour had the highest value for colour, aroma and texture while stiff dough prepared from yellow yam flour substituted with 25% jackbean flour had the lowest value for colour, aroma and texture, respectively.

Mouldability and smoothness ranged from 6.72 to 7.72 and 6.82 to 7.70, respectively. Stiff dough prepared from yellow yam flour at 15% jackbean flour substitution had the lowest value while stiff dough prepared from 100% yellow yam flour had the highest value for mouldability and smoothness. Smoothness indicates absence of lumps in the stiff dough. As regards the overall acceptability, stiff dough made from the formulation of yellow yam flour at 25% jackbean substitution had the lowest value for overall acceptability while stiff dough from 100% yellow yam flour had the peak value for overall acceptability. This might be due to the fact that consumers are traditionally used to stiff dough prepared from yam flour. However, stiff dough prepared from all blends of yellow yam and jackbean flour were accepted by the panelists.

CONCLUSION

The study indicates that inclusion of jackbean flour to yellow yam flour increases the protein content which can be useful in improving the protein requirement of food in developing countries like Nigeria.
The starch content, amylose and amylopectin content are increased variably with addition of jackbean flour.
Total carotenoid content is decreased with the addition of jackbean flour.
Blending of jackbean flour with yellow yam flour leads to lower bulk density, water absorption capacity, and final viscosity.
The colour properties (lightness, redness and yellowness), and browning index of stiff dough vary significantly with level of the substitution.
Stiff dough prepared from 100% yellow flour was the most preferred by the panelist .However, acceptable stiff dough (Amala) could be produced from yellow flour substituted with jackbean flour at 5%, thus reducing the protein-energy malnutrition in devel-

Table 1: Nutrient Composition of Yellow Yam-Jackbean Composite Flour

YYF:JBF (%)	**Moisture Content** (%)	**Crude fat** (%)	**Total Ash** (%)	**Crude Fibre** (%)	**Crude Protein** (%)	**CHO** (%)	**Starch** (%)	**Amylose of Starch** (%)	**Amylopectin of Starch** (%)	**Total Carotenoids** (μg/g)
100:0	7.63± 0.04^{d}	0.18± 0.00^{d}	1.03± 0.01^{bc}	4.83± 0.02^{a}	12.20± 0.02^{c}	74.13 ±0.02^{b}	77.09± 0.04^{a}	31.36± 0.04^{f}	68.70± 0.11^{c}	3.45± 0.01^{c}
95:5	9.40± 0.02^{a}	0.16± 0.01^{e}	0.94± 0.01^{de}	3.97± 0.01^{f}	11.79± 0.01^{d}	73.74± 0.03^{b}	78.09± 0.09^{a}	30.70± 0.22^{g}	69.31± 0.02^{b}	3.28± 0.06^{c}
90:10	5.88± 0.01^{g}	0.22± 0.00^{b}	1.13± 0.01^{a}	4.06± 0.00^{f}	12.52± 0.01^{a}	76.19± 0.01^{a}	77.84± 0.04^{a}	28.75± 0.25^{h}	71.26± 0.25^{a}	2.50± 0.07^{e}
85:15	9.25± 0.05^{b}	0.15± 0.01^{e}	0.97± 0.01^{cd}	4.01± 0.01^{f}	11.86± 0.01^{d}	73.76± 0.01^{a}	78.49± 0.06^{a}	34.47± 0.21^{d}	65.54± 0.21^{e}	4.11± 0.01^{a}
80:20	6.51± 0.01^{f}	0.25±0. 00^{a}	1.07± 0.01^{ab}	4.75± 0.00^{b}	12.34± 0.00^{bc}	75.08± 0.01^{a}	78.96± 0.05^{a}	36.75± 0.04^{b}	63.25± 0.04^{g}	2.81± 0.08^{d}
75:25	7.41± 0.02^{e}	0.19± 0.01^{cd}	1.09± 0.01^{ab}	4.23± 0.01^{e}	12.21± 0.01^{c}	74.87± 0.03^{a}	77.45± 0.01^{a}	38.05± 0.04^{a}	61.95± 0.04^{h}	2.55± 0.01^{e}
70:30	9.19± 0.04^{b}	0.18± 0.00^{d}	0.89± 0.01^{e}	3.88± 0.02^{g}	11.91± 0.01^{d}	73.95± 0.01^{b}	79.64± 0.04^{a}	32.93± 0.02^{e}	67.08± 0.02^{d}	2.80± 0.18^{d}
65:35	6.52± 0.05^{f}	0.21± 0.01^{bc}	1.15± 0.01^{a}	4.66± 0.01^{c}	12.44± 0.01^{ab}	75.02± 0.03^{a}	74.99± 0.03^{a}	28.85± 0.02^{h}	71.16± 0.02^{a}	2.41± 0.10^{e}
0:100	7.74± 0.02^{c}	0.22± 0.01^{b}	1.05± 0.09^{c}	4.42± 0.05^{d}	12.29± 0.20^{bc}	73.28± 0.55^{a}	77.99± 0.01^{a}	35.68± 0.08^{c}	64.33± 0.08^{f}	4.01± 0.16^{b}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$);
YYF- Yellow Yam Flour; JBF- Jackbean Flour; CHO- Carbohydrate

Table 2: Functional Properties of Yellow Yam-Jackbean Composite Flour

YYF:JBF	BD (g/ml)	WAC (%)	SP (%)	SI (%)	DISP (%)
100:0	0.83±0.01^{bc}	168.19±0.04^{cd}	12.84±0.00^{ef}	1.31±0.01^{b}	60.39±0.09^{g}
95:5	0.88±0.00^{a}	172.45±0.01^{a}	13.61±0.01^{cd}	1.27±0.01^{c}	74.53±0.04^{c}
90:10	0.85±0.01^{b}	171.12±1.28^{b}	14.08±0.05^{ab}	1.40±0.02^{a}	71.83±0.09^{d}
85:15	0.81±0.00^{cde}	168.94±0.03^{c}	12.72±0.10^{fg}	1.19±0.01^{def}	68.64±0.11^{f}
80:20	0.83±0.01^{bcd}	166.66±0.18^{e}	13.27±0.22^{de}	1.22±0.00^{cde}	76.69±0.15^{a}
75:25	0.81±0.01^{de}	167.33±0.17^{de}	14.33±0.03^{a}	1.44±0.07^{a}	70.73±0.27^{e}
70:30	0.76±0.01^{f}	150.42±0.25^{g}	12.38±0.40^{gh}	1.13±0.01^{f}	75.63±0.36^{b}
65:35	0.79±0.01^{e}	156.47±0.21^{f}	13.80±0.19^{bc}	1.24±0.00^{cd}	76.86±0.06^{a}
0:100	0.85±0.00^{a}	148.82±0.15^{h}	12.23±0.29^{h}	1.17±0.02^{ef}	74.31±0.21^{c}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); YYF- Yellow Yam Flour; JBF- Jackbean Flour

Table 3: Pasting Properties of yellow yam-jackbean composite flour

YYF :JBF	Peak viscosity	Trough viscosity	Breakdown viscosity	Final viscosity	Setback viscosity	Peak time	Pasting temperature
			RVU			Minutes	°C
100:0	2537.0±0.001^{a}	2368.0±0.01^{a}	169.0±0.02^{c}	3392.0±0.01^{a}	112.0±0.01^{g}	6.02±0.02^{a}	86.46±0.01^{d}
95:5	2246.0±0.01^{b}	2078.0±0.01^{b}	168.0±0.02^{d}	2853.0±0.01^{b}	775.0±0.01^{a}	5.68±0.01^{d}	85.66±0.01^{g}
90:10	1598.0±0.01^{c}	1386.0±0.01^{c}	212.0±0.01^{b}	1908.0±0.02^{c}	522.0±0.01^{b}	5.75±0.02^{c}	86.46±0.01^{d}
85:15	1539.0±0.01^{d}	1319.0±0.02^{d}	220.0±0.01^{a}	1741.0±0.01^{d}	422.0±0.01^{c}	5.41±0.01^{f}	86.46±0.01^{d}
80:20	1216.0±0.01^{e}	1092.0±0.02^{e}	124.0±0.01^{e}	1300.0±0.02^{e}	208.0±0.02^{d}	5.48±0.01^{e}	86.41±0.01^{e}
75:25	1005.0±0.07^{f}	886.0±0.01^{f}	53.00±0.01^{i}	716.0±0.02^{h}	108.0±0.01^{h}	5.74±0.01^{c}	88.06±0.01^{b}
70:30	700.0±0.02^{g}	608.0±0.01^{g}	119.0±0.01^{f}	1035.0±0.01^{f}	149.0±0.01^{e}	5.48±0.01^{e}	86.36±0.01^{f}
65:35	661.0±0.01^{h}	575.0±0.02^{h}	103.0±0.01^{g}	726.0±0.01^{g}	129.0±0.01^{f}	5.94±0.01^{b}	88.02±0.02^{c}
0:100	217.0±0.01^{i}	149.0±0.02^{i}	68.0±0.01^{h}	199.0±0.01^{i}	50.0±0.02^{i}	4.68±0.01^{g}	88.76±0.01^{a}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); YYF- Yellow Yam Flour; JBF- Jackbean Flour

Table 4: Colour Properties and Browning Index of Stiff Dough Prepared Of Yellow Yam-Jackbean Composite Flour

YYF:JBF	Lightness (L*)	Redness (a*)	Yellowness (b*)	Browning Index
100:0	44.93±0.01[d]	2.13±0.09[a]	7.40±0.11[cde]	55.07±0.24[a]
95:5	49.11±0.88[c]	2.04±0.04[a]	7.78±0.25[a]	50.89±0.88[b]
90:10	51.17±0.14[ab]	1.72±0.11[b]	7.05±0.11[f]	48.83±0.14[cd]
85:15	52.01±0.48[a]	1.41±0.03[cd]	7.23±0.16[ef]	47.99±0.48[d]
80:20	50.48±0.01[b]	1.45±0.01[c]	7.54±0.12[bcde]	49.52±0.01[c]
75:25	48.33±0.35[c]	1.32±0.02[cd]	7.27±0.07[def]	51.67±0.35[b]
70:30	50.99±0.10[ab]	1.25±0.14[d]	7.58±0.10[bcd]	49.02±0.10[cd]
65:35	51.94±0.20[a]	1.29±0.07[cd]	7.65±0.01[ab]	48.06±0.20[d]

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); YYF- Yellow Yam Flour; JBF- Jackbean Flour

Table 5: Sensory Qualities of Stiff Dough Prepared From Yellow Yam-Jackbean Composite Flour

YYF:JBF	Colour	Aroma	Texture	Mouldability	Smoothness	Overall acceptability
100:0	7.74±1.29[a]	7.44±1.50[a]	7.82±1.12[a]	7.72±1.33[a]	7.70±1.39[a]	7.88±1.17[a]
95:5	7.20±1.43[ab]	7.00±1.21[b]	7.30±1.09[b]	7.12±1.09[b]	7.02±1.10[b]	7.12±1.17[b]
90:10	7.20±1.31[ab]	7.24±1.30[b]	6.98±1.55[b]	6.86±1.60[b]	7.28±1.34[ab]	7.14±1.16[b]
85:15	7.20±1.26[ab]	6.96±1.23[b]	6.94±1.45[b]	6.72±1.49[b]	6.82±1.56[b]	6.90±1.47[b]
80:20	7.06±1.33[b]	7.02±1.41[b]	7.04±1.26[b]	6.76±1.36[b]	6.96±1.16[b]	6.92±1.29[b]
75:25	6.68±1.10[b]	6.70±1.20[b]	6.62±1.28[b]	6.90±1.18[b]	6.86±1.29[b]	6.78±1.13[b]
70:30	6.98±1.38[b]	6.84±1.46[b]	6.70±1.39[b]	6.84±1.54[b]	6.96±1.48[b]	6.98±1.44[b]
65:35	6.82±1.72[b]	6.84±1.63[b]	6.84±1.56[b]	7.08±1.29[b]	7.00±1.26[b]	7.14±1.28[b]

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); YYF- Yellow Yam Flour;
JBF- Jackbean Flour

oping countries.

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