Annals. Food Science and Technology
2016

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

[1] OKE, Emmanuel Kehinde, [1] IDOWU, Michael Ayodele, [2.]OMONIYI, Saheed Adewale
[1]Department of Food Science and Technology, P.M.B 2240, Federal University Of Agriculture, Abeokuta, Nigeria.
[2]Department of Home Science and Management, Federal University, Gashua, Yobe state, Nigeria
*E-mail: kennyoke35@gmail.com;

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 60^0C 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

Submitted:22.07.2016 Reviewed: 02.09.2016 Accepted: 14.10.2016

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 60^0C 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 ± 2^0C) 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.

$$Bulk\ density\,(\frac{g}{ml})\,\frac{Weight\ of\ sample}{volume\ of\ sample\ after\ tapping}$$

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 90^0C 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.

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

$$Solubilty\ index = \frac{Weight\ of\ dry\ solids\ after\ drying}{Weight\ of\ sample} \times 100$$

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 $p \leq 0.05$ using Duncan's multiple range test.

3. RESULTS AND DISCUTION

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 1: Proximate composition of wheat-tigernut composite flour (%)

WF:TF	Mc	Protein	Fat	Ash	C.Fibre	CHO
100:0	$13.38{\pm}0.16^{b}$	$11.84{\pm}0.01^{b}$	$0.86{\pm}0.25^{b}$	$0.87{\pm}0.03^{a}$	$3.02{\pm}0.06^{a}$	$70.0{\pm}0.20^{d}$
98:2	$13.36{\pm}0.04^{b}$	$11.60{\pm}0.01^{b}$	$0.95{\pm}0.21^{b}$	$1.73{\pm}0.01^{a}$	$3.12{\pm}0.04^{ab}$	$69.6{\pm}0.09^{d}$
96:4	$13.32{\pm}0.01^{b}$	$11.45{\pm}0.78^{b}$	$1.05{\pm}0.21^{ab}$	$3.47{\pm}0.03^{c}$	$3.21{\pm}0.03^{b}$	$68.1{\pm}0.31^{c}$
94:6	$13.27{\pm}0.15^{b}$	$11.24{\pm}0.22^{b}$	$1.25{\pm}0.28^{ab}$	$3.50{\pm}0.02^{c}$	$3.94{\pm}0.11^{c}$	$68.2{\pm}0.21^{c}$
92:8	$13.23{\pm}0.27^{b}$	$11.10{\pm}0.01^{b}$	$1.31{\pm}0.00^{a}$	$5.20{\pm}0.01^{d}$	$4.18{\pm}0.57^{d}$	$67.4{\pm}0.33^{b}$
90:10	$13.16{\pm}0.33^{b}$	$11.08{\pm}0.01^{b}$	$1.36{\pm}0.14^{a}$	$5.21{\pm}0.01^{d}$	$4.94{\pm}0.11^{e}$	$66.8{\pm}0.53^{b}$
0:100	$4.23{\pm}0.23^{a}$	$2.29{\pm}0.01^{a}$	$6.60{\pm}0.57^{c}$	$5.63{\pm}0.03^{e}$	$9.69{\pm}0.01^{f}$	$71.6{\pm}0.31^{a}$

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

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

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)

WF:TF	Peak	Trough	Breakdown	Final Viscosity	Setback	Peak time (min)	Pasting temp (^{0}C)
100:0	141.3±4.24[ab]	107.2±1.84[ab]	34.1±6.07[a]	195.5±7.35[b]	88.3±9.19[a]	6.27±0.09[ab]	87.3±0.00[b]
98:2	145.9±22.7[b]	100.6±22.3[ab]	45.3±0.35[a]	195.6±25.8[b]	94.9±3.41[a]	6.04±0.23[a]	77.8±10.9[ab]
96:4	149.6±11.7[b]	120.2±12.5[bc]	29.3±0.83[a]	197.2±10.7[b]	77.0±1.82[a]	6.50±0.14[a]	87.2±0.03[b]
94:6	184.3±0.71[c]	145.6±13.7[c]	38.7±14.4[a]	232.2±0.07[c]	86.5±13.7[a]	6.44±0.05[b]	71.8±0.03[a]
92:8	115.5±1.41[a]	76.7±1.82[a]	38.8±0.41[a]	154.9±5.87[a]	76.6±6.19[a]	6.03±0.05[a]	80.8±6.86[a]
90:10	124.0±0.00[ab]	93.3±0.00[ab]	30.7±0.00[a]	174.3±0.00[ab]	80.9±0.00[a]	6.07±0.00[a]	87.3±0.00[b]
0:100	129±36.8[a]	73±1.41[a]	56±38.1[a]	138±7.07[a]	65±5.66[a]	5.80±1.32[a]	82±18.9[a]

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^{0}C. Pasting temperature gives an indication of the gelatinization time during processing.

Table 4: Farinogram characteristics of wheat-tigernut composite flour dough

WF:TF	WAB (%)	DDT(min)	DST (min)	MTI(BU)	DOS (min)
100:0	59.9±0.07[e]	2.0±0.01[a]	8.0±0.04[a]	60.0±0.11[c]	55.0±0.14[c]
98:2	58.5±0.04[d]	2.0±0.01[a]	13.0±0.07[b]	40.0±0.07[b]	50.0±0.35[b]
96:4	56.4±0.07[b]	2.5±0.01[b]	16.5±0.01[e]	30.0±0.14[a]	40.0±0.18[a]
94:6	56.7±0.11[c]	2.0±0.01[a]	15.0±0.14[c]	30.0±0.14[a]	40.0±0.14[a]
92:8	55.7±0.07[a]	7.5±0.07[c]	16.5±0.01[e]	30.0±0.14[a]	60.0±0.35[d]
90:10	55.6±0.07[a]	7.5±0.07[c]	16.0±0.07[d]	30.0±0.11[a]	40.0±0.67[a]

Mean values with different superscripts within the same column are significantly different ($p < 0.05$;TF- Tigernut flour, WF -wheat flour, WAB- water absorption, DDT- dough development time, DST- dough stability, MTI- mixing tolerance index, DOS- 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 to7.5mins.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 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 stronger dough. As the substitution increase, 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 (Rodvigez-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.

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

[1] Abaejoh R., Djomdi, I. and Ndojouenkeu, R. (2006). Characteristics of Tigernut (*Cyperus esculentus*) Tubers and their Performance in the Production of a Milky Drink. Journal of Food Processing and Preservation, **Vol.30**:145-163.

[2] Adddy E.O and Eteshola E. (1994). Nutritive Value of a Mixture of Tigernut Tubers (*Cyperus esculentus* L) and Baobab Seeds (*Adansonia digitata* L). Journal of Science Food and Agriculture, **Vol 35**:437-440

[3] Adebowale A.A., Sanni, L.O and Awonorin, S.O. (2005) Effect of Texture Modifies on the Physiochemical and Sensory Properties of Dried Fufu. Journal of Food Science and Technology International, **Vol.11**:373:385

[4] Adegunwa M.O., Ganiyu, A.A., Bakare, H.A. and Adebowale, A.A. (2014). Quality Evaluation of Composite Millet-Wheat Chinchin. Agriculture and Biology Journal of North America, **Vol 5**(1): 33-39.

[5] Adejuyitan J.A., Otunola, E.T., Akande, E.A., Bolarinwa,I.F., *and* Oladokun, F.M *(2009).* Some Physicochemical Properties of Flour Obtained from Fermentation of Tigernut (*Cyperus esculentus*) Sourced from a Market in Ogbomoso, Nigeria. African Journal of Food Science, **Vol.3***:*51–5.

[6] Ade-Omowaye B.I.O, Akinwande,B.A., Bolarinwa,I.F and Adebiyi A.O (2008). Evaluation of Tigernut (*Cyperus esculentus*)- Wheatcomposite flour and bread. African Journal of Food Science, **Vol. 2**:87-89.

[7] Adeyemi I.A and Idowu M. A.(1990). The Evaluation of Pregelatinized Maize Flour in the Development of Maissa, a Baked Product. Nigerian Food Journal, **Vol.8**: 63-73.

[8] Alegría-Torán A *and* Farré-Rovira R. *(2003).* Horchata y salud: Aspectos nutricionales y dietéticos.*In:* Fundación Valenciana de Estudios Avanzados*, editor.* Jornada Chufa y Horchata*:* Tradición y Salud*. Valencia , Spain : Consellería de Agricultura, Pesca y Alimentación* 55–70

[9] Alex A.A., Kelly A.R, Odean M.L, Fulcher R.G and Susan D.A. (2008). Influence of Added Bean Flour (*Phaseolus vulgaris* L.) on Some Physical and Nutritional Properties of Wheat Flour totillas. Food Chemistry, **Vol. 109**:33- 41.

[10] Anderson J.W., Smith, B.M. and Gustafson, N.J (1994).Health Benefits and Practical Aspects of High Fibre Diets. American Journal of Clinical Nutrition, **Vol. 59**:1242S-1247S

[11] Anderson, J.W., Baird, P., Davis, R.H., Ferreri, S., Knudtson, M. *and Koraym* A (2009). Health

[12] Benefits of Dietary Fibre. Nutrition Review, **Vol. 67***:*188–205

[13] AOAC (2000). Official Methods of Analysis, Association of Official Analytical Chemists, Washington DC

[14] Attia A.Yaseen, Abd El-Hafeez A. Shouk and Mostafa T. Ramadan (2010). Corn-Wheat Pan Bread Quality as Affected by Hydrocolloids. Journal of American Science, **Vol. 6**(10):684-790.

[15] Belewu M.A and Belewu K.Y.*(2007).* Comparative Physicochemical Evaluation of Tigernut, Soybean and Coconut Milk Sources. International Journal of Agriculture and Biology, **Vol. 5**:785–787

[16] Berghofer E. (2007). Brotals "funktionales Lebensmittel". Getreide Melh Brot. **Vol. 54**(3):175-179.

[17] Biljan S, and Bojana F,.(2008). Nutritional and Sensory Evaluation of Wheat Bread Supplemented with Oleic-Rich Sunflower Seed. Food Chemistry, **Vol. 108**:119-129.

[18] Bixquert-Jiménez M.(2003). Horchata y Salud: Propiedades saludables y de prevención deenfermedades digestivas *In:* Fundación Valenciana de Estudios Avanzados*, editor.*

[19] Jornada Chufa y Horchata*:* Tradición y Salud*. Valencia , Spain : Consellería de Agricultura, Pesca y Alimentación* 71–85

[20] Borges O, Gonc¸alves B, Sgeoeiro L, Correia P and Silva A. (2008). Nutritional Quality of Chestnut Cultivars from Portugal. Food Chemistry, **Vol. 106**:976–84

[21] Bosch L., A. Alegeria and R. Farre (2005) .RP-HPLC Determination of Tigernut and Orgreat Amino Acid Contents- Food Science Technology International, **Vol. 11**:33-40

[22] Bouaziz M.A., Amara H.B., Attia H., Blecker Ch and Besbes S. (2010). Effect of the Addition of Defatted Date Seeds on Wheat Dough Performance and Bread Quality. Journal of Textural Studies, **Vol. 41** :(4): 511- 531

[23] Bugusu B. A., Campenella O. and Hamaker B. R. (2001).Improvement of Sorghum-Wheat Composite Dough Rheological Properties and Breadmaking Quality through Zein Addition. Cereal chemistry, **Vol. 78** (1):31-35

[24] Cantatejo M.J. (1997). Analysis of Volatile Earth-almond (*Cyperus esculentus L.*) Journal Agriculture of Food Chemistry, **Vol. 45**:1853-1860.
[25] Chukwuma E.R, Obioma N, Christopher O.I (2010) The Phytochemical Composition and Some Biochemical Effects of Nigerian Tigernut (*Cyperus esculentus* L.) Tuber. Pakistan Journal of Nutrition, **Vol. 9** (7):709–15.
[26] Daramola B. and Osanyinlusi S.A. (2006). Investigation on Modification of Cassava Starch using Active Components of Ginger Roots (Zingiber officinale Roscoe). African Journal of Biotechnology, **Vol. 5**(10): 917- 920
[27] Dubois V, Breton S, Linder M, Fanni J.*and* Parmentier M *(2007).* Fatty Acid Profiles of 80Vegetable Oils with Regard to their Nutritional Potential.. European Journal of Lipid Science Technology, **Vol.** 109:720–32.
[28] FAO/WHO/UNU.(1985). Expert Consultation Energy and Protein Requirements. World Health Organization, Geneva.
[29] Hussein Ahmed, M.S., Mohie M. Kamil., Nefisa A. Hegazy, S.A.H and Abo El-Nor (2013). Effect of Wheat Flour Supplemented with Barely and /or Corn Flour on Balady Bread Quality. Polish Journal of Food Nutrition and Science, **Vol.63** (1):11-18
[30] Karuna D., Noel, G. and Dilip, K (1996). Food and Nutrition Bulletin, 17: 2, United Nation University
[31] Kofi M.E. (1993). Local Packaging of Food in Ghana. Published by the United Nations University, Tokyo Japan. Food and Nutrition bulletin, **Vol.12**:1-15.
[32] Kohajdová, Z., Karovičová, J, Jurasová, M. and Kukurová, K.. (2011). Application of Citrus Dietary Fibre Preparations in Biscuit Preparation. Journal of Food Science, Nutrition and Resources, **Vol.50** (3):182-190.
[33] Lakshmi Menon, Swarnali Dutta Majumdar and Usha Ravi (2014). Mango (*Mangifera indica* L) Kernel Flour as a Potential Ingredient in the Development of Composite Flour Bread. Indian Journal of Natural products and Resources, **Vol. 5**(1):75-82
[34] Lee,M.R., Swanson, B.G, and Baik B.K. (2001). Influence of Amylase Content on Properties of Wheat Starch and Bread Making Qualities of Starch and Gluten Blends. Cereal Chemistry, **Vol.** 78: 701-706.
[35] Lin, L., Liu H, Yu Y, Lin S and Mau J. (2009). Quality and Antioxidant Property of Buckwheat
[36] Enhanced Wheat Bread. Food Chemistry, **Vol. 37**: 461-467.
[37] Loss, P.J., Hood,L.F. and Graham, A.J. (1981). Isolation and Characterization of Starch from
[38] Breadfruit. Cereal Chemistry, **Vol. 58**:282-286
[39] Manuel G., Bonastre O, Cristina M.R, Valentin P. and Encarnacion F. (2008). Studies on Cake Quality Made of Wheat- Chickpea Flour Blends. LWT- Food Science and Technology pp. 1701-1709.
[40] Mepba ,H.D, Eboh, L. and Nwaojigwa S.U. (2007). Chemical Composition, Functional and Baking Properties of Wheat- Plantain Composite Flours. African Journal of Food Nutrition and Development, **Vol. 7**(1): 1-22.
[41] Michiyo, W., Tomoko, M., Kikuchi, T.,Hiroshi, K and Naofumi, M. (2004). Application of Pre–Germinated Brown Rice for Breadmaking, Cereal Chemistry, **Vol. 3**:293 -317
[42] Mohammed I., Ahmed A.R. and Senge B (2012). Dough Rheology and Bread Quality of Wheat-Chickpea Flour Blends. Industrial Crops Production, **Vol. 36** (1): 196-202.
[43] Moorthy, S.N. and Ramanujan, T. (1986). Variation in Properties of Starch in Cassava Varieties in Relation to Age of the Crop. Starch/Starke, **Vol. 38**(2):58-61.
[44] Morita , N., Maeda T, Miyazaki M, Yamamori M, Miura H, Ohtsuka I. (2002). Dough and Baking Properties of High Amylase and Waxy Wheat Flours. Cereal Chemistry, **Vol. 79**: 491- 495
[45] Numfor , F.A., W.M. Walter and S.J. Schwartz (1996). Effect of Emulsifiers on the Physical Properties of Native and Fermented Cassava Starches. Journal of Agriculture and Food Chemistry,**Vol. 44**: 2595-2599
[46] Nwokeke Blessing, Adedokun Ishola and Osuji Chikwendu (2013). Effect of Blending on the
[47] Proximate, Pasting and Sensory Attributes of Cassava-African Yam Bean Fufu Flour. *International Journal of Scientific and Research Publications*, **Vol. 3**(8):1-7
[48] Odoemelan, S.A. (2003). Chemical Composition and Functional Properties of Conophor nut Flour. (Tetracarpidium conophorum). International Journal of Food Science and Technology **Vol. 38**:729-734
[49] Okafor J.N.C, Okafor G.I, Ozumba A.U, and Elemo G.N. (2012).Quality Characteristics of Bread
[50] Made from Wheat and Nigerian Oyster Mushroom (*Pleurotus plumonarius*) Powder. Pakistan Journal of Nutrition **Vol. 11**(1):5-10
[51] Oladele, A.K. *and* Aina J.O. *(*2007*).* Chemical Composition and Functional Properties of Flour Produced from Two Varieties of Tiger nut (*Cyperus esculentus*)*.* African Journal of Biotechnology **Vol. 6**(21)*:*2473*–247*6*.*
[52] Park, S.H. and Morita N. (2005). Dough and Breadmaking Properties of Wheat Flour Substituted by 10% with Germinated Quinoa Flour. Food Science and Technology International, Vol. 11(6):471-476
[53] Pomeranz, Y. (1988). Wheat: Chemistry and Technology. American Association of Cereal Chemists, St. Paul, *Minnesota*, U.S.A. PP. 153-180Rodriguez-Sandoval.E,G. Sandoval and M. Cortes-Rodríguez .(2012). Effect of Quinoa and

Potato Flours on the Thermomechanical and Breadmaking Properties of Wheat Flour. Brazilian Journal of Chemical Engineering, **Vol. 29**(03): 503 – 510

[54] Takashi, S.and Seib, P.A. (1988). Paste and Gel Properties of Prime Corn and Wheat Starches with

[55] and without Native Lipids. Journal of Cereal Chemistry, **Vol 65**: 474–480

[56] Wang, J.C. and Kinsella, J.E. (1976). Functional Properties of Novel Proteins; Alfalfa Leaf Protein. Journal of Food Science, **Vol.** 41: 286–289.

[57] Wang, J., Rossel, M., De Barber, C.B. (2002). Effect of the Addition Different Fibres on Wheat Dough Performance and Bread Quality. Food Chemistry, **Vol. 79** (2):221-226.

[58] Wise, D. (2009). The Tigernut My Top Bait. Available Online: http://www.carp.uk.net/articles/tigernuts.htm Accessed: Sept 21, 2009.

[59] Woo, K..S and Seib, (P.A. 2002). Cross Linked Resistant Starch: Preparation and Properties. Cereal Chemistry, **Vol. 79**: 819-825.

[60] Yeboah, S.O, Mitei, Y.C., Ngila, J.C, Wessjohann, L. Schmidt, J. *(*2012). Compositional and Structural Studies of the Oils from Two Edible Seeds: Tiger nut, *Cyperus esculentum*, and asiato, *Pachira insignis*, from Ghana. Food Research International, Vol 47: 259-266