PROXIMATE, FUNCTIONAL, PASTING AND RHEOLOGICAL PROPERTIES OF WHEAT- TIGER NUT COMPOSITE FLOUR

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Abstract
This study was carried out to investigate the effects of tigernut flour (TF) substitution with wheat flour on proximate, functional, pasting and rheological properties of wheat-tigernut composite blends for probable industrial uses. Yellow variety of tigernut was washed and dried in a cabinet dryer at 60°C for 72hrs and was processed into flour and blended with wheat flour at different ratios (98:2, 96:4, 94:6, 92:8 and 90:10) of wheat: tigernut flour, while 100% wheat flour and 100% tigernut flour served as controls. The composite flour blends were analyzed for proximate composition, functional (Bulk density, water holding capacity, water holding capacity of the gel, swelling power and solubility index), pasting characteristics and rheological properties (Farinograph). Moisture, protein, fat, ash, crude fibre and carbohydrate contents of the composite blends ranged from 4.23 to 13.38%, 2.29 to 11.84%, 0.86 to 6.6%, 0.87 to 5.63%, 3.02 to 9.69% and 66.8 to 71.6%, respectively. Substitution at 100% tigernut flour has high water holding capacity (7.25g/g), swelling power (7.64g/g), solubility index (4.00%) while 100% wheat flour has least water holding capacity of the gel. The bulk density decreased with tigernut flour addition with 100% tigernut having the least (0.67g/ml). Significant differences were found in the pasting characteristics of wheat-flour blends with increase in tigernut flour inclusion. Farinograph water absorption (55.6-59.9%), mixing tolerance index (30-60BU), degree of softening (40-60min) decreased, while dough development time (2.0-7.5min) and dough stability (8.0-16.5min) increased significantly with tigernut flour inclusion. The study showed that addition of tigernut flour has the advantage of improving the mineral and the fibre contents of flour, however addition of tigernut flour to wheat flour had a pronounced effect on the rheological properties of dough leading to lower water absorption, mixing tolerance index and degree of softening.

Keywords: Tigernut flour; wheat flour, proximate composition, pasting properties, rheological properties


1. INTRODUCTION

Flour is fine powder from cereals or other starch based produce. It is the key ingredient in bakery goods production which constitutes a staple in the diet of many countries including Africa. The flour for the bakery products is usually from wheat but the harsh climatic conditions in the tropical region is not conducive for the growth of wheat, thus the availability of adequate supply of wheat flour has been a major economic and political issue. Flours can also be made from root and tubers, legumes and from other sources in which wheat flour is substituted and it is otherwise known as composite flour. In many developing countries the use of composite flours have the following advantages (a) saving of hard currency, (b) promotion of high-yielding, native plant species (c) better supply of protein for human nutrition, and (d) better overall use of domestic agricultural production (Berghofer et al., 2000; Bugusu et al., 2001).

Tigernut (Cyperus esculentus L) is an underutilized crop which belongs to the division Magnoliophyta, Class-liliopsida, order-cyperales and family-cyperaceae and was found to be a cosmopolitan perennial crop of the same genus as the papyrus plant. Other names of the plant are earth almond as well as yellow nut grass (Odoemelan, 2003; Belewu and Belewu, 2007). In Nigeria, it is known as “Aya” “Ofio” and “Akiausa” by Hausa, Yoruba and Igbo tribes respectively, where three varieties (black, brown and yellow) are cultivated. Among these, only two varieties yellow and brown are readily available in the market. Tigernut has been demonstrated to be a
rich source of good quality oil (Dubois et al., 2007; Yeboah et al., 2012) and contain a moderate amount of protein (Oladele and Aina, 2007). It is a source of some useful minerals such as potassium, phosphorus and calcium (Bixquert-jimenez, 2003) as well as vitamin E and C (Belewu and Belewu, 2007). In addition, tigernut has been demonstrated to contain higher essential amino acids than those proposed in the protein standard by the FAO/WHO (1985) for satisfying adult needs (Bosch et al., 2005). It has been reported to be high in dietary fibre content (Alegria-Toran and Farre-Rovira, 2003) which could be effective in treatment and prevention of many diseases including colon cancer (Adejuyitan et al., 2009), coronary heart disease (Chukwuma et al., 2010), obesity, diabetes, gastrointestinal disorders (Anderson et al., 2009b) and losing weight. (Borges et al., 2008). In Nigeria, the utilization of tigernut is highly limited in spite of the fact that tigernut is cultivated widely in the Northern part of the country. Tigernuts are eaten raw mainly as snacks or fried and eaten mixed with roasted groundnuts (Abaejoh et al., 2006) It was reported that sweetened tigernut extract are bottled and sold in Ghana (Kofi, 1993). It also finds uses as a flavouring agent for ice cream and biscuits (Cantatejo, 1997) as well as in making oil, soap, starch and flour. Tiger nut flour has a unique sweet taste, which is ideal for different uses. It is a good alternative to many other flours like wheat flour, as it is gluten free and good for people who cannot take gluten in their diets. It is considered good flour or additive for the bakery industry, as its natural sugar content is high, avoiding the necessity of adding extra sugar (Anderson et al., 1994a).The flour is used to make cakes and biscuits and the oil is used for cooking (Wise, 2009).

Several information are available on the use of wheat-based composite flour in Nigeria comprising buckwheat (Lin et al., 2009), plantain (Mepba et al., 2007), modified corn starch (Woo and Seib, 2002), waxy corn starch (Lee et al., 2001; Morita et al., 2002), sunflower flour (Biljan and Bojana, 2008), chick pea (Manuel et al., 2008), bean flour (Alex et al., 2008) and tigernut of brown variety (Ade-omowaye et al., 2008). Information is however scanty on the use of composite flour from wheat and yellow variety of tigernut. Although tigernut seeds are cheap and readily available, but grossly underutilized and need more attention because of its nutritional qualities. This study is therefore aimed to produce flour blends from wheat and tigernut (yellow variety) and determine its proximate composition, functional properties, pasting characteristics and rheological properties for possible utilization in production of value added products at the household and industrial level.

2. MATERIAL AND METHODS

Raw materials
The raw materials used include Wheat flour, Tigernut (yellow variety) were purchased from Kuto market in Abeokuta, Nigeria.

Tigernut flour preparation
The method reported by (Ade-omowaye et al., 2008) was used for preparation of tigernut flour. Yellow tigernut (Cyperus esculentus) was sorted manually to remove unwanted materials like stones, pebbles and other foreign materials before washing with tap water. The cleaned nuts were dried in a cabinet dryer at 60°C for 72h. Dried nuts were milled using laboratory hammer mill (Fritsch, D-55743, Idar-oberstein-Germany) and the milled sample was sieved (using 250μm screen) to obtain the flour. The tigernut flour was packed and sealed in polyethylene bags at ambient temperature (26±2°C) and 760mmHg until further analysis.

Composite flour formulation
Composite flours samples were prepared by substituting tigernut flour for wheat flour in the percentage proportion of 0:100, 2:98, 4:96, 6:94, 8:92, 10:90 and 100:0 respectively.

Proximate composition of wheat-tigernut composite flour
The moisture, crude protein, fat, ash, crude fibre of flour samples were analyzed using the
method described by (AOAC, 2000) methods. Carbohydrate content of flour samples were calculated by difference.

**Functional properties of wheat-tigernut composite flour**

**Determination of Bulk density**

Bulk density was determined using the method described by (Wang and Kinsella, 1976). Ten grams of sample were weighed into 50ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top. The volume of the sample was recorded.

\[
\text{Bulk density} \left( \frac{g}{ml} \right) = \frac{\text{Weight of sample}}{\text{Volume of sample after tapping}}
\]

**Determination of Water holding capacity**

The water holding capacity of samples was determined using the method described by (Adeyemi and Idowu, 1990). Five grams of sample was weighed into a centrifuge tube and enough water was added to soak the flour and the slurry was centrifuged at 2000rpm for 20minutes. Excess water was poured off and the sample was reweighed. The difference in weight was divided by the weight of flour to obtain the apparent water holding capacity. The above procedure was repeated for fresh sample of flour; exact amount of water needed to soak the flour sample (App WHC) was added. The difference in weight after centrifuging was then used to calculate the true water holding capacity.

**Determination of Water holding capacity of the gel**

The water holding capacity of the gel was determined using the method described by (Adeyemi and Idowu, 1990). For water holding capacity of the gel, water was added to Five grams of flour and it was heated for 10-15minutes to obtain a gel. The gel was centrifuged and water holding capacity was evaluated as described for flour.

**Determination of Swelling power and solubility index**

The swelling power and solubility index was determined using the method described by (Takashi and Seib, 1988). One grams of flour was weighed into a 50ml centrifuge tube. 50ml of distilled water was added and mixed gently. The slurry was heated in a water bath at 90°C for 15 minutes. During heating the slurry was stirred gently to prevent clumping of the flour. On completion, the tube containing the paste was centrifuged at 3,000rpm for 10 minutes using a centrifuge machine. The supernatant was decanted immediately after centrifuging. The weight of the sediment was taken and recorded. The moisture content of sediment gel was thereafter determined to get dry matter content of the gel.

\[
\text{Swelling power} = \frac{\text{Weight of wet mass sediment}}{\text{Weight of dry matter in the gel}}
\]

\[
\text{Solubility index} = \frac{\text{Weight of dry solids after drying}}{\text{Weight of sample}} \times 100
\]

**Pasting characteristics of wheat-tigernut composite flour**

Pasting characteristics were determined with a Rapid Visco Analyzer (RVA TECMASTER, perten instrument). Three grams of sample were weighed into a dried empty canister, and then 25ml of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed properly so that no lumps were obtained and the canister was fitted into the rapid visco analyzer. A paddle was then placed into the canister and the test proceeded immediately automatically plotting the characteristic curve. Parameters estimated were peak viscosity, setback viscosity, final viscosity, trough, breakdown viscosity, pasting temperature and time to reach peak viscosity.
Rheological properties of wheat-tigernut composite flour

Determination of Dough rheology using Brabender - farinograph

Rheological properties of the dough samples were determined using a Brabender-Farinograph according to the method of (Wang et al., 2002; Bouaziz et al., 2010). The parameters that were determined are: Water absorption (WA) or percentage of water required to yield dough consistency of 500 BU (Brabender Units), dough development time (DDT, time to reach maximum consistency in minutes), dough stability (DS, time dough consistency remains at 500 BU), mixing tolerance index (MTI, consistency difference between height at peak and that 5 min later).

Statistical Analysis

Data obtained were subjected to statistical analysis. Means, Analysis of variance (ANOVA) were determined using SPSS Version 21.0 and the differences between the mean values were evaluated at p≤0.05 using Duncan’s multiple range test.

3. RESULTS AND DISCUSSION

Proximate composition of wheat-tigernut composite flour

Table 1 shows the proximate composition of wheat-tigernut composite flour. Significant (P<0.05) difference was observed in the moisture content, ash, protein, fat, crude fibre and carbohydrate. Statistical difference was not evidenced in the moisture content of the composite flour except for 100% tigernut flour which has lowest moisture content. However there was a slight reduction in the moisture content as the substitution of the flour increases. This can be attributed to lower moisture content of the tigernut flour thereby reducing the moisture content of the composite flour. The protein content of the composite flour decreased from 11.84 to 11.0 with increase in tigernut flour substitution. This may be attributed to low protein content of tigernut (Addy and Eteshola, 1994). As the substitution increase, there was an increase in the fat content of wheat-tigernut composite flour; this is due to high fat content of the tigernut flour. The fat content of 100% wheat flour (0.86%) while 100% tigernut flour has 6.6%. The substitution of 10% tigernut flour resulted in 1.36% fat. The result of 10% substitution of tigernut flour is lower as compared with the result of (Ade-omowaye et al., 2008) which has reported 4.6% for fat content of wheat-tigernut flour at the same level using brown variety. The ash content ranged from 0.87 to 5.63%. The ash content is an indication of the mineral content in the flour. The ash content of 100% tigernut flour obtained in this study was higher than the values of 3.97% reported for tigernut flour by (Oladele and Aina, 2007). The ash content of 100% wheat flour was higher than the value of 0.76% reported for wheat flour by (Okafor et al., 2012) this may be due to the brand of wheat flour used in this study. The crude fibre ranged from 3.02 to 9.69%. There was increase in the crude fibre content of the composite flour; this could be attributed to the high fibre content of the tigernut flour. (Adejuyitan et al., 2009) also reported tigernut to be high in fibre. The crude fibre of 100% tigernut flour obtained in this study was higher than the values reported for tigernut flour by (Oladele and Aina, 2007).

<table>
<thead>
<tr>
<th>WF:TF</th>
<th>Mc</th>
<th>Protein</th>
<th>Fat</th>
<th>Ash</th>
<th>C.Fibre</th>
<th>CHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>100:0</td>
<td>13.38±0.16&lt;sup&gt;a&lt;/sup&gt; 11.84±0.01&lt;sup&gt;b&lt;/sup&gt; 0.86±0.25&lt;sup&gt;b&lt;/sup&gt; 0.87±0.03&lt;sup&gt;a&lt;/sup&gt; 3.02±0.06&lt;sup&gt;a&lt;/sup&gt; 70.0±0.20&lt;sup&gt;d&lt;/sup&gt;</td>
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<tr>
<td>98:2</td>
<td>13.36±0.04&lt;sup&gt;b&lt;/sup&gt; 11.60±0.01&lt;sup&gt;b&lt;/sup&gt; 0.95±0.21&lt;sup&gt;b&lt;/sup&gt; 1.73±0.01&lt;sup&gt;a&lt;/sup&gt; 3.12±0.04&lt;sup&gt;b&lt;/sup&gt; 69.6±0.09&lt;sup&gt;d&lt;/sup&gt;</td>
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<td></td>
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</tr>
<tr>
<td>96:4</td>
<td>13.32±0.01&lt;sup&gt;b&lt;/sup&gt; 11.45±0.78&lt;sup&gt;bc&lt;/sup&gt; 1.05±0.21&lt;sup&gt;ab&lt;/sup&gt; 3.47±0.03&lt;sup&gt;c&lt;/sup&gt; 3.21±0.03&lt;sup&gt;b&lt;/sup&gt; 68.1±0.31&lt;sup&gt;c&lt;/sup&gt;</td>
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<td></td>
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</tr>
<tr>
<td>94:6</td>
<td>13.27±0.15&lt;sup&gt;b&lt;/sup&gt; 11.24±0.22&lt;sup&gt;b&lt;/sup&gt; 1.25±0.28&lt;sup&gt;ab&lt;/sup&gt; 3.50±0.02&lt;sup&gt;c&lt;/sup&gt; 3.94±0.11&lt;sup&gt;c&lt;/sup&gt; 68.2±0.21&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>92:8</td>
<td>13.23±0.27&lt;sup&gt;b&lt;/sup&gt; 11.10±0.01&lt;sup&gt;b&lt;/sup&gt; 1.31±0.00&lt;sup&gt;a&lt;/sup&gt; 5.20±0.01&lt;sup&gt;d&lt;/sup&gt; 4.18±0.57&lt;sup&gt;d&lt;/sup&gt; 67.4±0.33&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90:10</td>
<td>13.16±0.33&lt;sup&gt;b&lt;/sup&gt; 11.08±0.01&lt;sup&gt;b&lt;/sup&gt; 1.36±0.14&lt;sup&gt;a&lt;/sup&gt; 5.21±0.01&lt;sup&gt;d&lt;/sup&gt; 4.94±0.11&lt;sup&gt;c&lt;/sup&gt; 66.8±0.53&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0:100</td>
<td>4.23±0.23&lt;sup&gt;a&lt;/sup&gt; 2.29±0.01&lt;sup&gt;a&lt;/sup&gt; 6.60±0.57&lt;sup&gt;c&lt;/sup&gt; 6.53±0.03&lt;sup&gt;e&lt;/sup&gt; 9.69±0.01&lt;sup&gt;f&lt;/sup&gt; 71.6±0.31&lt;sup&gt;a&lt;/sup&gt;</td>
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<td></td>
</tr>
</tbody>
</table>

Mean values with different superscripts within the same column are significantly different (p <0.05; TF: Tigernut flour, WF: Wheat flour, Mc: Moisture content, C:Fibre: Crude Fibre, CHO: Carbohydrate)
Table 2: Functional properties of the wheat-tigernut composite flour

<table>
<thead>
<tr>
<th>WF:TF</th>
<th>BD (g/ml)</th>
<th>WHC (g/g)</th>
<th>WHC GEL (g/g)</th>
<th>SP (g/g)</th>
<th>SI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100:0</td>
<td>0.78±0.00a</td>
<td>1.32±0.78a</td>
<td>0.86±0.25b</td>
<td>5.75±0.18a</td>
<td>3.21±0.01a</td>
</tr>
<tr>
<td>98:2</td>
<td>0.73±0.04b</td>
<td>2.26±0.92a</td>
<td>0.95±0.21b</td>
<td>5.81±0.04a</td>
<td>3.59±0.01b</td>
</tr>
<tr>
<td>96:4</td>
<td>0.73±0.01bc</td>
<td>2.39±0.78a</td>
<td>1.05±0.21ab</td>
<td>5.75±0.04a</td>
<td>5.75±0.04a</td>
</tr>
<tr>
<td>94:6</td>
<td>0.73±0.01bc</td>
<td>2.42±0.78a</td>
<td>1.25±0.28ab</td>
<td>6.53±0.04b</td>
<td>6.53±0.04b</td>
</tr>
<tr>
<td>92:8</td>
<td>0.72±0.04ab</td>
<td>2.62±0.78a</td>
<td>1.31±0.00a</td>
<td>6.62±0.09b</td>
<td>6.62±0.09b</td>
</tr>
<tr>
<td>90:10</td>
<td>0.69±0.01ab</td>
<td>2.67±0.92a</td>
<td>1.36±0.14a</td>
<td>6.41±0.17b</td>
<td>6.41±0.17b</td>
</tr>
<tr>
<td>0:100</td>
<td>0.67±0.01a</td>
<td>7.25±0.07b</td>
<td>6.60±0.57c</td>
<td>7.64±0.29c</td>
<td>7.64±0.29c</td>
</tr>
</tbody>
</table>

Mean values with different superscripts within the same column are significantly different (p <0.05; TF: Tigernut flour, WF: Wheat flour, BD: Bulk density, WHC: Water holding capacity, WHC GEL: Water holding capacity of the gel, SP: Swelling power, SI: Solubility index)

Table 3: Pasting characteristics of wheat-tigernut composite flour (RVU)

<table>
<thead>
<tr>
<th>WF:TF</th>
<th>Peak Viscosity</th>
<th>Trough Viscosity</th>
<th>Breakdown Viscosity</th>
<th>Final Viscosity</th>
<th>Setback</th>
<th>Peak time (min)</th>
<th>Pasting temp (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100:0</td>
<td>141.3±4.24ab</td>
<td>107.2±1.84ab</td>
<td>34.1±6.07a</td>
<td>195.5±7.35b</td>
<td>88.3±9.19a</td>
<td>6.27±0.09ab</td>
<td>87.3±0.00b</td>
</tr>
<tr>
<td>98:2</td>
<td>145.9±22.7b</td>
<td>100.6±22.3ab</td>
<td>45.3±0.35a</td>
<td>195.6±25.8b</td>
<td>94.9±3.41a</td>
<td>6.04±0.23a</td>
<td>77.8±10.9ab</td>
</tr>
<tr>
<td>96:4</td>
<td>149.6±11.7b</td>
<td>120.2±12.5bc</td>
<td>29.3±0.83a</td>
<td>197.2±10.7b</td>
<td>77.0±1.82a</td>
<td>6.50±0.14b</td>
<td>87.2±0.03b</td>
</tr>
<tr>
<td>94:6</td>
<td>184.3±0.71c</td>
<td>145.6±13.7c</td>
<td>38.7±14.4c</td>
<td>232.2±0.07c</td>
<td>86.5±13.7a</td>
<td>6.44±0.05b</td>
<td>71.8±0.03c</td>
</tr>
<tr>
<td>92:8</td>
<td>115.5±1.41c</td>
<td>76.7±1.82a</td>
<td>38.8±0.41a</td>
<td>154.9±5.87a</td>
<td>76.6±19.6a</td>
<td>6.03±0.05a</td>
<td>80.8±6.86c</td>
</tr>
<tr>
<td>90:10</td>
<td>124.0±0.00ab</td>
<td>93.3±0.00ab</td>
<td>30.7±0.00a</td>
<td>174.3±0.00ab</td>
<td>80.9±0.00a</td>
<td>6.07±0.00a</td>
<td>87.3±0.00b</td>
</tr>
<tr>
<td>0:100</td>
<td>129±36.8c</td>
<td>73±1.41c</td>
<td>56±3.81c</td>
<td>138±7.07c</td>
<td>65±5.66c</td>
<td>5.80±1.32c</td>
<td>82±18.9</td>
</tr>
</tbody>
</table>

Mean values with different superscripts within the same column are significantly different (p <0.05; TF: Tigernut flour, WF: Wheat flour)

Functional properties of wheat-tigernut composite flour

Wheat flour (100%) had the highest bulk density while 100% tigernut flour had the least bulk density in the composite flour as shown in table 2. Significant differences (p<0.05) were observed as wheat was substituted with tigernut flour. The bulk density of 100% tigernut flour (0.67 g/ml) were similar with the values of 0.55 – 0.62 g/ml reported for tigernut flours by (Oladele and Aina, 2007) and that of wheat flour (0.78 g/ml) was also close to the values of 0.77 g/ml which was reported for wheat flour by (Adegunwa et al., 2014). It has been reported that bulk density is influenced by particle size and the density of the flour and is important in determining the packaging requirement and material handling (Karuna et al., 1996). Water holding capacity is the ability to hold its own and added water during the application centrifugation and heating. Its value ranges from 1.32 to 7.25g/100g. The water holding capacity was comparatively higher in the composite flour blends. This can be attributed to the high amount of fibre present in the tigernut flour. According to (Lakshmi et al., 2014), Starch and fibre content of the composite flour blends can cause a subsequent increase in water holding capacity and moisture retention. Water holding capacity of the gel ranges from 3.77 to 9.00g/100g. It was found that 100% tigernut flour had the highest water holding capacity of the gel while wheat flour (100%), had the lowest water holding capacity of the gel. A significant (p<0.05) difference was observed in the value of the water holding capacity of the gel. The effect of tigernut flour inclusion in wheat flour has a significant effect (p<0.05) on the swelling power of the composite flour. The swelling power ranges from 5.75 to 7.64 g/G. The swelling power of the flour blends increased with increase in tigernut flour. The result obtained in this study is lower to the findings of (Daramola and Osanyinlusi, 2006) for native and ginger modified starches respectively. Swelling power is a measure of hydration capacity, because the determination is a weight measure of swollen starch granules and their included water. (Moorthy and Ramanujan, 1986) reported that...
the swelling power of flour granules is an indication of the extent of associative forces within the granule. Swelling power is also related to the water absorption index of the starch-based flour during heating (Loss et al., 1981). The solubility index had a high value which ranged from 3.21 to 4.00%. 100% Tigernut flour had the highest solubility index while wheat flour substituted at 6% had the lowest solubility index. Significant difference (p<0.05) was observed in the value of solubility index.

**Pasting characteristics of wheat-tigernut composite flour**

Table 3 shows the pasting characteristics of wheat-tigernut composite flour blends. Peak viscosity is the maximum viscosity attained during or soon after the heating portion of the test ranged from 115.5 to 184.3RVU. Peak viscosity tend to increase as tigernut flour is incorporated up to 6%, but beyond this level the peak viscosity tend to decrease even below 100% wheat flour, this shows that for efficient water binding capacity of starch, the substitution should be limited to 6% tigernut flour incorporation in other to have high peak viscosity. A high peak viscosity implies that the composite flour will be suitable for product requiring high gel strength and elasticity such as bread (Adebowale et al., 2005). A high trough viscosity gives an indication of the ability of the paste to withstand breakdown during cooling. Therefore, the higher the trough viscosity, the greater the ability of the paste to withstand breakdown during cooling. The value ranged between 73 and 145.6 RVU with wheat-tigernut composite flour blends at 6% had the highest value for trough viscosity and Wheat-tigernut composite flour blends at 8% had the least value for trough viscosity. Break down viscosity measures the ability of paste to withstand breakdown during cooling. Its value ranged from 29.3 to 38.1RVU. The higher the value, the greater the ability of the starches to withstand breakdown. Wheat-tigernut composite flour at 2% had the highest value suggesting higher stability of starch. Final viscosity ranged between 154.9 to 232.2 RVU with wheat-tigernut composite flour blends at 6% had the highest value for final viscosity and 100% tigernut flour had the least value for final viscosity. Final viscosity is the most commonly used parameter to define the quality of a particular starch-based sample, as it indicates 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). As more and more tigernut flour was added to wheat flour, the final viscosity was on the increase suggesting higher resistance of paste to shear force during stirring. The variation in the final viscosity might be due to the sample kinetic effect of cooling on viscosity and the re-association of starch molecules in the samples (Nwokeke et al., 2013). Setback region is the phase where after cooling of the mixture a re–association between starch molecules occurs to a greater or lesser degree. It, therefore, affects retrogradation or re-ordering of the starch molecules. It has been correlated with texture of the food products (Michiyo et al., 2004). High set back viscosity is associated with weeping or syneresis (Nwokeke et al., 2013). The setback value of wheat-tigernut composite flour was between 65 and 94.9RVU. The higher the setback value, the higher the retrogradation during cooling and the lower the staling rate of the product made from the flour samples (Adeyemi and Idowu, 1990). Addition of wheat and tigernut flour blends could not have much effect in reducing the amylose retrogradation of bakery goods, but the blends could be an advantage in reducing retrogradation in fully gelatinized food product. Peak time is the time at which the peak viscosity occurred in minutes and it is a measure of the cooking time of the flour. Peak time value ranged between 5.80 and 6.50min with wheat-tigernut composite flour at 4% recorded the highest value for peak time suggesting more processing time, while 100% tigernut flour recorded the least peak time. Pasting temperature ranged from 71.8 to 87.3°C. Pasting temperature gives an indication of the gelatinization time during processing.
The greater the MTI value, the greater the weakening of the gluten network, as indicated by weakening areas than the control dough. The results obtained were in agreement with the findings of Attia et al., 2010. The dough stability ranged from 8.0 to 16.5min. Wheat flour substituted with tigernut flour at 4% and 8% had the highest stability while wheat flour (100%) was found to have the lowest stability. It gives an indication of the dough strength, with higher values suggesting a stronger dough. As the substitution increased, the dough stability also increased, which shows that the composite dough has a good gluten network and proper stability. Pomeranz, 1988 reported that dough with proper stability show good gluten network forming. Park and Morita, 2005 also reported that low stability time during the dough mixing period is an indicative of a weak gluten network structure of the dough. Mixing tolerance index (MTI) is a measure of tolerance of the dough to mixing. It was observed that increasing level of tigernut flour resulted in decrease of MTI. The value of mixing tolerance decreased ranging from 60.0 to 30.0BU. The greater the MTI value, the greater the weakened area. The results indicated that the dough prepared with 4%, 6%, 8% and 10% had significantly greater weakening areas than the control dough. The decrease in mixing tolerance index can be attributed to weakening of the protein network due to the mechanical shear stress (Rodriguez-sandoval et al., 2012). Degree of softening is a measure of the extent of mellowing of the dough. Its value ranges from 40.0 to 60.0min. Wheat flour substituted with tigernut flour at 8% had the highest degree of softening while wheat flour substituted with tigernut flour at 4%, 6% and 10% had the lowest degree of softening.

A higher pasting temperature implies higher water binding capacity, higher gelatinization (Numfor et al., 1996). Wheat flour (100%) and wheat-tigernut flour blends at 10% recorded the highest pasting temperature which indicates the presence of starch that is highly resistant to swelling during cooking time.

Rheological properties of wheat-tigernut composite flour

The results of wheat-tigernut flour using Brabender Farinograph are presented in the Table 4. The water absorption value ranges from 55.6 to 59.9%. Wheat flour (100%) had the highest water absorption while wheat flour substituted with tigernut flour at 10% had the least farinograph water absorption. There was a reduction in water absorption, as the substitution of the tigernut flour increased; this could be attributed to the reduction of gluten of wheat flour. Similar effects on water absorption was reported by (Hussein et al., 2013). Water absorption is an important dough property, which if increased may result in slower bread staling rate, but if decreased results into a faster bread staling rate (Pomeranz, 1988). Dough development time increased from a range of 2.0 to 7.5mins. Dough development time is defined as the difference in the time between the point of the first addition of water and the point immediately before the first detection of dough weakening. During this phase of mixing, water hydrates, the flour components and the dough are developed (Kohajdova et al., 2011; Mohammed et al., 2012). Increase in dough development time could be attributed to higher gluten content in wheat flour than tigernut flour. The result obtained was in agreement with the findings of Hussein et al., 2012; Moro and Rodriguez, 2012; Moro et al., 2012. Increase in mixing tolerance index can be attributed to weakening of the protein network due to the mechanical shear stress (Rodriguez-sandoval et al., 2012).
4. CONCLUSIONS

The study showed that the use of tigernut flour has the advantage of improving the mineral and the fibre contents of the composite flour, however addition of tigernut flour to wheat flour had a pronounced effect on the rheological properties of dough leading to lower water absorption, mixing tolerance index and degree of softening. The wheat-tigernut flour blends have higher protein and this suggest that the flour blends will be useful in production of bread or other baking products.

5. REFERENCES


