QUALITY ATTRIBUTES AND IN VITRO STARCH DIGESTIBILITY OF TIGER NUT-ENRICHED MAIZE TUWO

Adeoye, Babatunde Kazeem[1], **Akinbode**, Badiu Akinola[1], **Ibraheem**, Fatimoh[1]
[1]Department of Food Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology Akure, Ondo State, Nigeria.
Corresponding author's email: bkadeoye@futa.edu.ng

Abstract
This study investigated the effect of incorporating tiger nut flour on the quality attributes of maize tuwo. Maize grains and tiger nut were processed into flour and were combined at different ratios (85/15, 70/30 and 55/45%; maize/tiger nut; [w/w]) to produce 'tuwo' which was then subjected to various analyses. The protein and crude fibre contents of tiger nut were 7.0% and 8.7% respectively. The bulk density and water absorption capacity (WAC) of the flour blends ranged from (0.72 – 0.85 g/cm^3) and (1.93 – 3.63 % g/g) respectively. The pasting factors of the flour blends were peak viscosity (439-766 RVU), trough (430-751 RVU), final viscosity (933-1402 RVU), setback (493-651 RVU), peak time (6.73-7.0 min) and pasting temperature (82.30-87.65^{o}C). The protein content of 'tuwo' from the flour blends ranged from 4.88 – 7.61% compared to the control (4.62%; 100% maize flour). The lightness indices (L) of the flour blends were generally decreasing with tiger nut flour inclusion. The vitamins C and E contents of 'tuwo' samples increased with tiger nut inclusion while the FRAP (ferric reducing anti-oxidant property) of the food samples was decreasing with increasing content of tiger nut flour. Maize 'tuwo' from 30% tiger nut flour inclusion gave the highest value (8.11%) of in vitro starch digestibility. The sensory quality rating of the food product revealed that 'tuwo' from 100% maize flour was the most acceptable to consumers while 'tuwo' with 45% tiger nut flour inclusion gave the second best in terms of overall acceptability. Therefore, maize/tiger nut flour combination could find application in dough meal production.*

Keywords: Tiger nut, maize flour, pasting properties, starch digestibility, sensory quality.

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1. INTRODUCTION

Maize (*Zea Mays*) as a source of starch is the third most important cereal in the world after rice and wheat. Its utilization includes food uses, for industrial processing as a raw material and for animal feed formulation (Kent and Evers, 2004). However, utilization of maize for food production is the most common in developing countries as against industrial usage in the developed countries (Mejia, 2005). Maize is a major source of dietary energy for low income consumer in many parts of tropical Africa, including major urban areas (Ngoddy, 2005). It is an important cereal crop in Africa with a wide variability in utilization which include human food uses, animal feed formulation, and as a basic raw material for industrial purposes (Mejia, 2005).

Maize tuwo is one of the food products that can be obtained from maize in Nigeria. It is essentially a food gel or dumpling which is stiff, has a yield value and can be moulded into shapes (Muller, 2003). However, the utilization of tuwo and maize generally is limited by its extremely low protein content and so the consumption of its products has been implicated in malnutrition. It isone of the numerous maize-based food products from Africa, is particularly popular in Nigeria and across West Africa sub-region and is normally prepared from non-fermented maize flour to form a food dumpling or gel-like product through a combination of water, flour and thermal energy (Bolade et al., 2009). A food dumpling like Maize tuwo normally has such properties as being stiff after cooling, has yield value from a rheological assessment, can be moulded into shapes and has moisture content in the range of 64-80% (Muller, 2003). The ultimate consumption of maize tuwo is usually with any of the local vegetable soups (e.g. kubewa, kuka, tafshe, etc.) as a side dish with or without meat. This normally serves as a

source of additional nutrients such as protein, minerals and vitamins. The quality indicators usually used for maize tuwo acceptability include mild creamy or white colour, ease of hand-mouldability, good swallowability, pleasant taste and acceptable overnight keeping quality (Aboubacar et al., 1999; Bolade et al., 2002).
Tigernut (*Cyperus esculentum*) is a perennial grass-like plant with spheroid tubers, pale yellow cream kernel surrounded by a fibrous sheath. It is also known as yellow nut sedge, earth or ground almonds, "souchet" in French, "ermandeln" in German and "chufa" in Spanish (TTSL, 2005).Grossman and Thomas (1998) revealed that tigernuts have been cultivated for food and drink for men and planted for hogs for many years in Spain and that the lovely milky elixir is served in health spas, pubs, and restaurants as a refreshing beverage (competing successfully with other soft drinks). Unfortunately, despite these potentials in tigernuts, it has been a neglected crop in Nigeria. This probably may be due to inadequate knowledge on its production, utilization and nutritional value. Variety of food products can be derived from tiger nut tubers though there is little documentation at large. Various food processing techniques can be applied to tiger nut processing to modify its appearance, develop its natural flavour, stimulate the digestive juices, add variety to the menu, make it easily digestible and bio-available, destroy harmful microorganisms, improve its nutritional quality and prevent decomposition.
Nutritional deficiency such as absence/low content of lysine and tryptophan in maize grains can predispose maize-based food products to similar deficiency. Efforts had been made to ameliorate such deficiency by combining other food plant materials with maize grain in the process of enhancing its nutritional quality. One other way of enhancing the nutritional value of maize-based food product (maize 'tuwo') is to introduce tigernut flour which has a potential to add value in terms of antioxidant and improve its quality characteristics. Therefore, the objective of this study was to evaluate the quality attributes of 'tuwo' from maize-tiger nut flour blend.

2. MATERIALS AND METHODS

Fresh raw tigernuts(about 5 kg) and maize grains were purchased from the Oja-Oba Main Market Akure, Ondo State, Nigeria. The Nuts and seeds were identified and authenticated at the Department of Crop Soil and Pest Management, Federal University of Technology, Akure, Ondo State, Nigeria. All reagents used were of analytical grade.

1. Production of Maize Flour

Maize flour was prepared method described by Bolade et al. (2002). Five kilograms of maize grains was used for this study. Each batch was first tempered with water using a quantity of 3 - 4% (v/w) followed by decortication of the grains on a locally fabricated decorticator. This machine removed the germs and hulls of the grains. The decorticated grains (maize grits) were grounded into flour using a locally fabricated plate mill. The maize flour finally obtained was sieved using a sieve with 300 µm aperture and then kept in airtight polythene bags until needed.

2. Production of Tigernut flour

Tigernut flour was prepared as described by (Ndubuisi, 2005) with slight modifications. About 2000 g fresh tigernut were sorted, washed and drained. The drained tigernuts were spread on trays which were covered with foil paper and was dried using cabinet dryer at a temperature of 55°Cfor48hours. It was allowed to cool and was milled using an attrition mill to obtain tigernut flour. After milling, the tigernut flour was packagedinnylonbags and keptinanairtightjarat room temperaturepriorto further production and analyses.

3. Blending of The Flours from Maize and Tiger nut

The maize tuwo and tigernut flour were homogenously prepared as maize-tigernut blends in proportions of 85:15; 70:30; 55:45 and 100:0% maize flour as control. The bioactive compounds and antioxidant potential were analysed which includes vitamin C and E analysis and also the in vitro starch digestibility and other various analysis.

4. Production of maize-tigernut tuwo

Maize-tigernut tuwo was prepared from flour of each of the formulations using a method as described by Bolade et al. (2002) with slight modification. The overall ratio of flour to water used in maize-tigernut preparation was 1:3.5 (w/v). Cold slurry of the flour was first prepared by mixing 20% of the desired quantity of flour (1 kg) with 25% of the desired quantity of water (3.5 l). This was then followed by bringing 60% of the water into boiling and the cold slurry initially prepared was added to this boiling water coupled with vigorous stirring, using a wooden flat spoon, to form a pap-like consistency. The remaining quantity of the flour (80% of the desired total) was then added gradually to the boiling pap-like paste with continuous stirring so as to facilitate non formation of lumps and to ensure a homogenous gel formation. The remaining quantity of water (15% of the desired total) was finally added to the formed gel, covered properly without stirring, and allowed to cook for about 5 - 7 min after which it was stirred vigorously to ensure smoothness of the gel.

5. Proximate Analysis

These analyses were carried out in triplicate on each of mixes according to AOAC methods (2006)

6. Functional Properties

Bulk density determination of the composite flour

The method describe by Adebowale et al., 2012with slight modification. 30 g of flour sample was weighed and poured into 100 ml measuring cylinder. The samples were pressed down into the cylinder until it could no longer be pressed. The volume was determined and density calculate using Equation 1

$$\text{Density} = \frac{\text{mass}}{\text{volume}} \quad (1)$$

Determination of water absorption capacity of the composite flour

This was done according to the method described by Adebowale et al., (2012).

Determination of colour characteristics of composite flour

Colour properties (L*, a*, b*) of composite flour was determined by using a Chroma Meter CR-14 (Konica Minolta Inc., Japan) as described by Olatunde et al., (2016).

Determination of pasting properties of the flour blends

The pasting profile of flour sample was studied using a Rapid Visco-Analyzer (RVA) (Newport Scientific Pty. Ltd.) with the aid of a thermocline for windows version 1.1software (2008). The RVA was connected to a PC where the pasting properties and curve were recorded directly. Flour suspension was prepared by addition of the equivalent weight of 3 g flour to distilled water to make a total of 28 g suspension in the RVA sample canister. The heating and cooling cycles were automatically programmed in the following manner. The temperature was kept within 60°C to 99°C while maintaining a rotation speed of 160 rpm. The whole cycle was completed within 13 min. The viscosity was expressed in centipoises (cP). The parameters measured (RVU units) were:

Peak viscosity (RVU): Highest viscosity during the heating stage

Breakdown viscosity (RVU): The difference between the peak viscosity and the minimum viscosity at the end of the heating stage

Setback viscosity (RVU): The difference between the maximum viscosity during cooling and the minimum viscosity during heating

Final viscosity (RVU): The viscosity at the end of the cooling stage

Pasting temperature (°C): This is the temperature at which there is a sharp increase in viscosity of flour suspension after the commencement of the heating stage.

Peak time (min): Time taken for the paste to reach the peak viscosity.

7. Determination of in vitro starch digestibility of the maize-tigernut tuwo

In vitro starch digestibility of samples was determined using pancreatic amylase and alpha glucosidase (Sigh et al; 2005).

8. Antioxidant Properties DPPH determination

The percentage of antioxidant activity (aa%) of each sample was assessed by DPPH free radical assay. The measurement of the DPPH radical scavenging activity was performed according to methodology described by Brand-Williams et al. (2005).

Ferric Reducing/Antioxidant Power(FRAP) method

This method measures the ability of antioxidant to reduce ferric iron. It is based on the reduction of the complex of ferric iron and 2,3,5-triphenyl-1,3,4-triaza-2-azoniacyclopenta-1,4-diene chloride (TPTZ) to the ferrous form at low pH. This reduction was monitored by measuring the change in absorption at 593 nm, using a diode-array spectrophotometer (Antolovich et al., 2002).

Determination of Vitamin C of the maize-tigernut tuwo

The vitamin C content was determined using the ascorbic acid as the reference compound. 200µl of the extract was pipetted and mixed with 300µl of 13.3% of TCA and 75µl of DNPH. The mixture was incubated at 37 ^oC for 3 hours and 500µl 0f 65% H_2SO_4 was added and the absorbance was read at 520nm. (Benderitter et al., 2008).

Determination of Vitamin E of the maize-tigernut tuwo

A suitable weight of sample 1.0 g was placed in 100 ml flask fitted with a reflux condenser, then 10 ml of absolute alcohol and 20 ml of 1M alcoholic sulphuric acid were added. It was refluxed for 45 mins and cooled. 50 ml water was added; transferred to a separating funnel of low actinic glass with the addition of a further 50 ml of water. The unsaponifiable matter with 5 x 30 ml diethyl ether was extracted, washed the combine ether extract free from acid and dried over anhydrous sodium sulphate. The extract was evaporated at low temperature. Protecting it from sunlight, the residue was then dissolved in 10 ml absolute alcohol, then both the standard and the sample were transferred to a 20 ml volumetric flask and 5 ml of absolute alcohol was added, followed by 1ml conc. nitric acid. The flask was placed on a water bath at 90^{o}C for 3 min. cooled under running water and made up the volume to 20 ml with absolute alcohol. The absorbance was measured at 470 nm against blank containing absolute alcohol (Pearson, 2005).

Sensory Evaluation of Maize 'tuwo'

Maize-tigernut tuwo prepared from each of the maize formulations was evaluated for their sensory qualities and general acceptability. A scoring test was used which is designed to determine which of the products is most preferred. A 30-member semi-trained taste panels were requested to carry out the rating of the tuwo samples. The panelists were instructed on the use of sensory evaluation procedures. Each of the panelists were asked to rate the samples on the basis of colour, texture (mouldability), aroma, taste and overall acceptability using a nine-point hedonic scale (that is, 9 = like extremely; 5 = neither like nor dislike; 1 = dislike extremely) (Meilgaard et al., 2005).

Statistical Analysis

All analyses were carried out in triplicate. The mean and standard deviation of the data obtained were calculated. The data were evaluated for significant differences in their means with analysis of variance (ANOVA) ($p<0.05$). Differences between the means were separated using SPSS.

3. RESULTS AND DISCUSSION

1. Proximate Analysis of Maize Grain and Tiger Nut Seed

Table 1 shows the result of proximate analysis of maize grain and tigernut seed. Carbohydrate content of both maize grain and tigernut seed were 83.04% and 50.75% respectively. They were found to be lower than 69.9% reported by (Okafor et al. 2004) for the same seed. The moisture content of the maize grain and tigernut seed were 3.61% and 7.61% respectively and these were found to be less than 10% which is appropriate for long storage as stated by (Ndubuisi, 2005). Tigernut seed showed a higher amount of protein of 7.00% which was significantly higher than that of maize grain which was 4.48%.

Table 1: Proximate composition (g/100 g) of fresh maize grain and tigernut seed[1].

Flour source	Moisture	Protein	Lipid	Fibre	Ash	Carbohydrate
Maize grain	3.61±0.05	4.48±0.20	3.35±0.34	3.41±0.06	1.91±0.09	83.04±0.60
Tigernut seed	7.61±0.05	7.00±0.10	23.06±2.40	8.70±0.10	2.89±0.16	50.75±2.30

[1]Results are mean values ± standard deviation.

Tigernut seed had a fat content of 23.06% which was significantly higher than that reported by Ndubuisi (2005) while the value obtained for the maize grain of 3.35% was consistent with the result obtained by Sabanis and Tzia, (2009). The fibre content of tigernut seed was significantly higher than that of the maize of grain with 8.7% and 3.41% respectively. This is an indication that tigernut is good for aiding digestion of the flour samples in the colon when they are processed into dough meal and bread and reduce constipation often associated with bread (Jideani and Onwubali, 2009). According to a well documented study by Slavin (2005), it is now accepted that dietary fibre plays a significant role in the prevention of several diseases such as cardiovascular diseases, diverticulosis, constipation, irritable colon, cancer and diabetes . Ash content is a reflection of the mineral content present in a food product (Sanni et al., 2008). Therefore sample with higher ash content is expected to have a relatively higher mineral content. Tigernut seed had a higher ash content of 2.89% while the maize grain has a lower content of 1.91%.

2. Physico-Chemical Properties of Maize/Tiger Nut Flour Blend.

Table 2 shows the physico-chemical properties of maize/tigernut flour blend.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). Physicochemical properties of maize/tigernut flour blends are presented in Table 2.

Bulk density

The bulk density ranged from 0.72 g/ml - 0.85 g/ml. The bulk density of the flour decreased with increasing level of tigernut flour inclusion. The control sample had the highest bulk density (0.85± 0.02 g/ml). The bulk densities of samples A and B 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, 2007). 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

Water absorption capacity is the ability of a product to associate with water under a water limiting condition. Water absorption capacity of the maize/tigernut flour blend ranged from 1.93 ± 0.15 to 3.63 ± 0.09 % g/g and highest in the control sample (3.63 ± 0.09 % g/g).

Table 2: Physicochemical properties of maize/tigernut flour blends[1].

Flour source (Maize: Tigernut flour blend)	Bulk density (g/cm^3)	Water absorption capacity (g/g)
A	0.85 ± 0.02^a	3.63 ± 0.09^a
B	0.83 ± 0.02^a	3.15 ± 0.14^b
C	0.76 ± 0.01^b	2.57 ± 0.26^c
D	0.72 ± 0.01^c	1.93 ± 0.15^d

[1]Results are mean values ± standard deviation. Mean values within the same column having the same letter are not significantly different at P<0.05.
Key A: 100% Maize flour, 0% Tigernut flour, B: 85% Maize flour, 15% Tigernut flour, C: 70% Maize flour, 30% Tigernut flour, D: 55% Maize flour, 45% Tigernut flour.

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 etal., 2001; Morita et al., 2002). In this study, the water absorption capacity decreased with increasing level of tigernut flour inclusion. The decrease in the water absorption capacity of the composite flours might be attributed to the presence of hydrophilic amino acids which interferes with the ability of the tigernut 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 tigernut flour.

3. Pasting Properties of Maize/Tigernut Blend

The pasting properties of the samples are presented in Table 3. The peak viscosity of the samples ranged from 439 – 766 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 lowest in 45% tigernut flour substituted sample and highest in the maize flour (control). This is comparable to values obtained by Oladunmoye et al., (2017) in a work on the rheological properties of composite flour from wheat, maize and tigernut flour. The peak viscosity decreased with increasing level of tigernut flour inclusion. This increase may be attributed to the low starch content of the tigernut flour causing a low 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). Breakdown viscosity ranged from 9.0 – 26.0 RVU with highest value obtained in the sample B (26.0 RVU). At 45% tigernut flour inclusion, breakdown viscosity was lowest (9.0 RVU). Sample A (15.0 RVU) and sample C (9.0 RVU) were not significantly different from each other.

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 decreased with increasing level of tigernut flour inclusion. The final viscosity of composite flours in this study ranged from 933 to 1402 RVU. This viscosity was highest in sample A (1402 RVU) compared to the sample C (933 RVU). The decrease in final viscosity might be due to the reduced aggregation of amylose molecules (Miles et al., 2005) which is indicative of slow retrogradation (Lii et al. 2006). Setback value of composite flour ranged from 493 - 651 RVU compared to the control (651 RVU). Setback value decreased with increasing level of tigernut flour substitution. It is the phase of the pasting curve after cooling of the starch and this phase involves reassociation, 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 samples A and B had significantly higher set back value. 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 6.73- 7.00 minutes. The peak time was highest in sample B (7.00 min). Low peak time observed in the flour blends may be due to reduced starch content as a result of tigernut flour inclusion. However, low peak time is indicative of its ability to cook fast. The pasting temperature of flour samples ranged from 82.30 ^{o}C to 87.25 ^{o}C and values obtained increased with increase in the level of tigernut flour inclusion.

Table 3: Pasting properties of maize/tigernut flour blends.

Flour source (Maize: Tigernut flour blend)	Peak Viscosity (RVU)[1]	Trough (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (min)	Pasting temperature (°C)
A	766	751	15.0	1402	651	6.80	82.30
B	603	577	26.0	1104	527	7.00	84.00
C	455	440	15.0	933	493	6.80	86.35
D	439	430	9.0	1000	570	6.73	87.25

[1]RVU = Rapid visco unit.
Key A: 100% Maize flour, 0% Tigernut flour, B: 85% Maize flour, 15% Tigernut flour, C: 70% Maize flour, 30% Tigernut flour, D: 55% Maize flour, 45% Tigernut flour.

Table 4:Colour characteristics of 'tuwo' prepared from maize/tigernut flour blends[1].

'Tuwo' source (Maize: Tigernut flour blend)	L*	a*	b*	Chroma(C)	Hue (H)
A	97.22±4.23[a]	2.40±2.42[a]	5.10±0.61[d]	6.72±0.72[d]	69.42±2.32[d]
B	94.5±2.60[ab]	1.51±0.12[a]	8.70±0.50[c]	8.84±0.20[c]	80.11±1.28[a]
C	90.90±1.85[bc]	2.34±0.26[a]	10.10±0.61[b]	10.37±0.32[b]	76.87±1.33[b]
D	87.10±1.28[c]	3.65±0.31[a]	11.50±0.25[a]	12.02±0.46[a]	72.81±1.08[c]

[1]Results are mean values ± standard deviation. Mean values within the same column having the same letter are not significantly different at P<0.05.
Key A: 100% Maize flour, 0% Tigernut flour, B: 85% Maize flour, 15% Tigernut flour, C: 70% Maize flour, 30% Tigernut flour, D: 55% Maize flour, 45% Tigernut flour.

4. Colour Characteristics of Flour from Different Maize/Tigernut Flour Blends.

Table 4 shows the colour characteristics of flour from different maize/tigernut flour blend. The colour indices showed that colour lightness (L* - value) of flour from the control sample was significantly (p<0. 05) higher than that of all the other formulation including sample B (87.10) which was the lowest. This is an indication that maize flour has a high tendency of flours and maize tuwo varying lightness indices. The a* values ranged between (1.51 to 3.65). There was no significant difference between all the samples. b* values ranged from (5.11 to 11.50) and there was significant difference between the samples. The colour intensity (chroma) of flour from sample D (12.02) was significantly (p<0. 05) higher than that of all other formulations including sample A (6.72) which was the lowest. These observations with colour characteristics of formulation from maize/tigernut flour blend indicate that the inclusion of tigernut flour leads to a reduction in the lightness index value.

The changes noticed in the colours of the samples could be as a result of the drying temperature of the flours. The hue angle (h°) of the flour samples from different formulation also ranged from 69.42 to 80.11°. The hue angle shifting from 0 to 90° connotes a colour change from red to yellow while a shift from 90 to 180° connotes a colour change from yellow to green. However, the hue angle (h°) seems not to be a useful indicator for describing the colour changes in white maize grain food products in spite of being described as the coordinate that best reflects the visual colour in fruit ripening (Ferrer et al., 2005), as red-yellow green colour indices are seldom applicable in tuwo preparation. Colour is one of the important quality indicators influencing consumer acceptability of maize tuwo while mild creamy or white colour is most preferred.

5. Proximate Composition of Maize/Tigernut 'Tuwo'

Table 5 indicates the proximate composition of 'tuwo' made from maize/tigernut flour blend.

Table 5: Proximate composition (g/100 g) of 'tuwo' prepared from maize/tigernut flour blends.

'Tuwo' source (Maize:Tigernut flour blend)	Moisture	Protein	Lipid	Fibre	Ash	Carbohydrate
A	18.78±0.10^{a}	4.62±0.3^{b}	4.11±0.46^{d}	4.17±0.07^{e}	1.94±0.15^{c}	66.39±0.44^{b}
B	18.57±0.2^{b}	4.88±0.1^{b}	5.30±0.51^{d}	4.73±0.09^{d}	2.01±0.19^{c}	64.52±0.62^{b}
C	18.43±0.35^{c}	5.43±0.2^{b}	7.21±0.31^{c}	5.23±0.13^{c}	2.11±0.27^{c}	61.61±0.45^{c}
D	18.59±0.1^{b}	7.61±1.1^{a}	10.35±0.5^{b}	6.10±0.05^{b}	2.59±0.38^{b}	54.76±1.90^{d}

[1]Results are mean values ± standard deviation. Mean values within the same column having the same letter are not significantly different at P<0.05.
Key A: 100% Maize flour, 0% Tigernut flour, B: 85% Maize flour, 15% Tigernut flour, C: 70% Maize flour, 30% Tigernut flour, D: 55% Maize flour, 45% Tigernut flour.

All results of proximate composition of blends showed significant ($p < 0.05$) difference.
Results indicated slight increase in ash, protein, fat and decrease in moisture and carbohydrate content of blends. The moisture contents of all the formulations ranged from 18.43-18.78 g which are much greater than 10 g moisture level as the recommended maximum limit for shelf stable foods. It was reported that food with 5 - 15 g moisture level would have a shelf life of more than year. It was also observed that all formulations had significant increase in their ash content after inclusion of tigernut flour to a range of 1.94-2.49 g. This was observed to be due to the fact that tigernut flour had more ash content and so it contributed in the increase in ash contents of the formulations. It is also an indication of mineral increase as reported by Adejuyitan et al., (2007).
The result of ash obtained is slightly comparable to the ash contents (from 1.80-2.30 g) in complementary foods produced from sorghum, soybeans and oil seed. All formulations showed significant increase in protein contents to a range of 4.62 – 7.21 g. The addition of tigernut flour had significantly caused an increase in the levels of protein. All formulations reasonably are less than the 10 - 15 g protein, which are the Codex standard limit for recommended daily. The fat contents of all formulations increased to a range of 4.11-10.35 g after inclusion of tigernut flour soybeans.
All values of fat are comparable to the maximum level of 10 g recommended for complementary foods (Muller, 2003). These values are also comparable with the work of Asma et al. (2005) and Eshun et al. (2009). The carbohydrate contents of all formulations decreased to a range of 54.76-66.39 g which are also comparable to carbohydrate contents of complementary foods produced from cereal grain and legumes Abioye et al., (2011).

6. Antioxidant Properties of Maize/Tigernut 'Tuwo'

Table 6 shows the antioxidant properties of 'tuwo' from maize/tiger nut flour blends.

Scavenging assay effect of DPPH

The DPPH (2, 2-diphenyl-1-picrylhydrazil) is a stable free radical, which has been widely accepted as a tool for estimating free radical scavenging activities of antioxidants. DPPH is a stable free radical and accepts an electron or hydrogen radical to become a stable diamagnetic molecule (Liu et al., 2014). The reduction capability of DPPH radical is determined by the decrease in absorbance at 517nm induced by antioxidants. The experimental data (63.31, 63.61, 65.20 and 77.39) of the dough meals as shown in Table 6 revealed that the meals were likely to have the effects of scavenging free radicals especially the control sample. It was observed that the control had the highest free scavenging radical properties with reduction in this property as the level of tigernut inclusion increased which might be an indication of the tigernut inclusion having negative effect on the antioxidant property of the maize "tuwo. It might be due to the presence of certain substances present in tiger nut that is responsible for the reduction of the antioxidant properties.

Table 6: Antioxidant properties of 'tuwo' prepared from maize/tigernut flour blends[1].

Tuwo Sample (maize flour: tigernut flour)	DPPH (%)	FRAP (mg/g)	Vitamin C (mg/g)	Vitamin E (mg/g)
A	77.39 ± 0.39[a]	1.05 ± 0.03[a]	17.71 ± 0.23[d]	0.25 ± 0.01[c]
B	63.61 ± 0.48[c]	0.43 ± 0.02[b]	18.95 ± 0.09[b]	0.47 ± 0.20[b]
C	65.20 ± 0.16[b]	0.61 ± 0.06[c]	23.76 ± 0.06[a]	0.69 ± 0.01[a]
D	63.31 ± 0.20[c]	0.27 ± 0.10[d]	18.63 ± 0.10[c]	0.33 ± 0.01[bc]

[1]Results are mean values ± standard deviation. Mean values within the same column having the same letter are not significantly different at P<0.05.
Key A: 100% Maize flour, 0% Tigernut flour, B: 85% Maize flour, 15% Tigernut flour, C: 70% Maize flour, 30% Tigernut flour, D: 55% Maize flour, 45% Tigernut flour.

FRAP (Ferric Reducing Antioxidant Property)

FRAP is one of the methods used in analyzing the antioxidant property of food samples. FRAP measures the ability of antioxidant to reduce ferric iron. It is based on the reduction of the complex of ferric iron and 2,3,5-triphenyl-1,3,4- triaza-2-azoniacyclopenta-1,4-diene chloride (TPTZ) to the ferrous form at low pH. This reduction is monitored by measuring the change in absorption at 593 nm, using a diode-array spectrophotometer (Antolovich et al., 2002) It was observed that the control had the highest reduction ability of ferric solution with reduction in this property as the level of tigernut inclusion increased which might be an indication of the tigernut inclusion having negative effect on the antioxidant property of the maize "tuwo" or as a result of processing conditions which involved high temperature as reported by Brand-Williams et al., (2005).

Vitamin C

Vitamin C is one of the antioxidant component present in tigernut which has been found to scavenge free radicals in the body (Abaejoh et al., 2006). There was significant difference in the vitamin C content of 'tuwo' from maize/tigernut flour blend. The vitamin C content ranged from (17.71 to 23.76 mg/g) and there was significant difference ($p \leq 0.05$) in the samples. The values obtained from this study are higher than those reported by Adebowale et al., (2008) for 100% maize flour. Sample C had the highest vitamin C content while sample A which is the control sample had the least value. Increase in the vitamin C content with in the tiger nut flour inclusion was observed.

Vitamin E

This has also been found to be one of the antioxidant component of tigernut (TTSL, 2005) and has been included in maize flour for the potential of scavenging free radicals in the body. There was significant difference in the vitamin E content of 'tuwo' from maize/tigernut flour blend. As the level of tiger nut inclusion increased, there was increase in the vitamin E content of the 'tuwo'.The values ranged from (0.25-0.69 mg/g). Sample A which is the control sample had the least value of 0.25 mg/g while sample C had the highest vitamin E content of 0.69 mg/g. The values obtained from this study are lower than those reported by Adebowale et al., (2008).

7. In Vitro Starch Digestibility of 'Tuwo' Prepared From Maize/Tigernut Flour Blends

Table 7 shows the in vitro starch digestibility of 'tuwo' prepared from maize/tigernut blend. There was significant difference in the in vitro starch digestibility of 'tuwo'. Increase in the inclusion of tigernut led to increase in the in vitro starch digestibility values. The values ranged from 5.07% to 8.11% in this study. Sample D had a lower value as compared to the increase in the in vitro starch digestibility values observed with increase in the amount of tigernut added which may be an indication of the fact that sample C is the optimum inclusion level of tigernut flour.

Table 7: In vitro starch digestibility of 'tuwo' prepared from maize/tigernut flour blends[1].

'Tuwo' source (Maize: Tigernut flour blend)	In vitro starch digestibility (%)
A	5.07 ± 0.04^{d}
B	6.88 ± 0.03^{c}
C	8.11 ± 0.03^{a}
D	7.82 ± 0.03^{b}

[1]Results are mean values ± standard deviation. Mean values within the same column having the same letter are not significantly different at P<0.05.
Key A: 100% Maize flour, 0% Tigernut flour, B: 85% Maize flour, 15% Tigernut flour, C: 70% Maize flour, 30% Tigernut flour, D: 55% Maize flour, 45% Tigernut flour.

Martens et al. (2018) have reported that the variation in digestibility is due to the starch content amylose-amylopectin ratio, resistant starch and its granular structure. The values reported in this study are lower than those reported by Riley et al. (2004) which stated that the food samples with low amylose content are more digestible than food samples with high amylose content. This implies that food sample which are digested and absorbed at a faster rate would produce large increases in the blood glucose which may necessitate greater insulin and other endocrine responses when ingested (Wolever et al., 2002).

8. Sensory Evaluation of Re-Constituted Maize 'Tuwo' from Maize/Tigernut Combination

Table 8 presents the sensory scores associated with maize and tigernut dough meal and its control (maize meal) as follows: appearance (6.97-8.17), aroma (6.97-7.50), texture (6.67-7.90), taste (7.00-7.73), and overall acceptability (7.23-8.07). The control (100% maize meal) had highest scores in all parameters analysed. Samples B and C had the same values in texture (6.67), besides, 6.67 was the lowest value scored in texture. Colour is an important property for determining he appearance of a food product which is important in determining the overall acceptability (Eshun et al., 2006). The appearance of sample A (8.17) however, was preferred to that of others. In terms of appearance, 100% maize meal had significantly higher score of 8.17 (P<0.05) than other samples (6.97 – 7.37) which had no significant difference.

There was no significant difference in the aroma content of the samples. This suggests that inclusion of tigernut in maize 'tuwo' from 15%-45% does not affect the aroma characteristics based on this study. C had least scores in aroma (7.17), appearance (7.27) and texture (6.67) while D had the lowest scores in taste (7.00) and overall acceptability (7.23). Taste is an important organoleptic property in determining the overall acceptability of food product. Samples B, C and D can be compared with sample A (control). Samples A, B and C do not differ from one another but samples A and D showed significant difference. However, 100% maize meal had highest scores in aroma, taste, texture and appearance

Table 8:Sensory quality rating of 'tuwo' prepared from maize/tigernut flour blends[1]

'Tuwo' source (Maize:Tigernut flour blend)	Aroma	Appearance	Texture (Mouldability)	Taste	Overall Acceptability
A	7.5 ± 1.1^{a}	8.2 ± 0.9^{a}	7.9 ± 1.1^{a}	7.7 ± 1.1^{a}	8.1 ± 0.8^{a}
B	7.2 ± 1.1^{a}	7.4 ± 1.0^{b}	6.7 ± 1.1^{b}	7.0 ± 1.2^{ab}	7.2 ± 1.2^{b}
C	7.1 ± 1.1^{a}	7.3 ± 1.1^{b}	6.7 ± 1.3^{b}	7.3 ± 1.3^{ab}	7.4 ± 1.1^{b}
D	7.0 ± 1.5^{a}	7.0 ± 1.3^{b}	6.9 ± 1.0^{b}	7.2 ± 1.5^{b}	7.5 ± 0.9^{b}

[1]Results are mean values from 50 panelists. Mean values within the same column having the same letter are not significantly different at P<0.05.
Key A: 100% Maize flour, 0% Tigernut flour, B: 85% Maize flour, 15% Tigernut flour, C: 70% Maize flour, 30% Tigernut flour, D: 55% Maize flour, 45% Tigernut flour.

4. CONCLUSION

The inclusion of tiger nut flour up to 45% in maize-tiger nut composite flour could give a dough meal product of high quality that is comparable with 100% maize flour. The sensory evaluation has shown that 45% tiger nut flour could be included in the production of 'tuwo' that would be well accepted by the consumers. Thus, the dough meal would enhance the health, growth and wellbeing of the consumers. The use of maize and tiger nut in dough meal production would promote production, value addition and diversification of utilization of the crops in Nigeria and environs. This would create wealth and enhance food security.

This study had proven that 'tuwo' can be made from maize/tiger nut flour blend however more research into its nutritional, anti-nutritional content and shelf stability should be established. Further study should also be done on the rheological properties, swelling power and textural properties of tuwo produced from the maize/tiger nut flour blend. The optimum level of tiger nut inclusion in the production of maize 'tuwo' should also be established.

5. REFERENCES

[1]. Abaejoh, C. M., Slover, H. T., Thompson, R. H. J. R. and Merola, G. V. (2006). Determination of tocopherols and sterols by capillary gas chromatography. Journal of the American Oil Chemist's Society, 60: 1524-1528.

[2]. Abioye A., Ragone, D and Cavaleth, (2011). Sensory evaluation of fruit quality and nutritional composition of breadfruit (Artocarpus moracea) cultivars. Economics andBotany, 60(4): 335-346.

[3]. Aboubacar, D. P., Kumar, D., Verma, R., Langyan, S. and Sangwan, S. (1999). Nutritional Quality of Maize (In: Maize: Nutrition Dynamics and Novel Uses). Springer, pp. 135–140.

[4]. Adebowale, Y. A., Adeyemi A. I. and Oshodi A. A. (2005). Functional and Physicochemical Properties of Flours of Six Mucuna Species. African Journal Biotechnology; 4: 1461-1468.

[5]. Adebowale, A. A., Adegoke, M. T., Sanni, S. A., Adegunwa, M. O., and Fetuga, G. O. (2008).

[6]. Functional Properties and Biscuit Making Potentials of Sorghum-wheat Flour Composite. American Journal of Food Technology, 7: 372-379.

[7]. Adejuyitan, S. M., Sathe, A. K. Deshphande, S. S., Salunkhe, D. K. (2007). Functional Properties of lupine seed protein and protein concentrates. Journal of Food Science, 42:491-492.

[8]. Akanbi, C. T, Nazamid, S. and Adebowale, A. A. (2009). Functional and pasting properties of a tropical breadfruit (Artocarpus altilis) starch from Ile-Ife, Osun State, Nigeria, International Food ResearchJournal, 16: 151-157.

[9]. Aluge, O. O., Akinola, S. A. and Osundahunsi, O. F. (2016). Effect of Malted Sorghum on Quality Characteristics of Wheat-Sorghum-Soybean Flour for Potential Use in Confectionaries. Food and Nutrition Sciences, 7: 1241-1252.

[10]. Antolovich, M., Prenzler, P. D., Patsalides, E., McDonald, S., and Robards, K. 2002. Methods for testing antioxidant activity. Analyst, 127: 183-198.

[11]. AOAC (2006). Official Methods of Analysis, Association of Official Analytical Chemists, 19th ed. Washington DC.

[12]. Ohtsuka I. (2004). Invitro digestibility and resistant starch content of some industrialised commercial beans (Phaseolus vulgaris L.). Journal of FoodChemistry, 78:333-337.

[13]. Asma, E. S., Okafor, G. I. and Ugwu, F. C. (2005). Production and evaluation of cold extruded and baked ready-to eat snacks from blends of breadfruit (Treculia africana), cashew nut (Anacardium occidentale) and coconut (Cocos nucifera). Food Science Quality andManagement, 23: 65-77.

[14]. Bakare, H. A. (2008). Evaluation of rheological properties and baking performance of wheat composite flour produced from Iye peeled breadfruit (Artocarpuscomunis) and cassava. Ph.D Thesis, University of Ibadan, pp 170.

[15]. Benderitta, A., Saltzman, A., Virk, P., Pfeiffer, W. (2008). Nutrition and Dietetic Foods: 2nd ed. Chemical Publishing Co. Inc. New York.

[16]. Bolade M. K, Buraimoh M. S. (2009). Textural and sensory quality enhancement of sorghum tuwo. International Journal Food Science Technology. 41(2):115- 123.

[17]. Bolade M. K., Usman M. A., Rasheed A. A., Benson E. L., Salifou I. (2002).Influence of hydrothermal treatment of maize grains on the quality and acceptability of tuwo nmasara (traditional maize gel). Food Chemistry, 79:479-483.

[18]. Brand-Williams, W., Cuvelier, M. E.; Berset, C. (2005). Use of a free radical method to evaluate antioxidant activity. Lebensm. Wiss.Technology, 28, 25-30.

[19]. Doxastakis, G., Zafiriadis, I., Irakil, M., Marlani, H., and Tananaki, C. (2002). Lupin, soya and triticale addition to wheat flour dough and their

effects on rheological properties. Food Chemistry, 77: 219-227.
[20]. Eshun C., Ragone, D and Cavaleth, F., (2006). Sensory evaluation of fruit quality and nutritional composition of breadfruit (Artocarpus moracea) cultivars. Economics and Botany, 60(4): 335-346.
[21]. Ferrer, W. C., Barrey, H. R., and Westhoff, D. C., (2005). Food Microbiology 3rd edition, Copy right 1999 by Mc Graw – Hill, Inc. Tata Mc Graw – Hill edition(1978) Tenth reprint 1991.
[22]. Grossman, A. C. and Thomas, L. G. (1998). The Horchata Factory: Origin of the Word Horchata and the Beverage www.horchatafactory.com / copy right W. W. Norton& Company, Inc. http//wwwhorchatafactory.com/horchataindex.hx ml.
[23]. Ikegwu, O. J., Okechikwu, P. E. and Ekumankana, E. O. (2010). Physico-Chemical and Pasting Characteristics of Flour and Starch from Achi (Brachystegiaeurycoma) Seed. Journal of Food Technology, 8(2): 58-66.
[24]. Jideani and Onwubali, (2009). Evaluation of sorghum (Sorghum bicolor) as replacement for maize in the diet of growing rabbits (Oryctolagus cuniculus). Asian-Australian Journal of Animal Science 15, 565–569.
[25]. Karuna D, Noel G. and Dilip, K. (1996). Food and Nutrition Bulletin, 17: 2, United Nation University.
[26]. Kaur, M. and Singh, N. (2005). Studies on functional, thermal and pasting properties of flours from different chickpea (Cicer arietinum L.) cultivars. FoodChemistry, 91 (3): 403-411.
[27]. Kent, T., and Evers, H. (2004). Consumer acceptability and perceptions of maize meal in Giyani, South Africa. Dev. South. Afr. 28, 271–281.
[28]. Kim M., Lopez-Ridaura, R., Willett, W. C., Rimm, E. B., Liu, S., Stampfer, M. J., Manson, J. E., and Hu, F. B. (1995). Magnesium Intake and Risk of Type 2 Diabetes in Men and Women Diabetes Care; 27:134-40.
[29]. Lapham, J and Drennan, D.S.H. (1990). The Fate of Yellow Nutsedge (Cyperus esculentus): Seed and Seedlings in Soil. Weed Science. 38: 125-128.
[30]. 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, 78: 701-706.
[31]. Lii, C. Y, Tsai, M. L., Tseng, K. H. (1996). Effect of Amylose Content on Rheological Property of Rice Starch. Cereal Chemistry, 73:415-420.
[32]. Liu, C., Zhao, Y., Li, X., Jia, J. Chen, Y. and Hua, Z. (2014). Antioxidant capacities and main reducing substance contents in 110 fruits and vegetables eaten in China. Food and Nutrition Sciences, 5: 293-307.
[33]. Lorenz, K. and Collins, F (1990). Quinoa (Chemopodiumquinoa) Starch physiochemical properties and functional characteristics. Starch/Starke, 42 (3): 81- 86.
[34]. Mahajan, A. and Dua, S. (2002). Salts and pH induced changes in functional properties of amaranth (Amaranthus tricolor l.) seed meal. Cereal Chemistry, 79 (6), 834–837.
[35]. Malomo, O., Ogunmoyela, O. A. B., Adekoyeni, O. O., Jimoh, O., Oluwajoba, S. O. and Sobanwa, M. O. (2012). Rheological and functional properties of soy-poundo yam flour. International Journal Food ScienceNutrition and Engineering, 2(6): 101-107.
[36]. Martens, B. M. J, Gerrits, W. J. J., Bruininx, M. A. M. and Schols, H. A. (2018). Amylopectin structure and crystallinity explains variation in digestion kinetics of starches across botanic sources in an in-vitro pig model. Journal of Animal Science and Biotechnology, 9(1), 91
[37]. Maziya-Dixon, B., Dixon, A. G. O., and Adebowale, A. A. (2004). Targeting different end uses of cassava: genotypic variations for cyanogenic potentials and pasting properties. A paper presented at ISTRC-AB Symposium, 31 October – 5 November 2004, Whitesands Hotel, Mombasa, Kenya.
[38]. Meilgaard, J., Banerji, A., Manyong, V., Tomlins, K., Mittal, N. and Hamukwala, P., (2005). The formulation of a nutraceutical bread mix using sorghum, barley, and flaxseed. M.S. Thesis, Texas A&M University, College Station, TX.
[39]. Mejia, M. (2005). Review: maize research and production in Nigeria. African Journal Biotechnology 3, 302–307.
[40]. Miles, M. J., Morris, V. J., and Ring, S. G. (1985). Gelation of amylose. Carbohydrate Research, 135:25.
[41]. Moore M. (2004) Documents Prepared for Bottlegreen for the Product Tiger White: www.tigerwhitedrinks.com Copyright Miam Ltd. Pp 1-22.
[42]. Morita N., Maeda T., Miyazaki M., Yamamori M., Miura, H, and Ohtsuka I. (2002). Dough and baking properties of high amylase and waxy wheat flours. CerealChemistry, 79: 491-495.
[43]. Muller S. (2003). Practical Food Microbiology and Technology. AVI Books, Van Nostrand Reinhold Company, New York, USA.
[44]. Ngoddy, M. (2005). A Sweetmeat Plant, a Perfume Plant and Their Weedy Relatives: A Chapter in the History of Maize. Economic Botany, 46: 64-71.
[45]. Okafor, C., Van der Merwe, B., Erasmus, C. and Taylor, J. R. N. (2004). African maize porridge: a food with slow in vitro starch digestibility. Food Chemistry, 72:347-353.

[46]. Olaunmoye, O. O., Aworh, O. C., Ade-Omowaye, B. I and Elemo, G. (2107). Subtitution of wheat with cassava starch. Nutrition and Food Science.

[47]. Olatunde, G. O., Arogundade, L. K. and Orija, O. I. (2017) Chemical, functional and pasting properties of banana and plantain starches modified by pre-gelatinization, oxidation and acetylation. Cogent Food & Agriculture , 3: 1-12.

[48]. Patindola, J., Wanga, Y. and Jane J. (2005). Structure and functionality changes in starch following rough rice storage. Starch/Stärke 57, 197–207.

[49]. Pearson, D. (2005). The Chemical Analysis of Foods; Manual of Analysis CBA – 301 Series (7th Ed) Churchill, Livingstone London. Pp 7 – 11.

[50]. Peroni, F. H. G., Rocha, T. S. and Franco, C. M. L. (2006). Some structural and physicochemical characteristics of tuber and root starches. FoodScience and Technology International, 12: 505-510.

[51]. Plaami, S. (1997) Myoinositol phosphates: analysis, content in foods and effects on nutrition. LWT-FoodScience and Technology. 30, 633-647.

[52]. Riley V., Oladele, A. K. and Aina, J. O. (2004). Chemical composition and functional properties of flour produced from two varieties of tigernut (Cyperusesculentus). African Journal of Biotechnology, 6 (21): 2473-2476.

[53]. Sabanis and Tzia, (2009) Chemical and physical properties of processed sorghum grain carbohydrates. Journal of Animal Science, 40(2):335-341.

[54]. Sanni, E., Meenakshi, J., Banerji, A., Manyong, V., Tomlins, K., Mittal, N. and Hamukwala, P. (2008). Using a discrete choice experiment to elicit the demand for a nutritious food: willingness-to-pay for orange maize in rural Zambia. J. Health Econ. 31, 62–71.

[55]. Shittu, T. A., Lasekan, O. O., Sanni, L. O. and Oladosu, M. O. (2001). The effect of drying methods on the functional and sensory characteristics of pupuru-a fermented cassava product. ASSET, 1(2): 9- 16.

[56]. Sigh, M., Siddhuraju, P., and Becker, K.(2005). Nutritional and antinutritional composition, in vitro animo acid availability, starch digestibility and predicted glycemic index of differentially processed mucuna beans (Mucuna pruriens var. utilis): an underutilised legume. Food Chemistry 91:275-286.

[57]. Slavin G. M. (2005). Consumer acceptability of yellow maize products in Zimbabwe. Food Policy 33, 352–361.

[58]. Wolever, D., Onwuka, G. I., Onwuka, N. D. (2002). Invitro digestibility and resistant starch content of some industrialised commercial beans (Phaseolus vulgaris L.). Journal of FoodChemistry, 78:333-337.