Original Research Article

Pasting Properties of Flour Blends from Water yam, Yellow maize and African yam bean Seeds

Abstract

Pasting properties of flour blends from water yam, yellow maize and African yam bean were investigated in this study. Peak viscosity ranged from 133.50 to 166.25RVU, Trough viscosity ranged from 85.08 to 135.20RVU, break down viscosity ranged from 28.17 to 50.58RVU, final viscosity ranged from 5.05 to 5.49 min and pasting temperature ranged from 80.25 84.15°C. Addition of yellow maize and African yam bean affected ($p<0.05$) the peak viscosity, trough viscosity, break down viscosity, final viscosity, and setback viscosity in different trends. However, peak time and peak temperature of the flour sample were not statically ($p<0.05$) affected by the blend ratio in this study. Amongst the flour samples investigated in this study, flour sample DIN (60%WY:10%YM:30%AYB) showed promise for value added products such as noodles among other flour products. They flour sample adjusted to be the best sample could be used as a good replacement for wheat flour and when achieved, it will reduce the cost of importation.

Key words: Pasting, flour blend, water yam and yellow maize

1.0 Introduction

Water yam (*Dioscorea alata* L) is the most widely distributed species of yam, though the total quantity produced in less than that of white yam. Water yam (*D. alata)* is grown widely in tropical and sub-tropical regions of the world. Water yams (Dioscoreaalata L.) are grown widely in tropical and subtropical regions of the world. They are plants yielding tubers and contain starch between 70 and 80 % of dry matter (Zhang and Oates, 1999). Yams, the edible tubers of various species of the genus Dioscorea, are important staple foods and a potential source of ingredients for fabricated foods in many tropical countries because of their high starch content. Virtually all production of yam is used for man food. The tubers are processed into various types of food including yam slices, yam balls, mashed yams, yam chips, yam flakes and yam starches. Root and tubers starches have unique physicochemical properties due their amylose and amylopectin ratio.

Maize (*zea mays*),is known in some English-speaking countries as corn. Most historians achieve corn was domesticated in the Tehuacsan valley of Mexico (Bressani*etal.*, 1990). Maize is a major source of starch. Cornstarch (Maize flour) is a major ingredient one in home cooking and in many industrialized food products.

African yam bean (*Sphenostylis stenocarpa)* is an industrialized tropical African tuberous legume. The utilization of African yam bean has been linked with sociocultural values in the cultures of some ethnic group in Nigeria. There are varieties of seed color (Oshodi*etal.*, 1995) and size (Adebowale etal., 2010). Protein content of AYB is up to 19 % in the tubers and 29% in the seed grain.

The ratio of amylose to amylopectin, the characteristics of each fraction in terms of molecular weight, distribution and length of branching and conformation influence the viscosity of starch pasting (Zhang and Oates, 1999).

Pasting properties indicates what physical changes may be expected during the processing of starchy foods. This could also enable one modify the starches if necessary to suit product and processing demands. Therefore, the objective of the study was to evaluate the pasting characteristics of flour blends to pre-determine its potential for the manufacture of value-added produce such as noodles.

2.0 Materials and Methods

The water yam was identified as TDA 297 and bought at National Root Crop Research Institute (NRCI), Umudike, Abia State, Nigeria. The yellow maize and the cream colored African yam bean were identified and bought at National Institute of Horticulture (NIHOT) Mbato sub zone, Okigwe, Imo State.

2.1 Preparation of raw materials

2.1.1 Water yam flour

Water yam was washed, peeled manually under water containing 0.20% solution of sodium metabisulphate. Slicing of the water yam (3mm x 5mm) was done with a stainless knife. The sliced water yam were removed and allowed to drain for1 h under air current and dried at 60^{o}C for 6h in a Chirana type air convention oven (Hs201A). Dried chips were cooled for 2h at room temperature under air current and milled using Brabender roller mill (Model 3511A). The flour sample was sieved through 0.50mm mesh size, packaged and sealed in polyethylene bag for further use.

2.1.2 African yam bean flour

The cream colored African yam bean seeds were sorted cleaned in an aspirator (Model: OB 125 Bindapst Hungary) located at the Food Processing Laboratory of Federal Polytechnic, Mubi. Cleaned seeds were soaked for 1h at room temperature. The seeds were sundried for days at ($30^{o} \pm 2^{o}$C) and milled with Brabender roller mill (Model 3511A) to pass through screen with 0.50mm openings. The flour was stored in an air plastic container at room temperature for further use.

2.1.3 Yellow maize flour

The yellow maize grain were sorted, and cleaned in an aspirator (Model: OB 125 Bindapst Hungary) located at the Food Processing Laboratory of Federal Polytechnic, Mubi. The cleaned maize grains were conditioned at 40^{o}C for 30min in a stainless steel container. The seeds were sundried for 4 days at ($30^{o} \pm 2^{o}$C) and then cracked and milled with Brabender roller mill (Model 3511A). The seed coats were removed to obtain the maize flour to pass through a screen with 0.50mm openings. The flour was stored in an air tight plastic container at room temperature for further use.

2.2 Flour blending ratio

The flour from the water yam, yellow maize and African yam bean (AYB) were blended in the ratio as shown in (Table 1)

Table 1: Flour blending ratio

Coded samples	WY (%)	YM (%)	AYB (%)	Total (%)
AFK	30	40	30	100
BGL	40	30	30	100
CHM	50	20	30	100
DIN	60	10	30	100
EJO	100	0	0	100

Sample EJO = Control (100% water yam)

WY = Water Yam

YM= Yellow Maize

AYB= African yam bean

AFK= 30 % WY:40 % YM:30 % AYB

BGL=40 % WY : 30 % YM :30 % AYB

CHEM = 50 % WY : 20 % YM : 30 % AYB

DIN = 60 % WY : 10 % YM : 30 % AYB

2.3 Determination of pasting properties

All determinations were done in triplicates and reported as mean values. The pasting characteristics were determined with a rapid viscous – analyzer (RVA), Model RVA 30+, Newport scientific, and Australia). The pasting profile was read with the aid of thermocline from windows software connected to a computer (Newport Scientific, 1998).

2.4 Statistical Analysis

The experimental design was a 3 x 3 factorial in Complete Randomized Design (CRD) where the three flour sources and their combination ratios were the two factors under consideration. Data generated from the study were subjected to Analysis of Variance (ANOVA) and means separated using $FLsd_{0.05}$ with SPSS version 22.0

3.0 Results

The result of the pasting properties of the raw flour blends are shown in Table 2.

Table 2: **Pasting Properties of Water Yam, Yellow, Maize and African Yam Bean Flour Blend**

Sample	Peak 1 (RVU)	Trough 1 (RVU)	Breakdown (RVU)	Final; Visc (RVU)	Setback (RVU)	Peak time Min	Pasting Temperature (^{o}C)
AFK	128.50^{b}±1.00	87.42^{d}±0.00	41.08^{c}±1.00	186.42^{d}±0.00	99.00^{d}±0.00	5.33^{a}±5.00	82.77^{a}±0.00
BGL	163.17^{a}±0.00	135.00^{a}±0.00	28.17^{c}±0.00	243.58^{c}±0.00	108.58^{c}±0.00	5.48^{a}±0.00	84.15^{a}±0.00
CHM	166.25^{a}±0.00	115.67^{a}±0.00	50.58^{a}±0.00	293.33^{a}±0.00	177.67^{a}±0.00	5.05^{a}±0.00	83.60^{a}±0.00
DIN	133.50^{a}±0.00	133.50^{c}±0.00	48.42^{b}±0.00	145.25^{c}±0.00	60.17^{c}±10.00	5.33^{a}±0.00	80.25^{a}±0.00
EJO	161.17^{a}±0.00	123..25^{b}±1.00	37.92^{d}±1.00	247.33^{b}±0.00	124.08^{b}±0.00	5.49^{a}±0.00	80.45^{a}±1.00

Where Visc = Viscosity

Values are mean of triplicate determination ± standard deviation. Means with the same superscript within the column are not significantly ($p<0.05$) different from each other.

Keys

Sample EJO = Control (100% water yam)

WY = Water Yam

YM= Yellow Maize

AYB= African yam bean

AFK= 30 % WY:40 % YM:30 % AYB

BGL=40 % WY : 30 % YM :30 % AYB

CHEM = 50 % WY : 20 % YM : 30 % AYB

DIN = 60 % WY : 10 % YM : 30 % AYB

The result showed that the peak viscosity (PV) of the flour blends ranged from 128.50 to 166.25RVU, with sample CHM having the highest value, while sample AFK had the least peak viscosity. The peak viscosity of the flour Samples BGL, CHM and EJO were not significantly ($p > 0.05$) different from one another but were statistically ($p > 0.05$) higher than other flour samples. Trough value ranged from 85.08 to 135.00RVU with flour sample EJO having the highest value, while flour sample DIN had the least value. All the flour samples statistically ($p > 0.05$) different from one another in trough value. Increase in yellow maize substitution in the flour blend might have increased the trough except at 30% inclusion. The Break down viscosity values ranged from 28.17 to 50.58RVU with flour sample CHM having the highest value, while flour sample BGL had the least break down value. All the flour samples significantly ($p > 0.05$) differed from one another in breakdown viscosity. The final viscosity values ranged 145.25 to 293.33RVU with flour sample CHM having the highest value, while flour sample DIN had the least value. All the flour samples significantly ($p > 0.05$) differed from one another in final viscosity. Addition of yellow maize and African yam bean reduced the final viscosity excerpt in sample CHM. The set-back values ranged from 60.17 to 177.67RVU, with flour sample CHM having the highest value, while flour sample DIN had the least value. All the flour samples significantly ($p > 0.05$) differed from one another in setback viscosity. Addition of yellow maize and African yam bean might have reduced the setback viscosity except in sample CHM. The final viscosity, and set back viscosity of the samples appear to follow the same trend with inclusion of yellow maize and African yam bean in the flour blends. The peak time setting values ranged from 5.05 to 5.49 minutes, with flour sample EJO having the highest value, while sample CHM had the least value. There was no statistical ($p > 0.05$) difference in the peak time of the flour blends. Addition of yellow maize and African yam bean resulted in a definite but insignificant ($p > 0.05$) decrease in peak time. The pasting temperature values ranged from 80.25 to 84.15oC, with sample BGL having the highest value (84.15), while flour sample DIN had the least value (80.25). There was no significantly ($p > 0.05$) difference in the pasting temperature of the flour samples.

4.0 Discussion

4.1 Peak viscosity of raw flour (RVU)

The peak viscosity of the raw water yam flour and the blends are shown in Table 2. The raw flour peak viscosity ranged from 128.50 -166.17 (RVU). The observed peak viscosity value of water yam in this study was higher than the earlier reported value of 117.45 – 124.88 RVU (Adetutu, 2011) but lower than the range of 131.56 – 178.05 RVU as reported by Baah et al. (2009). Anuonye and Saad (2015) suggested that the variation is likely due to differences in analytical viscometers and yam varieties. High peak viscosity is an indication of high starch content and also related to water binding capacity of starch. Water yam starches have been reported to have high peak viscosity (Anuonye and Saad, 2015). The values of peak viscosity observed for the composite flours were lower in this study than that reported by (Adebowale et al. 2010). Lower values of peak viscosity indicated that a greater amount of gelatinization had occurred in the initial samples or there had been fortification of flours with legumes or oilseeds. The presence of African yam been flour at 30% levels therefore could have contributed to the lowering of the raw blend peak viscosity.

Peak viscosity is the ability of starch to swell freely before their physical breakdown. According to Baah et al. (2009) peak viscosity as the name implies, is the maximum viscosity attained soon after starch slurry become viscous due to starch granule swelling and leaching out of soluble component into solution.

Ingbiam (2004) reported that peak viscosity is an indication of the water binding capacity of starch or blend, and provides an index of the viscous load likely to be encountered by a mixing cooker. The lower peak viscosity especially with samples AFK and DIN of the composite flour was perhaps due to the protein and fat content as a result of blending. This is similar to the finding of Dautant et al. (2007).

4.2 Trough of the raw flour (RVU)

The trough viscosity of the raw water yam flour and the blends are shown in Table 2 The raw flour trough in this study ranged from 85.08 – 135.00RVU. This result is similar to earlier work by Faustina (2009), who reported RVU value of range 80.13 – 141.02. However, trough viscosity observed in this study for composite flour was lower than the values reported by (Idowu, 2015); Adebowale et al., 2010). The trough is the minimum viscosity value at constant temperature phase of the RVA profile and measure the ability of paste to withstand breakdown during cooling (Adebowale et al., 2008; Anuonye and Saad, 2015). The flour with high trough value appears to be a superior quality flour sample for products like noodles. However, a low trough value was recorded for yam flour and the various blends in this study. This might have been as a result of denatured native starch structure and the high protein content of the composite flour samples. The trough, also called, shear holding strength, hot paste viscosity or paste stability is often associated with a breakdown in viscosity (Ragaee et al., 2006).

4.3 Breakdown viscosity of the raw flour

The breakdown viscosity of the raw water yaw flour and the blends are shown in Table 2 The raw flour breakdown viscosity in this study ranged from 28.17 – 50.58(RVU). The values observed for water yam in this study was closed to the values reported earlier (Oke et al., 2013; Faustina, 2009). The observed minimal variation was probably because of the difference storage period, climatic conditions, edaphic and biotic factors of water yam. Similarly, the values for composite flours in this study fell within the range of earlier reported values. (Adebowale et al., 2008; Onwurafor et al., 2016). Breakdown is peak viscosity minus trough viscosity in RVU and it is regarded as a measure of the degree of disintegration of granules or paste stability (Dengate, 1984, Fernanadez and Berry, 1989, Newport scientific, 1998, Oluwalana et al., 2011). Adebowale et al (2005) reported that the higher the breakdown in viscosity, the lower sample could be target for industrial use because of hot paste stability. The composite flour developed in this study appeared to have potential for hot paste stability.

4.4 Final viscosity of the raw flour (RVU)

The final viscosity of the raw water yam flour and the blends are shown in Table 2. The final viscosity values of the raw flour ranged from 145.25 – 293.3RVU. The value observed for water yam flour in this study was higher than the value reported by (Adetutu, 2011, Otegbayo, 2014) but was comparable to the reported value by Wireko-manu *et al.,* (2011). Final viscosity is the most commonly used parameter to define the quality of a particular starch-base sample, as it indicate the ability of the material to form a viscous paste or gel after cooking and cooling as well as the resistance of the paste to shear force during stirring (Adeyemi and Idowu, 1990). Lower amount of water yam flour which translates to higher inclusion of yellow maize flour resulted to increase in the final viscosity of the composite flour. The marked increase observed in the composite flour of sample CHM might be due to the alignment of the chains of amylase in the combined starch. Shimelis et al., (2006) reported that less ability of starch paste or gel after cooling is commonly accomplished with high value of breakdown. This implies that composite flour of sample CHM will be less stable after cooling compared to other flour samples.

4.5 Setback viscosity of the raw flours (RVU)

The setback viscosity of the raw water yam flour and the blends are shown in Table2. The raw flour set back viscosity value in this study range from 60.17 – 177.67 RVU. The value observed for water yam flour in this study was within the earlier reported values (Adebowale et al., 2010; Adeowale et al 2008) and observed differences might be due to differences in the research materials. Generally, the addition of maize and African yam bean “diluted” the setback viscosity of the composite flour in this study. Set back viscosity is a stage where retrogradation or re-ordering of starch molecule occurs (Adebowale et al, 2008). Adeyemi and Idowu (1990) reported that the higher the setback value, the lower the retrogradation during cooling and the lower the staling rate of the products made from the starch has a high set back as a result of retrogradationcompares with other root and tuber crops (Mali et al., 2003). Generally, the tendency of yam starch paste to retrograde may be a limiting factor for its use in food industries.

However, addition of maize and African yam bean in making composite will exhibit higher resistance to retrogradation. Hence the firming up of water yam flour improved the pasting profile. Set back viscosity has been correlated with the texture of the various products and high setback is also associated with syneresis or weeping during freeze/thaw cycles (Maziya-Dixon et al., 2007). Certain food productions, such as noodles and pounded yam will require retrogradation which are characterized by high set back, high viscosity, high paste stability (Lawal, 2004). Otegbayo (2014) reported that implication of the high set back viscosity of stored yam is that their starched will have greater tendency to retrograde, thus will be more useful as ingredients in products such as noodles where starch retrogradation is desired.

4.6 Peak time of the raw flour samples

The peak time of the raw water yam flour and their blends are shown in Table 2. The raw flour peak time value in this study ranged from 5.05 – 5.49 minutes. The observed time in this study for water yam flour was comparable to the values reported in an earlier study by Oke et al. (2013) for different varieties of water yam flour. Similarly, the observed values for composite flour in this study was comparable to the value reported earlier (Anuonye and Saad 2015). The peak time, which is a measure of the cooking time, was not generally influenced by the addition of other materials on the water yam flour. However, this was not the case with earlier studies as reported by (Adebowale et al., 2008; Anuonye and Saad, 2015).

4.7 Pasting temperature of the raw flour samples

The pasting temperature of the raw water yam flour and the blends are shown in Table 2. The values of the pasting temperature of the raw flour samples ranged from 80.25 – 85.15 ^{o}C. The values observed for water yam flour in this study was comparable to earlier study by Oke et al. (2010). The values observed for composite flour in this study fell within earlier reported range (Idowu, 2015; Anuonye and Saad, 2015). When starch or starch-based foods are heated in water beyond a critical temperature, the granules absorb a large amount of water at the critical temperature, which is characteristics of a particular starch; the starch undergoes an irreversible process known as gelatinization. This is characterized by enormous swelling, increased viscosity, translucency and solubility, and loss of anisotropy (birefringence) Shimelis et al., 2006; Ikegwu et al., 2010). The temperature at the onset of this rise in viscosity is referred to as the pasting temperature (Adebowale et al. 2008). Ikegwu et al (2009) reported that pasting temperature is one of the pasting properties which provide an indication of the minimum temperature is for sample cooking, energy cost involved and other components stability. For technical and economic reasons, starches/flours with lower pasting time and temperature may be more preferred when all other properties are equal (Iwuoha, 2004; Baah et al., 2009). Gelatinization and pasting of starch/flour are of great importance to the food industry in particular because they influence the texture, stability and digestibility of starchy foods and, thus, determine the application and use of starch/flour in various food products (Oke et al., 2013).

5.0 Conclusion

The pasting characteristics of the flour blends varied significantly. The decrease in some pasting characteristics of some blends was attributed to the interaction of starch with protein, and fat from the added African yam bean seed flour.The pasting properties obtained indicated that these flour samples have useful technological properties for many applications in food processing such as noodles and other pasta products. It is therefore recommended that for profitable and cost effective pasta products productions in the tropics, different combinations of water yam, yellow maize and African yam beans should be used as viable alternative to wheat flour.

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