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Proximate composition, physical and sensory properties of biscuits produced from blends of maize (*Zea mays*) and tigernut (*Cyperus esculentus*) flour

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Physical, proximate and sensory properties of biscuits produced from different blends of maize and tigernut flour were evaluated. The blends (Maize flour: Tigernut flour) were: A - 100:0; B - 90:10; C - 80:20; D - 70:30; E - 60:40; F - 50:50. Diameter, height, weight, spread ration, bulk density and dispersibility of the maize-tigernut biscuits ranged from 4.00 – 4.05cm, 0.30 – 0.60cm, 16.42 - 20.99g, 6.66 – 10.05, 0.61 - 0.65g/ml and 75 – 78% respectively. Moisture, protein, fat, crude fibre, ash and carbohydrate respectively, were 3.70 - 4.60%, 3.94 - 11.72%, 21.17 - 24.17%, 1.21 - 2.32%, 2.03 - 3.38% and 55.52 - 66.27%. Energy varied from 471.37 – 497.21 Kcal/100g. Sample E with 40% tigernut flour was significantly (P≤0.05) the highest in protein and least in carbohydrate. There was slight to moderate degree of likeness for the sensory attributes (aroma, appearance, colour, crispness, flavour, mouthfeel, texture and overall acceptability) of the biscuits with the aroma, colour, flavor and mouthfeel of sample E significantly (P≤0.05) the greatest. Substitution of up to 40% oftigernut flour could form a basis for preference in the production of maize-tigernut biscuits. This will serve as a means of value addition to tigernut a less utilized tuber.

Key words: Tigernut flour, maize flour, biscuits, proximate composition, physical and sensory properties.

INTRODUCTION

Biscuits are a ready-to-eat, cheap and convenient food product that is consumed among all age groups in many countries (Hussein et al., 2006). They are an important baked product in the human diet, which are usually consumed with a beverage and are also used as weaning foods for infants (Abu-Salem and Abou-Arab, 2011). Biscuits are a good source of protein and minerals, but are mainly classified as energy giving food been a rich source of fat and carbohydrate (Kure et al., 1998). Biscuits, soda breads and corn bread among others are often referred to as quick breads indicating that they do not need time to rise before baking (Rombauer et al., 2006). To distinguish biscuits from bread, biscuits are made with a leavening agent rather than yeast. The main ingredients for biscuit production include wheat flour, water, sugar, fat and eggs, shortening, salt, baking powder, milk, and flavouring agents (Javaid et al., 2009; Adebowale et al., 2012; Musa and Lawal, 2013). They can be prepared for baking in several ways; the dough can be rolled out flat and cut into rounds, which expand when baked. Biscuits and other pastry products are common products of soft wheat flour (Ikuomola et al., 2017). The use of imported wheat that is cultivated in the tropical region makes biscuit production expensive (Olaoye et al., 2006). Hence the advocate for the use of composite flour in which flour from locally available tubers, cereals and legumes replace wheat flour. Some of which include potatoes, cassava, sorghum, maize, pearl millet, plantain, acha grain, bambara-nuts etc. Due to the increased rate of biscuits consumption and other baked products in most countries, the composite flour programme promises to save a significant amount of foreign exchange, provide traditional nutritious food to more people at a lower cost and to utilize indigenous crops to a greater extent.

Tiger-nut (*Cyperus esculentus*) also called sedge, chufa, earth-almond, nutgrass and nutsedge is a crop of the sedge family widespread across much of the world (Akajiaku et al., 2018). It is a root crop which grows widely in wet places as grass and is sometimes cultivated

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for its small and sweet tubers. There are three varieties namely black, brown and yellow, among these only two varieties (the yellow and brown) are readily available in the market, and the yellow variety is preferred because of its inherent properties of bigger size, attractive colour and fleshier nature (Gambo and Da'u, 2014). In Nigeria, tigernut is known as 'Aya' in Hausa, 'Ofio' in Yoruba, and 'Ahiausa' in Igbo where these varieties (black, brown and yellow) are cultivated (Umerie et al., 1997). Tigernut produces high-quality oil protein (Adejuyitan, 2011), and an excellent source of some useful minerals (iron, calcium phosphorus, potassium, sodium, magnesium, zinc and traces of copper) and vitamin E that are essential for body growth and development (Oaldale and Aina, 2007). It is said to be aphrodisiac, carminative, diuretic, emmanogogue stimulant and tonic and also plays a role in the treatment of flatulence, indigestion, diarrhea, dysentery and excessive thirst (Adejuyitan, 2011). Tigernut can be eaten raw as a snack or crushed with the resulting white paste made into porridge or processed into refreshing beverage drinks (Akajiaku et al., 2018). It can also be processed into flour. The chemical composition and functional properties of flour produced from the brown and yellow varieties of tigernut (*Cyperus esculentus*) have been studied (Oladele and Aina, 2007) which could provide a useful application in food formulation. The inclusion of 33.33% of tigernut in the diet of cockerel status was reported by (Bamgbose et al. 2003). The flour is gluten-free and also considered a good flour for the bakery industry as its natural sugar content is really high, avoiding the necessity of adding too much of extra sugar providing a good option for diabetics (Belewu and Abodunrin, 2006).

Maize (*Zea-mays*) flour which is obtained from the grains of maize plant is the second most produced and consumed flour after wheat flour. It is uniquely rich in dietary fibre, protein, vitamin B6, magnesium and omega 6 oils, vital for good heart, optional bowel functions and fight against infections. It is relatively less expensive to buy and can be used to prepare different food products like the cornmeal, bread, pancake etc. Fortified maize flour has been used in the eradication of malnutrition in some parts of the world (Lance et al. 2002). Vitamin B-complex such as B1 (thiamine), B2 (niacin), B3 (riboflavin), B5 (pantothenic acid) and B6 that makes it commendable for hair, skin, digestion, heart and brain. It contains vitamin C, A and K together with a large amount of beta-carotene and a fair amount of selenium that helps to improve thyroid gland and play important role in the proper functioning of the immune system (Rai et al., 2017). Maize is highly rich in carbohydrates and releases energy slowly in the bloodstream ensuring that you stay energized whole day. It is a potent antioxidant that guards the body against harm by free radicals responsible for cellular damage and/or cancer (Rai et al., 2017).

The inherent nutritional and therapeutic advantage of tiger nut and maize flour can make them serve as a good substitute in the bakery industry. With the progressive increase in the consumption of biscuits and other baked products, the use of maize-tigernut flour will help conserve foreign exchange and will provide nutritious food for the people at affordable cost and broaden the utilization of indigenous crops in food formulation. This study, therefore, focused on the production of biscuits from different blends of maize andtigernut flour and the evaluation of the proximate, physicochemical and sensory properties of the produced biscuits.

MATERIALS AND METHODS

Tigernut tubers, maize grains and other ingredients

Fresh tigernut (*C. esculentus*) tubers and maize (*Z. mays*) were purchased from Mile III market in Diobu Port Harcourt as well as the other ingredients: baking powder, salt, sugar, margarine, milk, nutmeg, eggs and flavour that made up the recipe.

Preparation oftigernut and maize flour

Tigernut flour was obtained using the method by Oladele and Aina, (2007). Briefly, thetigernut s were sorted and selected to remove damaged samples, carefully washed to remove sand from the skin, drained, oven-dried at 60^oC for 24 h and then milled. Fine flour was obtained by sieving through a 250 mm laboratory test sieve. For the maize flour, the grains after sorting to remove foreign matters and broken grains were winnowed, milled into flour using attrition mill (Globe P44 Shanghai China), and sieved using 250 mm laboratory test sieve to obtain fine flour. The flours were packaged in well-labelled airtight plastic containers and stored in a refrigerator until required for use.

Preparation of composite flour and the recipe for maize-tigernut biscuit production

The composite flour used for the baking of the biscuits was prepared by substituting different blends oftigernut flour to maize flour in the ratio shown in Table 1. To obtained a homogenous flour, the different combinations were individually homogenized in a rotary mixer (Philips, type HR 1500/A, Holland), and then stored in airtight plastic containers and preserved in a refrigerator until required for analyses. The recipe for the biscuit production is presented in Table 2.

Preparation of the maize-tigernut biscuits

Biscuit was produced following the method by Giwa et al. (2010). Briefly, the various maize-tigernut flour blends were mixed separately with the same quantity of other

Table1. Blend of maize and tigernut flour used for the production of the maize-tigernut biscuit.

Sample ID	A	B	C	D	E	F
Blend (MF:TF)	100:0	90:10	80:20	70:30	60:40	50:50

MF =Maize flour
TF = Tigernut flour

Table 2. Recipe for the maize-tigernut biscuit preparation.

Ingredients	Quantities
Margarine (g)	50
Flour (g)	100
Nutmeg	1
Sugar (g)	30
Baking powder (g)	1
Milk powder (g)	5
Salt (g)	0.10
Egg	1 medium size
Flavour	2 teaspoons

[4] Modified from Victor et al. (1995)

ingredients (sugar, baking powder, water, baking fat and salt). The fat was creamed with sugar until fluffy, the other dry ingredients were added, and water was added until the desired texture of the batter was obtained. The batter was kneaded on a rolling table to acquire the desired thickness. The batter was later cut to round shape with the aid of biscuit cutter. This was placed on a lightly greased oven pan and baked in the oven at 200^{o}C for10 mins, cooled and packaged

Determination of the physical properties of the maize-tigernut biscuits

The produced biscuits were examined for spread ratio, dispersibility and bulk density. The height, weight and diameter of the cookies were measured and the Spread Ratio calculated by dividing the diameter of the cookies by the height (Giami and Barber, 2004).

Dispersibility was measured according to the method by Kulkarni et al. (1991). Briefly, to 10 g of the sample in a 100 ml measuring cylinder was added distilled water and made up to mark. After vigorous stirring, the content of the cylinder was allowed to settle for 3 h. Dispersibility was given as the difference of the settled sediment from 100 ml.

Bulk density was obtained following the method of Jones et al. (2000). The volume of 100 g of the flour was measured in a measuring cylinder (250 ml), the bottom of measuring cylinder was gently tapped on the laboratory table several times until there was no further diminution of the sample level. Bulk density was calculated based on weight and volume.

Proximate composition of the tigernut-maize flour biscuit

Standard AOAC (2006) methods were used in evaluating the proximate composition. Moisture content was calculated after drying at 105^{o}C to constant weight in an air oven (Thermo Scientific-UT 6200, Germany). Protein was determined by the Kjeldahl method. Fat was estimated by exhaustive extraction of a known weight of samples with petroleum ether using rapid Soxhlet extraction apparatus (Gerhardt Soxtherm SE- 416, Germany). The gravimetric method was used in ash determination after incineration in a muffle furnace (Carbolite AAF-11/18, UK) for 24 h at 550^{o}C. The crude fibre was obtained by the difference after the incineration of the ash-less filter paper containing the insoluble materials from the hydrolysis and washing of moisture-free defatted sample (0.5 g). Carbohydrate content was obtained by the difference: 100 - (MC + Ash + Crude protein + Fat + Crude fibre). Atwater factor of 4.0 Kcal/g for protein and carbohydrate and 9 Kcal/g for fat was used in calculating the energy content (Kcal/100g) of the biscuits

Sensory analysis

Sensory attributes (aroma, appearance, colour, crispness, flavour, mouthfeel, texture and overall acceptability) was performed using the 9-point hedonic

Table 3. Physical properties of biscuits made from different blend of maize – tigernut flour.

Sample identity	Blend (MF:TF)	Diameter (cm)*	Height (cm)	Weight (g)	Spread Ratio	Bulk density (g/ml) *	Dispersibility (%) *
A	100:0	4.00±0.01	0.40±0.01[c]	16.42±0.01[c]	10.00±0.01[b]	0.61±0.01	78.00±0.05
B	90:10	4.00±0.00	0.60±0.03[a]	16.95±0.02[c]	6.66±0.03[d]	0.63±0.02	77.00±0.05
C	80:20	4.03±0.01	0.50±0.02[b]	19.62±0.15[b]	8.06±0.02[c]	0.61±0.15	76.00±0.10
D	70:30	4.01±0.01	0.40±0.02[c]	19.72±0.01[b]	10.03±0.02[b]	0.65±0.01	77.00±0.11
E	60:40	4.05±0.02	0.30±0.03[d]	20.99±0.02[a]	13.50±0.03[a]	0.60±0.02	75.00±0.09
F	50:50	4.02±0.01	0.40±0.11[c]	16.51±3.18[c]	10.05±0.11[b]	0.65±0.01	77.00±0.10

Values are means ± standard deviation of duplicate determinations.
Means with the same superscript in the same column do not differ significantly(P≤0.05)
*No significant differences in the means
MF - Maize flour, TF - Tigernut flour

scale by a panel of 20 assessors consisting of staff and students from the university community. The degree of likeness of the product attribute was expressed as 1 – dislike extremely, 2 – dislike very much, 3 – dislike moderately, 4 – dislike slightly 5 – nether like or dislike, 6 – like slightly 7 – like moderately, 8 – like very much, 9 – like extremely.

STATISTICAL ANALYSIS

Data were analyzed statistically by analysis of variance and difference between means separated using the Least Significance Difference (LSD) procedure. The non-parametric Friedman test and 2-sample t-test were employed in determining the statistical differences at (P ≤ 0.05) among the product sensory attributes.

RESULTS AND DISCUSSION

Physical properties of the maize-tigernut biscuits

The diameter, height, weight, spread ration, bulk density and dispersibility of the maize-tigernut biscuits are shown in Table 3. There was no significant difference (P≤0.05) in the diameter of the biscuits which was between 4.00 – 4.05 cm. This is an indication of the uniform extensibility of the maize-tigernut biscuit dough and the even thermal expansibility during baking. The height of the biscuits varied significantly (P≤0.05) from 0.30 – 0.60 cm for sample E (with 40% tigernut flour) and B (with 10% tigernut flour) respectively. The trend was that of decrease with increase in substitution of the tigernut. Spread ratio of the biscuit varied significantly (P≤0.05) from 6.66 – 10.05 for samples with 10 and 50% of tigernut flour (Sample B and F) respectively. The spread ratio increased significantly (P≤0.05) with an increase intigernut flour. Higher spread ratio is desirable as reductions are attributed to the hydrophilic nature of flours (Okpala et al., 2013). Dispersibility which is the ease of reconstitution of the maize-tiger nut flour blends in water did not vary significantly (P≤0.05). The values ranged from 75% for sample E with 40%tigernut flour to 78% for sample A without tigernut flour. These were similar to the report of Adebowale et al., (2012).

Proximate composition of the maize-tigernut biscuits

The proximate composition of the biscuits made from different blends of Maize and tigernut flour are shown in Table 4. The moisture content of the biscuit samples varied significantly (P ≤ 0.5) from 3.70 – 4.60%. Sample D with 30% of tigernut flour had significantly (P ≤ 0.5) the least moisture content. The variation in moisture content can be attributed to environmental and experimental factors (Obasi et al., 2012). The moisture content of this maize-tiger nut biscuits is lower than the moisture content of some commercial biscuits sold in Nigeria (Musa and Lawal, 2013). The low moisture content is desirable for the prevention of microbial activities and extension of the shelf-life of the biscuits if protected from absorbing moisture through proper packaging.

The protein content ranged from 3.94% for Sample A (100% maize flour) to 11.72% for sample E (with 40%tigernut flour). The protein values of the maize-tigernut biscuits were similar to those of commercially available biscuits in Nigeria (Musa and Lawal, 2013) and significantly (P≤0.05) higher than the protein content of Bambara and acha based biscuits reported by Ayo and Andrew, (2016). The biscuit from the 100% maize flour had the least protein content, the addition of tigernut resulted in significant (P≤0.05) increase in protein content of the biscuits. Maize is limiting in lysine and tryptophan, while the yellow variety oftigernut has been reported to be rich in protein (7.15%) and contain 6.50 mg/16g N of lysine (Oladele and Aina, 2007; *Shaker* et al*.,* 2009), this can complement the maize protein.

Fat content increased with increase in tigernut flour substitution. Sample A (100% maize flour) had significantly (P ≤ 0.5) the least fat content of 21.70% and sample F (with 50% tigernut flour) had significantly (P≤0.05) the highest fat content of 24.85%. The fat content could be a function of the butter used in biscuit

Table 4. Proximate composition (%) of biscuits made from different blend of maize – tigernut flour.

Sample identity	Blend MF:TF	Moisture	Protein	Fat	Crude fibre	Ash	Carbohydrate	Energy (Kcal/100g)
A	100:00	4.10±0.14[b]	3.94±0.18[d]	21.17±1.34[c]	2.32±1.41[a]	2.20±0.07[c]	66.27±0.38[a]	471.37±2.04[c]
B	90:10	4.30±0.28[b]	10.66±0.14[b]	23.15±2.77[b]	1.54±0.31[bc]	2.03±0.04[c]	58.32±2.07[c]	484.27±1.06[b]
C	80:20	4.20±0.14[b]	9.25±0.00[c]	23.21±0.83[b]	1.21±1.71[c]	2.20±0.07[c]	59.93±0.89[b]	485.61±0.76[ab]
D	70:30	3.70±0.28[c]	10.53±0.33[b]	23.35±0.91[ab]	1.67±0.33[b]	2.15±0.00[c]	58.60±0.55[c]	486.67±0.75[a]
E	60:40	4.60±0.07[a]	11.72±0.75[a]	24.17±2.05[a]	1.48±0.37[bc]	2.51±0.79[b]	55.52±3.30[e]	486.49±1.20[a]
F	50:50	4.60±0.28[a]	11.22±0.31[a]	24.85±2.53[a]	1.78±0.65[ab]	3.38±2.09[a]	57.18±0.79[d]	497.21±2.04[c]

Values are means ± standard deviation of duplicate determinations.
Means with the same superscript in the same column do not differ significantly (P≤0.05)
*No significant differences in the means
MF - Maize flour, TF - Tigernut flour

production. and it was significantly (P≤0.05) higher than some commercially available biscuits in Nigeria (Musa and Lawal, 2013). High-fat content can create the challenge of rancidity during storage, although fat facilitates absorption of fat-soluble vitamins, provides essential fatty acids and important volatile compounds for flavor and sensory qualities (FAO 2001; Musa and Lawal, 2013).

The ash content of the maize-tigernut biscuits was between 2.03% for sample B (with 10% tigernut flour) and 3.38% for F (with 50% tigernut flour). These values were similar to the ash content of Bambara and acha based biscuits (Ayo and Andrew, 2016) but significantly (P≤0.05) lower than some commercially available biscuits in Nigeria (Musa and Lawal, 2013). Ash is the inorganic residue after the incineration of organic matter hence an index of mineral availability.

The crude fibre content varied significantly (P≤0.05) from 1.21 - 2.32% for sample C (with 30%tigernut flour) and sample A (100% maize flour) respectively. The values were comparable with those of wheat-maize biscuits (Giwa and Abiodun, 2010). Crude fibre composition is a measure of the quality of indigestible cellulose, pentose, lignin and other components of this type present in food (Akajiaku et al. 2018). Crude fibre has little food value but it plays a role in the increased utilization of nitrogen and absorption of some other micronutrients and provides bulk necessary for peristaltic action in the intestinal tract.

The carbohydrate content of the samples varied significantly (P≤0.5) from 55.52 - 66.27%. Sample A (100% maize flour) had significantly (P≤0.5) the highest carbohydrate content of while Sample E with 40% tigernut flour was significantly (P≤0.05) the least. The carbohydrate content of the maize-tigernut biscuit is similar to some of the commercially available biscuits in Nigeria (Musa and Lawal, 2013) and significantly (P≤0.05) lower than the carbohydrate content of Bambara and acha based biscuits (Ayo and Andrew, 2016) and wheat-maize biscuits (Giwa and Abiodun, 2010). This may be attributed to the raw materials used, as maize is mostly a carbohydrate food with 66.27% of carbohydrate as evidenced in this study and the yellow variety of tigernut has been reported to have carbohydrate content of 46.99% (Oladele and Aina, 2007). The energy content of the biscuit varied from 471.37 – 497.21 Kcal/100g for sample A (100% maize flour) and F (with 50% tigernut flour) respectively. The variation could be attributed to variation in fat contents of the samples. These values were significantly (P≤0.05) higher than those of wheat-maize biscuits (Giwa and Abiodun, 2010)

Sensory evaluation

Shown in Figure 1 are some examples of the maize-tigernut biscuit that were evaluated while the sensory attributes of the biscuits are presented in Figure 2. Sample C (with 20% tigernut flour) and E (with 40% tigernut flour) respectively, had significantly (P≤0.05) the least and highest likeness for aroma (6.40 - 7.15), colour (6.30 - 7.10), flavor (5.95 - 7.10) and mouthfeel (5.65 – 7.25). The degree of likeness for appearance varied from 5.90 - 7.50 for sample A (100% maize flour) and F (with 50% tigernut flour). There was no significant (P≤0.05) difference in the texture (6.15 – 6.50), crispiness (6.20 - 6.75), and overall acceptability (6.75 – 7.25) of the biscuit samples. On a 9-point hedonic scale, the ratings that are ≥ 6 but ≤ 7 signified that the assessors had slight to moderate likeness for the sensory attributes while ratings that are ≥ 5 but ≤ 6 signified indifferences in the likeness of the attributes. The biscuit samples were acceptable to the assessors and the likeness for aroma, colour, flavor and mouthfeel for sample E with 40% tigernut flour substitution was significantly (P≤0.05) the greatest. Substitution of up to 40% of tigernut flour to maize was

Figure 1. Examples of the biscuits made from different blends of maize and tigernut flour.

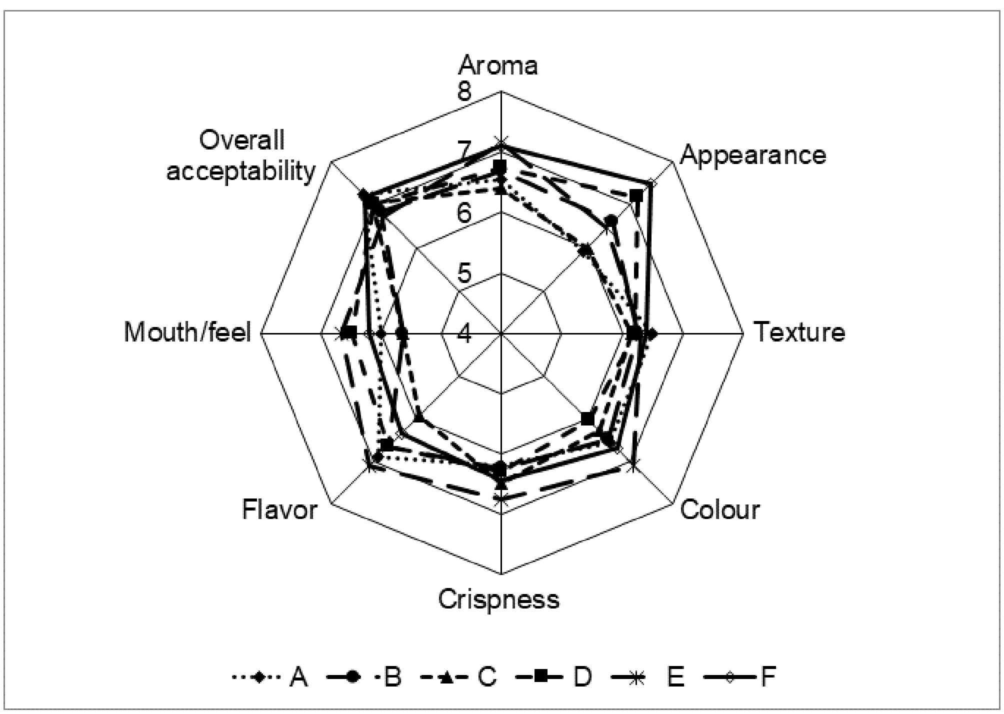

Figure 2. Sensory properties of biscuit made from different blends of maize-tiger nut flour Blend (Maize flour : Tigernut flour); A - 100:0; B - 90:10; C - 80:20; D - 70:30; E - 60:40; F - 50:50

more acceptable to the assessors and could form the basis for preference in the production of maize-tigernut biscuits. This will serve as a value addition to this less utilized tuber.

CONCLUSION

The study revealed that acceptable and good quality biscuits can be produced from the different substitution of tigernut flour to maize flour. The physical parameters (diameter, height, spread ratio and dispersibility) and the proximate composition of the maize-tigernut biscuits were comparable with some commercially available biscuits in Nigeria. Sample E with 40% tigernut flour had significantly (P≤0.05) the highest amount of protein and the least amount of carbohydrate. There was slight to moderate degree of likeness for the sensory attributes of the biscuits with the aroma, colour, flavor and mouthfeel of sample E significantly (P≤0.05) the greatest. Substitution of up to 40% of tigernut flour to maize could form the basis for preference in the production of maize-tigernut biscuits, as a means of value addition to this less utilized tuber

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