Croatian Journal of Food Science and Technology
journal homepage: www.ptfos.unios.hr/cjfst/

Original scientific paper *DOI: 10.17508/CJFST.2019.11.1.04*

Functional and pasting properties of wheat/tigernut pomace flour blends and sensory attributes of wheat/tigernut pomace flour meat pie

IDOWU MICHAEL AYODELE[1], ADEOLA ABIODUN ADEROJU[2], OKE EMMANUEL KEHINDE[*1], AMUSA AYODEJI JOSEPH[1], OMONIYI SAHEED ADEWALE[3]

[1]*Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.*
[2]*Food and Nutrition Research Programme, Institute of Food Security, Environmental Resources and Agricultural Research, Federal University of Agriculture, Ogun State Abeokuta, Nigeria.*
[3]*Department of Home Science and Management, Federal University, Gashua, Yobe State Nigeria*

ARTICLE INFO

Article history:
Received: February 10, 2018
Accepted: January 19, 2019

Keywords:
functional properties,
sensory qualities,
wheat flour,
tigernut pomace flour,
meat pie

ABSTRACT

This study investigated the functional and pasting properties of wheat and tigernut pomace flour blends, as well as the sensory attributes of the meat pie obtained from the composite flour. Tigernut pomace flour was substituted for wheat flour in the amount of 2 – 10%. Unsubstituted wheat flour served as the control. The composite blends were analysed for functional and pasting properties. The sensory attributes of the meat pie obtained from the composite flour were also determined. Bulk density, water absorption capacity, swelling power, and the solubility index of the blends ranged from 0.70 - 0.75 g/mL, 0.62 - 0.96%, 4.06 - 4.47 g/g, and 2.45 - 13.7% respectively. Peak, trough, breakdown, final, and setback viscosities, peak time, and pasting temperature ranged from 113.6 - 135.9 RVU, 76.7 - 90.2 RVU, 36.0 - 45.8 RVU, 170 - 183.7 RVU, 91.0 - 93.6 RVU, 5.07 - 6.03 min, and 88.4 -90.0 RVU respectively. In terms of appearance, the meat pie samples prepared from tigernut-substituted flour blends did not show significant difference ($p < 0.05$) from the control sample. The control sample had the highest overall acceptability, although samples from the composite blends were also found to be acceptable. Hence, tigernut pomace flour could be substituted for wheat at the amount of 10% to produce an acceptable meat pie.

Introduction

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. Another name for the plant is earth almond, as well as yellow nut grass (Odoemelan, 2003; Belewu and Belewu, 2007). In Nigeria, it is known as Aya in Hausa, Ofio in Yoruba, and Akiausa in Igbo, 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., 2011) and also that it contains a moderate amount of protein (Oladele and Aina, 2007). It is a source of some useful minerals such as potassium, phosphorus, and calcium (Bixquert-Jiménez, 2003), as well as vitamin E and C (Belewu and Belewu, 2007). In addition, tigernut has been demonstrated to contain a higher amount of essential amino acids than that proposed in the protein standard by the FAO/WHO (1985) for satisfying adult needs (Bosch et al., 2005). It has been reported to have a high dietary fibre content (Alegría and Ferre, 2003), which means that it could be effective in the 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., 2009), and losing weight (Borges et al., 2008). One way to improve the utilization of

[*]Corresponding author E-mail: kennyoke35@gmail.com

tigernut may be to use it in pastries such as meat pie.

Meat pie is a popular snack traditionally made from wheat flour. It is the most popular pastry and it can be eaten while hot or warm (Ike et al., 2015). However, due to the global rising concern regarding coeliac disease (associated with consumption of wheat, oat, rye, and barley) and the inability of some tropical countries (such as Nigeria), to produce wheat at the economic level, the use of composite flour in preparing meat pie is desirable. Furthermore, the low mineral and fibre content of wheat flour could be improved by the addition of tigernut pomace.

The recent applications of tigernut in baked products has been studied extensively. Ade-omowaye et al. (2008) reported the use of the brown variety of tigernut in bread making, using a 10-50% dilution of wheat flour with tigernut flour. The report further shows that only the bread baked using the 10% dilution of wheat flour with tigernut (brown variety) flour was acceptable. Zahra and Ahmed (2014) reported on exploring the suitability of incorporating tigernut flour as a novel ingredient in gluten-free biscuits. Corn flour was diluted with tigernut flour in biscuit formulation at three levels of 10, 20, and 30% of tigernut flour. The report further shows that a mixture of corn and tigernut flour can be successfully incorporated into gluten-free cereal based products resulting in biscuits of acceptable quality. Oke et al. (2017) also reported the use of the yellow variety of tigernut in bread making, using a 2-10% dilution of wheat flour with tigernut flour. The report further shows that the incorporation of tigernut flour into wheat flour bread production has dramatically improved the investigated parameter, as well as bread quality. The bread baked from the 8% dilution of wheat flour with tigernut flour was acceptable. However, there is a dearth of information on the use of tigernut pomace in the preparation of meat pie. This study therefore aimed to produce flour blends from wheat and tigernut pomace, and determine its functional properties and pasting characteristics, and then assess the sensory qualities of the meat pie produced from wheat-tigernut pomace flour blends.

Materials and methods

Materials

Wheat flour, tigernut of the yellow variety, carrot (*Daucus carota*), canned corned beef, nutmeg, salt, sugar, margarine, baking powder, onions, and eggs were purchased from the Eleweran market in Abeokuta, Ogun State, Nigeria.

Preparation of tigernut pomace flour

The method described by Sánchez-Zapata et al. (2009) was used for the preparation of tigernut pomace (TPF). Yellow tigernut *(Cyperus esculentus)* was sorted to remove unwanted materials like stones, pebbles, and other foreign materials, before washing with tap water. It was soaked in water for eight hours; the soaked nuts were wet milled using a laboratory hammer mill (Fritsch, D-55743, Idar-Oberstein-Germany). The tigernut milk co-products were pressed inside a muslin cloth to obtain the extract, which is tigernut pomace. The tigernut pomace was dried in a cabinet dryer at 60 °C for 72 hours. The tigernut pomace was packed and sealed in polyethylene bags until further analysis.

Blends formulation

Different composite flour samples were prepared by combining 100%, 98%, 96%, 94%, 92%, and 90% wheat flour with 0%, 2%, 4%, 6%, 8%, and 10% tigernut pomace, respectively, using the method described by Oke et al. (2017).

Meat pie preparation

The method described by Kohajdová and Karovicová (2008) with slight modifications was used for the preparation of the meat pie. A straight dough process was used for the preparation of the meat pie. Ingredients such as sugar (6 g), nutmeg (2 g), salt (1 g), margarine (3 g), baking powder (2 g), water (60-65 mL), and tigernut pomace were added in appropriate proportions to each of the flour blends and the control flour. The substitution level of tigernut pomace into wheat flour was (2%, 4%, 6%, 8%, and 10%) for making meat pie dough. The blends were mixed with ingredients in a spiral mixer (for 5 min). Water was added to the flour inside the spiral mixer and the mixture was kneaded for three minutes. The resulting dough was scaled and shaped. Other ingredients, such as diced boiled carrot (2 g), canned corned beef (2 g), and blended onion (2 g), were put into the one side of the dough, the other side was folded over, and the edges were pressed close with a fork. Then it was subjected to baking at the temperature of 180 °C for 30 minutes.

Functional properties of wheat-tigernut pomace flour blends

Determination of bulk density

Bulk density (Eq. 1) was determined using the method described by Wang and Kinsella (1976). Ten grams of the sample were weighed into a 50 mL graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top. The volume of the sample was recorded.

$$Bulk\ density\ \left(\frac{g}{mL}\right) = \frac{Weight\ of\ sample}{Volume\ of\ sample\ after\ tapping} \qquad \text{Eq. 1}$$

Determination of the water absorption capacity

This was determined using the methods described by Beuchat (1977). A one-gram sample was weighed into a 25 mL graduated conical centrifuge tubes and about 10 mL of water was added. The suspensions were allowed to stand at room temperature (30 ± 2 °C) for 1 hour. The suspension was centrifuged at 2000 rpm for 30 minutes. The volume of water on the sediment was measured and the absorbed water was expressed as per cent water absorption based on the original sample weight.

Determination of the swelling power and the solubility index

The swelling power (Eq. 2) and the solubility index (Eq. 3) were determined using the method described by Takashi and Siebel (1988). One gram of flour was weighed into a 50 mL centrifuge tube. 50 mL of distilled water was added and mixed gently. The slurry was heated in a water bath at 90 °C for 15 minutes. During the heating, the slurry was stirred gently to prevent clumping of the flour. On completion, the tube containing the paste was centrifuged at 3000 rpm 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 the dry matter content of the gel.

$$Swelling\ power = \frac{Weight\ of\ wet\ mass\ sediment}{Weight\ of\ dry\ matter\ in\ the\ gel} \qquad \text{Eq. 2}$$

$$Solubility\ index\ (\%) = \frac{Weight\ of\ dry\ solids\ after\ drying}{Weight\ of\ sample} \times 100 \qquad \text{Eq. 3}$$

Pasting characteristics of wheat flour-tigernut pomace blends

Pasting characteristics were determined with a Rapid Visco Analyzer (RVA) (RVA TECMASTER, perten instrument-2122833, Australia). Three grams of sample were weighed into a dried empty canister, and then 25 mL of distilled water was dispensed into the canister containing the sample. The suspension was thoroughly mixed to avoid lumps and the canister was fitted into the rapid visco analyzer. A paddle was then placed into the canister and the test proceeded immediately by automatically plotting the characteristic curve. The estimated parameters were peak viscosity, setback viscosity, final viscosity, trough, breakdown viscosity, pasting temperature, and time to reach peak viscosity.

Sensory evaluation of the meat pie

A preference test was used to determine the sensory attributes of meat pie samples. The sensory evaluation was conducted in the sensory evaluation laboratory of the Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Nigeria. A panel consisting of 50 judges who regularly ate meat pie were asked to indicate their preference for appearance, texture, aroma, colour, mouth feel, and overall acceptability using a 9-point hedonic scale as reported by Iwe (2002), with values dislike extremely=1, dislike very much=2, dislike moderately=3, dislike slightly=4, neither like nor dislike=5, like slightly=6, like moderately=7, like very much=8, like extremely=9.

Statistical analysis

Statistical analysis was done using the Analysis of Variance (ANOVA) and in cases where there was significant difference, means were separated using the Duncan's multiple range test.

Results and Discussion

The functional properties of wheat-tigernut pomace composite flour is shown in Table 1. The functional properties are those parameters that determine the application and end use of food materials for various food products. The bulk density of the wheat flour-tigernut pomace composite flour ranged from 0.70 to 0.75 g/mL. Wheat flour (100%) had the lowest bulk density while wheat flour substituted at 8% had the highest bulk density. The bulk density is generally affected by particle size and the density of flour or the flour blend, and it is very important in determining the packaging requirement, raw materials handling, and application in wet processing in the food industry (Adebowale et al., 2008; Ajanaku et al., 2012). The bulk density obtained in this study was higher than the values of 0.57 - 0.64 g/mL reported by Ade-omowaye et al. (2008) on the brown variety of tigernut flour; the difference could be attributed to the type of the tigernut variety used in this study. The water absorption capacity of the flour ranged from 0.62 to 0.96%. Significant differences ($p < 0.05$) were observed in the blends regarding the water absorption capacity. Wheat flour substituted at 6% had the lowest water absorption capacity and wheat flour substituted at 10% had the highest water absorption capacity. The water absorption capacity is an index of the ability of a flour product to associate with water under a condition where water is limiting (Omueti et al., 2009). A high water absorption capacity is attributed to polymers with a loose starch structure, while a low value indicates the compactness of the molecular structure. Therefore, the low water absorption capacity of the flour blends obtained in this study has good ability to bind water. The swelling power ranged from 4.06 to 4.47 g/g. There was a significant difference ($p < 0.05$) in the swelling power of the blends, wheat flour substituted at 10% had the least swelling power while wheat flour substituted at 4% had the highest swelling power. The results obtained in this study are lower than the values of 8.9 and 12.9 reported by Daramola and Osanyinlusi (2006) for native and ginger modified starches, respectively. Moorthy and Ramanujan (1986) reported that the swelling power of a flour granule is an indication of the extent of associative forces within the granules. The swelling capacity can also be related to the water absorption index of starch-based flour during heating. The solubility index had a high value which ranged from 2.45 to 13.7%. A significant difference ($p < 0.05$) was observed in the value of the solubility index. Wheat flour substituted with tigernut pomace at 4% had the lowest solubility index, while wheat flour substituted with tigernut pomace at 10% had the highest solubility index.

Table 2 shows the pasting properties of wheat-tigernut pomace composite flour. Pasting properties help to predict the behaviour of a starch-based food system as it affects some properties such as the aesthetics, texture, and digestibility of the final products (Onweluzo and Nnamuchi, 2009). The decrease in peak, trough, and final viscosities, as well as the peak time of the blends as the quantity of tigernut pomace flour increased, is similar to the report by Ahmad et al. (2016). The pasting temperature of the blends increased with the increase in tigernut pomace flour. Apart from the blend containing 2% of the tigernut pomace flour, the blends exhibited a reduction in breakdown viscosity as the tigernut pomace flour increased. There was a significant ($p < 0.05$) difference in the pasting properties of the blends, except for the breakdown and setback viscosities. High peak viscosity indicates a high starch content and this could explain why the 100% wheat flour sample had the highest peak viscosity. Thus, the tigernut pomace flour reduced the thickening power of wheat, since higher peak viscosity corresponds to a higher thickening power of starch (Avula and Singh, 2009). Trough is the minimum viscosity value in the constant temperature phase of the RVA pasting profile and it measures the ability of the paste to withstand breakdown during cooling. Breakdown viscosity is a measure of the degree of disintegration of granules caused due to the continuous shear and stress at elevated temperatures (Ahmad et al., 2016). Breakdown viscosity measures the ability of paste to withstand breakdown during cooling. The higher the value, the greater the ability of the starches to withstand breakdown. Final viscosity is the ability of a material to form a viscous paste, while setback measures the retrogradation tendency or the syneresis of flour upon cooling of cooked flour pastes (Ahmad et al., 2016).

Table 1. Functional properties of wheat-tigernut pomace flour blends

WF:TP	BD (g/mL)	WAC (%)	SP(g/g)	SI (%)
100:0	$0.70±0.00^{a}$	$0.87±0.00^{c}$	$4.16±0.00^{c}$	$6.61±0.00^{d}$
98:2	$0.71±0.00^{b}$	$0.88±0.00^{d}$	$4.10±0.00^{b}$	$3.79±0.00^{b}$
96:4	$0.73±0.00^{c}$	$0.90±0.00^{a}$	$4.47±0.00^{f}$	$2.45±0.00^{a}$
94:6	$0.71±0.00^{b}$	$0.62±0.00^{a}$	$4.19±0.00^{e}$	$5.38±0.00^{c}$
92:8	$0.75±0.00^{a}$	$0.69±0.00^{b}$	$4.19±0.00^{d}$	$9.18±0.00^{e}$
90:10	$0.74±0.00^{d}$	$0.96±0.00^{f}$	$4.06±0.00^{a}$	$13.7±0.00^{f}$

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); WF: Wheat flour, TP: Tigernut pomace, BD: Bulk density, WAC: Water absorption capacity, SP: Swelling power, SI: Solubility index

Table 2. Pasting characteristics of wheat-tigernut pomace flour blends

WF:TP	Peak (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temp (°C)
100:0	135.9±1.98^{a}	90.2±0.21^{b}	45.8±1.77^{a}	183.7±2.53^{b}	93.6±5.44^{a}	6.03±0.14^{b}	88.4±1.70^{b}
98:2	130.0±6.40^{b}	82.2±3.50^{b}	47.7±2.90^{a}	174.6±6.68^{b}	93.0±3.11^{a}	5.07±0.05^{a}	88.6±1.20^{b}
96:4	126.6±0.00^{b}	81.2±0.00^{b}	44.9±0.00^{a}	175.7±0.00^{b}	94.5±0.00^{a}	5.87±0.00^{b}	88.8±0.00^{b}
94:6	125.8±0.71^{c}	84.6±1.10^{c}	42.3±1.77^{a}	176.7±2.61^{c}	93.1±1.66^{a}	5.90±0.00^{b}	88.8±0.34^{a}
92:8	116.8±4.0^{a}	77.1±3.20^{a}	40.0±0.71^{a}	170.9±3.30^{a}	91.0±0.00^{a}	5.80±0.10^{a}	88.9±1.20^{a}
90:10	113.6±2.01^{b}	76.7±1.20^{a}	36.0±1.77^{a}	170.0±0.50^{b}	93.0±3.11^{a}	5.83±0.50^{a}	90.0±0.00^{b}

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

Table 3. Mean score for sensory attributes of the meat pie from wheat-tigernut pomace flour blends

WF:TP	Appearance	Texture	Aroma	Colour	Mouthfeel	Overall Acceptability
100:0	7.84±0.91^{a}	7.36±0.80^{d}	6.98±1.13^{c}	7.32±0.71^{c}	7.70±0.97^{b}	7.80±0.90^{c}
98:2	7.14±1.31^{a}	6.68±1.06^{bc}	6.54±1.13^{abc}	6.80±0.97^{b}	7.12±1.14^{a}	7.42±0.95^{ab}
96:4	6.82±1.29^{a}	6.94±0.92^{c}	6.14±0.96^{ab}	6.63±1.11^{ab}	6.67±0.94^{a}	7.00±1.10^{a}
94:6	6.06±1.22^{a}	6.33±0.95^{b}	6.04±1.18^{a}	6.23±1.03^{a}	6.65±1.31^{a}	6.53±1.06^{a}
92:8	5.94±1.28^{a}	6.42±1.54^{b}	6.66±1.38^{bc}	6.30±1.31^{a}	6.54±1.88^{a}	6.52±1.82^{a}
90:10	7.46±13.2^{a}	5.80±1.55^{a}	6.56±1.54^{abc}	6.42±1.46^{ab}	6.84±1.62^{a}	6.88±1.57^{a}

Mean values with different superscripts within the same column are significantly different ($p < 0.05$); WF- Wheat flour, TP- Tigernut pomace

The higher the setback, the lower the retrogradation of the flour paste during cooling and the staling rate of the product made from the flour (Adeyemi and Idowu, 1990). The range of values of peak time observed for the blends suggests a reduction in cooking time as the tigernut pomace level increased. The pasting temperature, which provides an indication of the minimum temperature required for cooking the samples, was similar for the composite flours. Wheat flour containing the 10% tigernut pomace flour with the highest pasting temperature may indicate the presence of starch that is highly resistant to swelling during cooking. Table 3 shows the sensory attributes of the meat pie prepared from wheat-tigernut pomace blends. The appearance of the meat pie shows that the substitution with tigernut pomace at the level of 8% has the lowest appearance score, while the substitution at 100% wheat flour (control) had the highest appearance score as statistically shown. The texture of the meat pie from wheat-tigernut pomace blends ranged from 5.80 - 7.36. The meat pie prepared from 100% wheat flour had the highest score for texture, while meat pie prepared from the 10% substitution of tigernut pomace had the lowest score for texture. In terms of aroma and colour, a significant ($p < 0.05$) difference was observed in the aroma and colour sample of the meat pie prepared from wheat-tigernut pomace blends. The aroma and colour of the meat pies ranged from 6.04 to 6.98 and 6.23 to 7.32, respectively. The meat pie prepared from 100% wheat flour had the highest score for aroma and colour, while the meat pie prepared from the 6% substitution of tigernut pomace had the lowest score for aroma and colour. The mouthfeel of the meat pie ranged from 6.54 to 7.70, with the meat pie prepared from 100% wheat flour having the highest mouthfeel, while the meat pie prepared from the 8% substitution of tigernut pomace had the lowest mouthfeel score. The overall acceptability ranged from 6.52 to 7.80. The meat pie produced from 100% wheat flour was most preferred while the 10% substitution of tigernut pomace was least preferred by the panellists. Based on all the substitutions for meat pie, the addition of tigernut pomace flour was accepted. So, the addition of tigernut pomace flour up to 10% could be acceptable for meat pie production. It was generally observed that the sensory attributes of meat pie decrease with the increase in tigernut pomace flour; this could be due to the familiarity of the panellists with meat pies produced from wheat flour.

Conclusion

The study showed that blending wheat flour with tigernut pomace had a significant effect on the functional properties of the flour blends. However, tigernut pomace up to the level of 10% can be incorporated into wheat flour to produce meat pies without affecting their overall acceptability. Hence, wheat-tigernut pomace blends can be used in the production of other baked products with improved functional properties.

References

Adebowale, A.A., Sanni, L.O., Onitilo, M.O. (2008): Chemical composition and pasting properties of tapioca grit from different cassava varieties and roasting method. *Afr. J. Food Sci.* 2, 77-82.

Adejuyitan, J.A., Otunola, E.T., Akande, E.A., Bolarinwa, I.F., Oladokun, F.M. (2009): Some physicochemical properties of flour obtained from fermentation of tigernut (*Cyperus esculentus*) sourced from a market in Ogbomoso, Nigeria. *Afr. J. Food Sci.* 3, 51–5.

Ade-Omowaye, B.I.O., Akinwande, B.A., Bolorinwa, I.F., Adebiyi, A.O. (2008): Evaluation of tigernut (*Cyperus esculentus*)–wheat composite flour and bread. *Afr. J. Food Sci.* 2, 87-91.

Adeyemi, I.A., Idowu, M.A. (1990): The evaluation of pregelatinized maize flour in the development of maissa, a baked product. *Nig Food J.* 8, 63-73.

Ahmad, M., Wani, T.F, Wani, S.M., Masoodi, F.A., Gani, A. (2016): Incorporation of carrot pomace powder in wheat flour: effect on flour, dough and cookie characteristics. *J. Food Sci. Tech.* 53(10), 3715–3724. https://doi.org/10.1007/s13197-016-2345-2

Ajanaku, K.O., Ajanaku, C.O., Edobor-osoh, A., Nwinyi, O. C. (2012): Nutritive value of sorghum ogi fortified with groundnut journal seed (*Arachis hypogeal*). *Amer. J. Food Tech*. 79, 82-88. https://doi.org/10.3923/ajft.2012.82.88

Alegría, T., Farré, R. (2003): Horchata and Health: Aspects Nutritional and Dietetic. In: Valencian Foundation for Advanced Studies, Jornada Chufa and Horchata (ed), Tradition and Health Valencia, Spain. Ministry of Agriculture, Fisheries and Food, pp 55-70.

Anderson, J.W., Baird, P., Davis, R.H., Ferreri, S., Knudtson, M., Koraym A. (2009): Health benefits of dietary fibre. *Nutr. Rev.* 67, 188–205. https://doi.org/10.1111/j.1753-4887.2009.00189.x

Avula, R.Y., Singh, R.K. (2009): Functional properties of potato flour and its role in product development – A review. *Food* 3, 105-112.

Belewu, M.A., Belewu, K.Y. (2007): Comparative physicochemical evaluation of tigernut, soybean and coconut milk sources. *Int. J. Agric. Bio.* 5,785–787.https://doi.org/1560-8530/2007/09-5-785-787

Beuchat, L.R. (1977): Functional and electrophoretic characteristics of succinylated peanut flour protein. *J. Agric. Food Chem.* 25, 258 – 261. https://doi.org/10.1021/jf60210a044

Bixquert-Jimenez, M. (2003): Horchata and health, healthy properties and in deenfermedadesdigestive prevention. Valencian Studies Foundation, Ministry of Agriculture, Fisheries and Food.

Borges, O., Goncalves, B., Soeiro de Carvalho, J.L., Correia, P., Silva, A. P. (2008): Nutritional quality of chestnut (*Castanea sativa* Mill.) cultivars from Portugal. *Food Chem.* 106, 976–984. https://doi.org/10.1016/j.foodchem2007.07.011

Bosch, L., Alegeria, A., Farre, R. (2005): RP-HPLC Determination of tigernut and orgreat amino acid contents- *Food Sci. Tech. Int.* 11, 33-40. https://doi.org/10.1177/1082013205051266

Chukwuma, E.R., Obioma, N., Christopher, O.I. (2010): The phytochemical composition and some biochemical effects of Nigerian tigernut (*Cyperus esculentus* L.) tuber. *Pak. J. Nutr.* 9(7), 709–15 https://doi.org/10.3923/pjn.2010.709.715

Daramola, B., Osanyinlusi, S.A. (2006): Investigation on modification of cassava starch using active components of ginger roots (*Zingiberofficinale* Roscoe). *Afr. J. Biotechnol*. 5(10), 917-920.

Dubois, V., Breton, S., Linder, M., Fanni, J.,Parmentier, M. (2007): Fatty acid profiles of 80vegetable oils with regard to their nutritional potential. *Euro. J. Lipid Sci. Tech.* 109, 720–732. https://doi.org/10.1002/ejlt.200700040

FAO/WHO/UNU (1985): Expert Consultation Energy and Protein Requirements. World Health Organization, Geneva.

Ike, C.C., Emeka-Ike, P.C., Nwokorie, C.C., Anochie, C.C (2015): Microbiological quality evaluation of locally prepared snacks sold in Aba metropolis, Abia State, Nigeria. *Int. J. Sci. Engr. Appl. Sci. (IJSEAS)* 1(7): 2395-3470.

Iwe, M.O. (2002): Hand Book of Sensory Methods and Analysis. Rojoint Communication Publishers Ltd. Enugu.

Kohajdová, Z. and Karovicová, J. (2008): Influence of hydrocolloids on quality of baked goods. *Acta Sci. Polono. Tech. Aliment* 7(2), 43-49.

Moorthy, S.N., Ramanujan, T. (1986): Variation in properties of starch in Cassava varieties in relation to age of the crop. *Starch/Stärke* 38(2), 58-61.

Odoemelan, S.A. (2003): Chemical composition and functional properties of conophor nut flour. (*Tetracarpidium conophorum*) flour. *Int. J. Food Sci. Tech.* 38(6), 729-734. https://doi.org/10.1046/j.1365-2621.2003.00725.x

Oke, E.K., Idowu, M.A., Sobukola O.P., Bakare, H.A. (2017): Quality attributes and storage stability of bread from wheat–tigernut composite flour. *J. Cul. Sci. Tech.* https://doi.org/10.1080/15428052.2017.1404537

Oladele, A.K., Aina, J.O. (2007): Chemical composition and functional properties of flour produced from two varieties of tigernut (*Cyperus esculentus*). *Afr. J. Biotechnol.* 6 (21), 2473-2476.

Omueti, O., Otegbayo, B., Jaiyeola, O., Afolabi, O. (2009): Functional properties of complementary diets developed from soybean (*Glycine max*), groundnut (*Arachis hypogeal*) and crayfish (*macrobrachium spp*). *Electron J. Environ. Agric. Food Chem.* 8 (8), 563-573.

Onweluzo, J.C., Nnamuchi, O.M. (2009): Production and evaluation of porridge type breakfast product *Trecuilaafricana*and sorghum bicolour flours. *Pak. J. Nutr.* 8, 731-736. https://doi.org/10.3923/pjn.2009.731.736

Sanchez-Zapata, E., Fernandez-Lopez, J., Perez-Alvarez, J.A. (2012): Tiger nut (*Cyperus* *esculentus*) commercialization: Health aspects, composition, properties, and food applications. *Comprehen. Rev. Food Sci. Food Safety* 11, 366-372. https://doi.org/10.1111/j.1541-4337.2012.00190.x

Takashi, S., Seibel, P.A, (1988): Paste and gel properties of prime corn and wheat starches with and without native lipids. *J. Cereal Chem.* 65, 474–480.

Wang, J.C., Kinsella, J.E. (1976): Functional properties of novel proteins: alfalfa leaf Protein. *J. Food Sci*. 41(2), 286-292. https://doi.org/10.1111/j.1365-2621.1976.tb00602.x

Yeboah S.O., Mitei Y.C., Ngila, J.C., Wessjohann, L., Schmidt, J. (2011):Compositional and structural studies of the oils from two edible seeds: Tiger nut, *Cyperusesculentum*, and asiato, *Pachira insignis*, from Ghana. *Food Res. Int.* 47, 259–266. https://doi.org/10.1016/j.foodres.2011.06.036