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Proximate, Functional and Pasting Properties of Composite Flours Made from Wheat, Breadfruit and Cassava Starch

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ABSTRACT

This study investigated the quality of composite flour from wheat-breadfruit-cassava starch for use in confectionary product. Breadfruit, whole wheat grains and cassava starch were processed into flour. Composite flours (Breadfruit flour: Wheat flour: Cassava starch) were made in the ratios; 80%: 10%:10% (WB1C), 70%: 20%: 10% (WB2C), 60%: 30%: 10% (WB3C) and 80%: 40%: 10% (WB4C) while the control was 100% Wheat (WO). The proximate, functional, pasting and mineral content of composite flours were determined using standard method. The protein content of the composite flours ranged from 6.81 - 9.34% compared to the control (Wo) 10.1%. The range of the other proximate compositions determined were: crude fibre (0.9 - 4.81%), crude fat (0.55 - 0.91%), total ash (0.86 - 2.49%), moisture content (3.26-12.0%) and carbohydrate (73.82 - 85.85%). The moisture and protein contents of composite flours decreased with increasing substitution of breadfruit flours. Crude fibre, total ash and carbohydrate content of composite flours increased with increasing breadfruit flour substitution. Bulk densities of composite flour samples which ranged from 0.82 – 0.85 g/ml, were not significantly different from that of the control. The water absorption capacity (WAC), Oil absorption capacity (OAC) of composite flours ranged from 246.0 – 275 % g/g, 158.1 – 140 %g and the control 280 % g/g, 125.5 %g/g respectively. The WAC increased with increasing breadfruit flour substitution. Peak viscosity of composites flours increased with increasing breadfruit flour substitution. Peak viscosity (123.24 RVU), holding strength (73.61 RVU) and final viscosity (138.61 RVU), setback (65.89 min) and pasting temperature (61.80 ^oC) were highest at 40% breadfruit flour substitution. Hence, wheat-cassava-breadfruit flour at 40% substitution with breadfruit flour could find application in confectionary and pastry industries.

Key words:Breadfruit flour, Wheat flour, Cassava starch, Composite flour, Proximate composition

INTRODUCTION

Composite flour technology is important because of the advantage of reducing the huge amount of money spent on wheat flour importation, coupled with the prospects of the utilisation of underutilised crops. Breadfruit (*Artocarpus altilis*) is widely cultivated crop in South-western, Nigeria. It is grown mainly as a subsistence crop and is a popular staple food in Polynesia, Jamaica and the Caribbean (Ragone and Cavaleth, 2006). In Nigeria, breadfruit is known as Iyanjaloke, or Gbere fruit among Yoruba tribes (Bakare, 2008). The fruit is high in carbohydrate, low in fat, protein and a good source of minerals (Iron), vitamins especially niacin, riboflavin and pro- vitamin A (Graham and Negron, 1981). Short shelf-life is a major challenge facing breadfruit utilization, though the processing of breadfruit into flour extends its shelf-life (Olaoye *et al*., 2007). Incorporation of cassava starch flour as composite in breadfruit influences the functional, proximate and rheological properties of blends used in confectionary production (Akanbi *et al*., 2009).

The resistance and extensibility of dough's developed during mixing and stretching can be improved in gluten free flours by the incorporation of starch such as cassava starch flour into the dough (Paredes-Lopez, 2002).

Wheat is the most desired cereal for the production of confectionary product due to its high gluten content. The high gluten content in wheat contributes greatly to dough sponginess and elasticity (Spiekermann, 2006). The increasing demands for wheat, as a result of increasing populations, urbanisation and changing food habits (Oloye, 2006) especially in the developing countries, has led to increased importation (Giami *et al*., 2004).

Previous works on wheat flour substitution with breadfruit flour suggest that a good quality product can be produced form its composite. Olaoye *et al*. (2007), reported that wheat flour substitution with 15% breadfruit flour could give biscuits of an acceptable sensory attribute. Also, Amusa *et al.* (2002) reported a similar trend with bread production. Lin *et al.* (2009) reported the production of good quality composite bread on wheat flour substitution with buckwheat flour up to 15%. In another study, Hallen *et al*. (2004) reported a substitution level of up to 20% cowpea flour as suitable for producing quality bread with characteristics similar to 100% wheat bread. This study investigated the quality characteristics of wheat-cassava starch substituted with up to 10 – 40% breadfruit flour for potential use in confectionary industries.

MATERIALS AND METHODS

Materials

Breadfruit was purchased from a local farm in Ile-Ife, Osun State, Nigeria while the wheat flour was purchased from Oba market in Akure, Ondo State, Nigeria. Cassava starch was obtained from Matna Food Company Limited Ogbese, Ondo State. Nigeria and all other chemicals used were of analytical grade purchased from Sigma-Aldrich, U.S.A.

Production of Breadfruit Flour

Matured breadfruits was cleaned to remove foreign matter, it was hand peeled, decorticated, washed, thinly sliced, blanched at 105 °C for 5 min, drained, and oven dried (Laboratory oven, DHG 9101.1SA) at 105 °C for 3 h. The dried chips were milled into flour using a disc mill (Atlas exclusive, Alzico Ltd mill) and sieved through a 250 mm mesh of US standard sieve. Five blends were prepared by mixing wheat flour, breadfruit flour and cassava starch flour in proportions as shown in Table 1.

Table 1: Formulation of composite flours from wheat, breadfruit flour and cassava starch

Samples	Wheat Flour (%)	Breadfruit Flour (%)	Cassava Starch (%)
Wo	100	0	0
WB$_1$C	80	10	10
WB$_2$C	70	20	10
WB$_3$C	60	30	10
WB$_4$C	50	40	10

WO = 100% Wheat Flour (Control), WB1C= 80%Wheat Flour / 10% Breadfruit Flour / 10% Cassava Starch, WB2C = 70%Wheat Flour / 20% Breadfruit Flour / 10%Cassava Starch, WB3C = 60%Wheat Flour / 30% Breadfruit Flour / 10%Cassava Starch, WB4C = 50% Wheat Flour / 40% Breadfruit Flour / 10% Cassava Starch.

Analyses

Determination of Proximate Composition of Flours

The crude protein, fat, ash, moisture and crude fibre contents of the flours were determined using standard method as described by AOAC (2005). The carbohydrate content was calculated by difference of protein, fat, ash, fibre and moisture contents from 100. Crude protein was determined by multiplying crude nitrogen content by 6.25.

Functional Properties of Composite flours

The bulk density of the flour samples was determined as described by Narayana and Narasinga, (1984). A calibrated measuring cylinder was weighed and filled with the flour sample till 50 ml mark was reached. Tapping was done constantly until there was no further change in volume. The measuring cylinder was weighed with the contents. The difference in the initial and final volume of the sample after tapping was measured as the bulk density of flour samples in g/ml (eq. 1).

Bulk density (g/ml) = (Weight of the sample)/(Volume occupied)………(1)

The procedure of Sathe and Salunkhe (1981) was used to determine the water and oil absorption capacity. About 15 ml of water/oil was added to 1 g of sample, the suspension was then stirred using magnetic stirrer for 2 min. The suspension was transferred into centrifuge tubes and centrifuged at 4,000 rpm for 20 min. The supernatant obtained was discarded. The water /oil absorption capacity was expressed as weight of water or oil bound by 100 g dry flour. The result was expressed as a percentage of water/oil absorbed by the sample on % g/g basis (Eq. 1 and 2).

Water Absorption Capacity (%g/g) = (Volume of water absorbed)/(weight of sample used)……. (2)

Oil Absorption Capacity (%g/g) = (Volume of oil absorbed)/(weight of sample used) …..(3)

The least gelation property of the composite flours were determined using the method described Onwuka and Onwuka (2005) with a slight modification. Sample suspension 2-50% (w/v) was prepared in 5 ml distilled water in a test tube and was boiled in water for an hour, rapidly cooled under running cold water. Least gelling concentration was determined as the concentration of samples after inverted test tube did not fall or slip.

Pasting Properties of Composite Flour

Pasting properties were determined using a Rapid ViscoAnalyser 3C (RVA, model 3C, Newport Scientific PTY Ltd, Sydney, Australia) as described by Ross *et al.* (1987). Three grams of samples were weighed into a weighing vessel while 25ml of distilled water was dispensed into a new test canister. The slurry was heated from 50 ^oC to 95 ^oC with a holding time of 2 min and cooled to 50 ^oC for 2 min holding time. The rates of heating and cooling were done at a constant rate of 11.25 ^oC/min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile.

Statistical Analysis

The data obtained were made in triplicates and analysed using one way Analysis of variance (ANOVA) of Statistical Package for Social Sciences (SPSS version 17.0). Significant means were separated using the New Duncan's Multiple Range Test (NDMRT) at 95% confidence interval.

RESULTS AND DISCUSSION

Proximate composition of Composite Flour

The proximate composition of the composite flours is presented in Table 2. The protein, moisture and fat contents of the composite flours decreased with increasing level of wheat flour substitution with breadfruit flour. The protein, moisture, crude fibre, crude fat and carbohydrate contents ranged from 6.81 ± 1.59 - 9.34 ± 0.14; 8.7 ± 0.20 - 4.31 ± 0.03; 2.24 ± 0.76 - 4.81 ± 0.20; 0.50 ± 0.20 - 0.82 ± 0.13; 1.14 ± 0.12 - 1.54 ± 0.12 and 77.86 ± 0.34 - 82.03 ± 4.42 respectively. The protein content was significantly higher in 10% substituted breadfruit flour sample (9.34 ± 0.14) and significantly lower in 40% substituted flour (6.81 ± 1.59) compared to 100% wheat flour (10.1 ± 0.6). This is in contrary to the findings of Malomo *et al*. (2011) that the crude protein content decreased with increasing breadfruit and bread nut flour substitution. High moisture content favours the inhibition and development of contaminating microorganisms, whose growth and activities cause spoilage in foods (Okafor and Ugwu, 2014). The moisture content was significantly lower in WB_4C (4.31 ± 0.03) compared to other composite flours and control. The higher the moisture content of food materials the lower the shelf stability (Aluge *et al.,* 2016). Thus, WB_4C could have shelf stable characteristics on storage. This finding supports that of Olaoye *et al*. (2007) who reported low moisture content in biscuits made from breadfruit-wheat composite. The ash, fibre and carbohydrate content of the composite flours increased with increasing level of substitution as oppose to the findings of Malomo *et al.* (2011) that carbohydrate, crude fibre decreases with increasing substitution of breadfruit flour and bread nut flour. However, the variation observed in this study may be due to effect of different cultivars. Ash content is an indication of the mineral content of a food (Ndife *et al.,* 2013). The crude fibre, total ash and carbohydrate contents were significantly higher in WB_4C and different form other samples including the control. Composite flour from wheat-breadfruit-cassava flour could be used to manage cases of protein energy malnutrition which is prevalent in most developing countries of the world (Akinola *et al*., 2015).

Functional properties of composite flour

Functionality of foods is the characteristics of food ingredient other than nutritional quality, which has a great influence on its utilization (Mahajan and Dua, 2002). The functional properties of wheat-breadfruit-cassava composite flours are presented in Table 3. The bulk density ranged from 0.82 g/ml - 0.85 g/ml. The bulk density of the flour increased with increasing level of breadfruit flour substitution. The control sample had the lowest bulk density (0.82± 0.01 g/ml). The bulk densities of all composites flours investigated were not significantly different from each other ($p \geq 0.05$). The values obtained for the bulk densities were within the range reported by Malomo *et al. (*2012) in a study on yam-soy blend (0.71 - 0.8 g/ml). Bulk density is influenced by particle size (Karuna *et al.,* 1996) and starch polymers structure (Plaami, 1997). Loose structure of the starch polymers could result in low bulk density. Low bulk density is desired in flour blends as it's contributes to lower dietary bulk, ease of packaging and transportation (Aluge *et al*., 2016).

Water absorption capacity is the ability of a product to associate with water under a water limiting condition. Water absorption capacity of the composite flours ranged from 240.0 ± 0.05 - 275 ± 0.03 % g/g and lowest in the control sample (240 ± 0.05 % g/g). A desirable characteristics of composite starches is the absorption of water during mixing in doughs (Doxastakis *et al*., 2002). Several authors have reported increased water absorption in composite flours compared to wheat flour alone (Lee *et al*., 2001; Morita *et al.,* 2002). In this study, the water absorption capacity increased with increasing level of breadfruit flour substitution. The increase in the water absorption capacity of the composite flours might be attributed to the presence of hydrophobic amino acids which interferes with the ability of the breadfruit starch to absorb water (Kaur and Singh, 2005). This effect might be due to the loose association of amylose and amylopectin in the native starch granules and the weak binding forces that maintains the starch granules structure (Lorenz and Collins, 1990; Sanni *et al.,* 2006) in breadfruit flour.

The oil absorption capacity is the flavor retaining capacity of flour which is very important in food formulations (Odoemelam, 2000). The oil absorption capacity increased with increasing breadfruit flour substitution and values ranged from 125.5±0.05 – 158.1±0.03% g/g. The values obtained were higher than those reported by previous authors who worked on breadfruit flour; 0.50 ml/g to 1.25 ml/g (Appiah *et al.,* 2011), 2.8 ml/g (Odoemelam, 2005). This variation might be due to effect of wheat flour which was part of the composite flours. Flours with lower oil absorption capacity have higher flavor retention abilities (Oladele and Aina, 2007).

Gelation is an aggregation of denatured molecules. Least gelation concentration of the samples ranged from 10.0±0.01 to 13.0±0.04 %. Least gelation of samples increased significantly with increasing breadfruit flour substitution. The variations in data with previous work on breadfruit flour by Akubor and Badifu (2004) could be due to the starch components present in wheat flour. The gelling properties of flours are linked to the ratios of proteins, carbohydrates and lipids composed in such flour (Sathe *et al*., 1982).

Table 2: Proximate composition of Wheat-Breadfruit-Cassava starch flours

Sample	Moisture Content (%)	Crude Protein (%)	Crude Fibre (%)	Crude Fat (%)	Crude Ash (%)	CHO (%)
W_O	$12.0^{a} \pm 1.00$	$10.1^{a} \pm 0.6$	$0.90^{e} \pm 0.03$	$0.91^{a} \pm 0.09$	$0.86^{d} \pm 0.14$	$73.82^{e} \pm 0.31$
WB_1C	$8.7^{b} \pm 0.20$	$9.34^{b} \pm 0.14$	$2.24^{d} \pm 0.76$	$0.82^{b} \pm 0.13$	$1.14^{c} \pm 0.12$	$77.86^{d} \pm 0.34$
WB_2C	$7.4^{c} \pm 1.50$	$8.06^{c} \pm 0.58$	$3.58^{c} \pm 0.17$	$0.72^{c} \pm 0.16$	$0.10^{e} \pm 0.08$	$79.14^{bc} \pm 0.37$
WB_3C	$5.9^{d} \pm 0.10$	$7.40^{d} \pm 0.40$	$4.23^{ab} \pm 1.07$	$0.61^{d} \pm 0.28$	$1.20^{c} \pm 0.18$	$80.66^{bc} \pm 1.67$
WB_4C	$4.31^{e} \pm 0.03$	$6.81^{e} \pm 1.59$	$4.81^{a} \pm 0.20$	$0.50^{e} \pm 0.20$	$1.54^{b} \pm 0.12$	$82.03^{b} \pm 4.42$

Values are means ± Standard deviation, same superscripts are not significantly different along the column ($p \leq 0.05$).WO = 100% Wheat Flour (Control), WB1C= 80% Wheat Flour / 10% Breadfruit Flour / 10% Cassava Starch, WB2C = 70% Wheat Flour / 20% Breadfruit Flour / 10% Cassava Starch, WB3C = 60% Wheat Flour / 30% Breadfruit Flour / 10% Cassava Starch, WB4C = 50% Wheat Flour / 40% Breadfruit Flour / 10% Cassava Starch.

Table 3: Functional property of Wheat-Breadfruit-Cassava starch flours

Sample	Bulk density (g/ml)	Water Absorption Capacity (% g/g)	Least Gelation Capacity (%)	Oil Absorption Capacity (% g/g)
W_O	$0.82^{b} \pm 0.01$	$240.0^{a} \pm 0.05$	$10.0^{d} \pm 0.01$	$125.50^{e} \pm 0.05$
WB_1C	$0.83^{b} \pm 0.00$	$246.0^{e} \pm 0.02$	$12.0^{c} \pm 0.03$	$140.0^{d} \pm 0.03$
WB_2C	$0.83^{b} \pm 0.01$	$257.0^{d} \pm 0.03$	$12.0^{c} \pm 0.02$	$146.2^{c} \pm 0.06$
WB_3C	$0.83^{b} \pm 0.03$	$260.0^{c} \pm 0.03$	$12.50^{b} \pm 0.03$	$150.1^{b} \pm 0.02$
WB_4C	$0.85^{a} \pm 0.10$	$275.0^{b} \pm 0.03$	$13.0^{a} \pm 0.04$	$158.1^{a} \pm 0.03$

Values are means ± Standard deviation, same superscripts are not significantly different along the column ($p \leq 0.05$).WO = 100% Wheat Flour (Control), WB1C= 80% Wheat Flour / 10% Breadfruit Flour / 10% Cassava Starch, WB2C = 70% Wheat Flour / 20% Breadfruit Flour / 10% Cassava Starch, WB3C = 60% Wheat Flour / 30% Breadfruit Flour / 10% Cassava Starch, WB4C = 50% Wheat Flour / 40% Breadfruit Flour / 10% Cassava Starch

Table 4: Pasting properties of Wheat-Breadfruit-Cassava starch flours

Samples	Peak Viscosity (RVU)	Holding Strength (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Value (RVU)	Peak Time (min)	Pasting Temp (°C)
W_O	102.80[a]	70.20[b]	48.69[a]	121.50[c]	52.00[d]	6.04[a]	61.45[a]
WB_1C	105.80[c]	65.81[d]	48.38 [a]	119.81[c]	53.80[d]	5.76 [b]	61.53[a]
WB_2C	113.58[b]	68.08[bc]	45.58[b]	127.72[b]	58.53[c]	5.64[bc]	61.41[a]
WB_3C	114.22[b]	66.37[cd]	40.19[c]	129.69[b]	63.19[b]	5.51[cd]	61.71[a]
WB_4C	123.24[a]	73.61[a]	33.47[d]	138.61[a]	65.89[a]	5.45[d]	61.80[a]

Values are means ± Standard deviation, same superscripts are not significantly different along the column (p≤0.05).WO = 100% Wheat Flour (Control), WB1C= 80% Wheat Flour / 10% Breadfruit Flour / 10% Cassava Starch, WB2C = 70% Wheat Flour / 20% Breadfruit Flour / 10% Cassava Starch, WB3C = 60% Wheat Flour / 30% Breadfruit Flour / 10% Cassava Starch, WB4C = 50% Wheat Flour / 40% Breadfruit Flour / 10% Cassava Starch

Pasting properties of Composite Flour

The pasting properties of the samples are presented in Table 4. The peak viscosity of the samples ranged from 102.80 – 123.24 RVU. The peak viscosity is indicative of the viscous load likely to be encountered during mixing (Maziya-Dixon *et al.,* 2004). The higher the peak viscosity the higher the swelling index, while low paste viscosity is indicative of higher solubility as a result of starch degradation or dextrinization (Shittu *et al.,* 2001). The peak viscosity was highest in 40% breadfruit flour substituted sample and lowest in the wheat flour (control). This is comparable to values obtained by Bakare (2016) in a work on the rheological, properties of composite flour from breadfruit and wheat flour. The peak viscosity increased with increasing level of breadfruit flour substitution. This increase may be attributed to the high starch content of the breadfruit flour causing a high gelatinization and swelling index. In starches, high viscosity is desired for industrial applications in which a high thickening power at high temperatures is required (Kim *et al.,* 1995).

The holding strength of composite flour is the minimum viscosity after the peak, making the starch granules of the flour remains undisrupted when the flour paste is subjected to a holding period of constant temperature, time and shear stress (Bakare, 2008). The holding strengths of the composites flours in this study ranged from 65.81 to 73.61 RVU. The holding strength was highest in WB_4C (73.61 RVU) and lowest in WB_1C (65.81 RVU) compared to the Control sample (70.20 RVU).

Breakdown viscosity ranged from 33.47 – 48.69 RVU with highest value obtained in the W_o (48.69 RVU). At 40% breadfruit flour substitution, breakdown viscosity was lowest (33.47 RVU). WB_1C (48.69 RVU) and W_o (48.38 RVU) were not significantly different from each other. The breakdown viscosity decreased with increasing level of breadfruit flour substitution. This implies that the composite flours would not breakdown on heating and such can find applications in foods processed by heating at high temperatures. Breakdown viscosity is the measure of the tendency of swollen starch granules to rupture when held at high temperatures and continuous shearing (Patindol *et al.,* 2005). Breakdown viscosity is indicative of paste stability (Akanbi *et al.,* 2009).

Final viscosity is the ability of starch to form a viscous paste on cooling. The final viscosity increased with increasing level of breadfruit flour substitution. The final viscosity of composite flours in this study ranged from 121.50 to 138.61 RVU. This viscosity was highest in WB_4C (138.61 RVU) compared to the control (121.50 RVU). The increase in final viscosity might be due to the aggregation of amylose molecules (Miles *et al.,* 1985) which is indicative of quick retrogradation (Lii *et al.* 1996). Setback value of composite flour ranged from 53.80 - 65.89 RVU compared to the control (52.00 RVU). Setback value increased with increasing level of breadfruit flour substitution. It is the phase of the pasting curve after cooling of the starch and this phase involves re-association, retrogradation or re-ordering of starch molecules. Setback value is the tendency of starch to associate and retrograde on cooling. Peroni *et al*. (2006) indicated that flours with low setback may have low values of amylose which have high molecular weight. The lower the retrogradation, the higher the setback value, during cooling of the products made from the flour (Ikegwu *et al*., 2010). High setback is associated with syneresis. The composite WB_3C and WB_4C had significantly higher set back value compared to the control and WB_1C. The setback value of the control and WB_1C were not significantly different. Thus, the control and WB_1C could form a much better flour paste that could find applications in the confectionary industries.

The time at which peak viscosity occurred in minutes is termed peak time (Adebowale *et al.,* 2005). The peak time of the composite flour in this study ranged from 5.45- 5.76

minutes. The peak time was highest in the control (6.04 min). The peak time of the composite flour decreased with an increasing level of breadfruit flour substitution. Low peak time observed in the flour blends may be due to reduced starch content as a result of breadfruit flour substitution. However, low peak time is indicative of its ability to cook fast. The pasting temperature of flour samples ranged from 61.41 ^{o}C to 61.80 ^{o}C and values obtained were not significantly different from the control.

CONCLUSION

Substitution of wheat-cassava flour with breadfruit flour affects the nutrient, functional and pasting properties of composite flour. The inclusion of breadfruit flour up to 40% in wheat-cassava composite flour could give a confectionary product of high quality that is comparable with 100% wheat flour. Wheat-breadfruit-cassava flour can be used to address micronutrient deficiencies which are prevalent in the developing countries of the world. Composite flours from wheat-cassava- breadfruit could be used in the achievement of desired food security, in developing countries where they are abundant. In this way it will advance the promotion, utilisation and processing of breadfruit for improved industrial and domestic use.

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