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QUALITY EVALUATION AND SENSORY PROPERTIES OF *AGIDI* PRODUCED FROM BLENDS OF MAIZE (*ZEA MAYS*) AND PIGEON PEA (*CAJANUS CAJAN*)

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ABSTRACT

Agidi is a traditional fermented starchy food which is smooth-textured, semi-solid (gel-like) with creamy glassy white color cooked from wet-milled and wet-sieved maize paste. It is rich in carbohydrate but low in protein resulting in protein-energy malnutrition. Pigeon pea is a legume with rich source of protein (20-24%), essential amino acids (Lysine, methionine, tryptophan) and fibers. It has remarkable nutritional profile and health benefits. It is an underutilized crop from the family of Leguminosae (*Fabaceae*) and a good alternative for improving the protein content and nutritional value of carbohydrate dense food products. The influence of 25 %pigeon pea substitution with maize in the processing of 'agidi' was studied producing five samples coded A (100% Maize (control), B (75% Maize and 25% Pigeon pea), C (50% Maize and 50% pigeon pea), D (25%Maize and 75% Pigeon pea), E (100% Pigeon pea) and analyzing the nutritional quality and sensory properties in order to further exploit the functionality and acceptability of 'agidi'. Comparing control (100% maize) and sample E (100 % pigeon pea), significant ($p<0.05$) differences were observed in terms of the nutritional quality. Sample E has a smaller values of moisture (9.55 %), viscosity (150 Cps,) with a higher protein content (19.50 %), calcium (212.50 mg/100g), potassium (285.50 mg/100g), Iron (1.16 mg/100g), saponin (0.207 mg/g), a slightly decreased sour taste, flavor and mouth-feel intensity with the addition of pigeon pea, and with an important nutritional intake (ash: 0.75%, protein: 19.50%, crude fiber: 13.70%). Hence, combining pigeon pea with maize in the processing of 'agidi' at the substitution level up to 25% did not vary much from the control (100% maize) and was highly accepted by the consumers.

1. Introduction

Malnutrition is a medical and a social disorder often as a result of poverty and ignorance. Factors that contribute to malnutrition and poor nutrition outcomes are mainly due to production and consumption pattern. In Nigeria, the underlying causes of malnutrition include poverty, inadequate food production, inadequate food intake and improper combination of available indigenous foods due to ignorance. One of the fundamental ways of ensuring food security entail developing and improving food preparation, processing and preservation technologies (Oguche *et al.*, 2017).

In underdeveloped country like Nigeria cereals are the major staples consumed. Cereals are good source of digestible starch, non-starch polysaccharides and second–class protein due to their deficiency in essential amino acids - lysine and tryptophan (Stadimayr *et al*., 2012). In Nigeria maize is mostly used in the production of *agidi*. This product has different names in different localities such as *eko* (Yoruba), *akasan* (Benin), *komu* (Hausa) and *agidi* (Igbo).

*Agidi*is a traditional fermented starchy food which is smooth-textured, semi-solid (gell-like) with creamy glassy white colour cooked from wet-milled and wet-sieved maize paste (Kolawole *et al*., 2020). It is rich in carbohydrate but low in protein resulting in protein-energy malnutrition (Stadimayr *et al.*, 2012). It is usually consumed by infants and adults with stew, vegetables, bean cake or bean pudding or with spices and seasonings added to improve its taste while rich ones may contain minced meat (Akpapunam *et al.*, 2019).

Pigeon pea is a legume with rich source of protein (20-24%), essential amino acids (Lysine, methionine, tryptophan) and fibres. It has remarkable nutritional profile and health benefits. It is an underutilized crop from the family of Leguminosae (*Fabaceae*) and a good alternative for improving the protein content and nutritional value of carbohydrate based food products.

Pigeon pea gives similar maize slurry texture adequate for *agidi* purpose and therefore pigeon pea can be used to improve the protein content and other nutritional values in *agidi*. It can also be used instead of maize in the production of *agidi* since it also contains some appreciable amount of carbohydrate and some starch granules which are required for the formation of a semi solid gel like texture product like *agidi*.

A good number of researches has been conducted on fortification of *agidi* using soy bean flour but no research work has been carried out with pigeon pea in *agid*i production.

This study is aimed at production and evaluation of *agidi* from maize, blends of maize and pigeon pea and pigeon pea only.

2.Materials and methods

2.1. Materials

The raw materials include the following: Maize (*Zea mays*), Pigeon pea (*anus cajan*), Water and Uma leaves (*Thaumatococcusdaniellii*). All the raw materials were procured from Ogige market (a local market in Nsukka, Enugu State).

2.2.1. Samples

Sample Blends: 100:00, 75:25, 50:50, 25:75 and 00:100 for maize and pigeon pea respectively.

2.2.2. Preparation of Agidi samples

The *agidi* samples were prepared following the method of Nkama *et al.* (2000). Maize grains and pigeon pea seeds were cleaned to remove stones, dirt, and other foreign bodies that may affect the quality of the final product. Two kilograms (2kg) each of the cleaned grains were steeped in 4000ml of clean tap water in a stainless bowl for 48 hours at room temperature. The soaking water being replaced at 12 hours intervals. The fermented grains were rinsed with clean water and wet-milled in attrition machine. The milled paste was wet sieved using a double clean muslin cloth and residue discarded. The filtrate was allowed to sediment for 24 hours during which fermentation set in. It was decanted and a fine slurry was obtained. The slurry (500 ml) was cooked with water (750 ml) at 80 ºC for 30 minutes while stirring continuously until a thick gel like structure is formed. It is then packaged hot in 'Uma' leaves or a polyethylene bag and allowed to solidify taking the shape of the packaging material used. It cooled, for 30minutes and stored in refrigerator for further analysis (Ogeihor *et al*., 2005)

2.2.3. Proximate Analysis

The proximate analysis (moisture, ash, protein, fat, fibreand carbohydrate) of the agidi samples were determined using the official method of analysis of the Association of Official Analytical chemist (AOAC, 2010). Energy was calculated using Atwater conversion factor (fat × 9 + carbohydrate × 4 + protein × 4 kcal/100g)

2.2.4. Mineral Content

Calcium, Potassium and Iron Analysis were determined according to AOAC (2010)

2.2.5. Physical Analysis of the slurry and agidi

The pH was determined using a pH meter as described by AOAC (2010).

2.2.6. *Determination of Titratable Acidity*

The titratable acidity was determined using the method described by AOAC (2010). Ten (10ml) of each sample blend slurry was pipetted into a conical flask and 25ml of distilled water was added. Two milliliter (200ml) of 0.1M NaOH was poured into a burette and titrated against the sample in the flask using 3 drops of phenolphthalein as indicator. It was titrated until a pink colouration was observed and the corresponding burette reading taken in the equation below:

Titratable acidity (g/100g) = Titre value × M × 90 × 100

Volume of the sample × 100

Where M = Molar concentration of NaOH.

2.2.7. Determination of Viscosity

The viscosity of the slurry was determined using the method described by Bolaji*et al.* (2014). The viscosity of different blend slurry samples were measured in duplicate at ambient temperature using a digital rotational Brookfield viscometer. Their reading was taken after 1 min rotation at speed (100rpm). Spindle number #6 was used for all the measurement. A 100ml beaker was used for the measurement with the viscometer guard leg on. The samples were poured into the beaker to reach a level that covers the immersion groove on the spindle shaft. All viscosity measurements were carried out immediately on blend slurry.

2.2.8. Texture Determination

The texture of the *agidi* sample blends were determined using a universal penetrometer as described by Rosenthal (2015). The weighted cone of the penetrometer was allowed to come in contact with the food material thereby penetrating its surface under its own weight. The distance that it penetrates was then recorded.

2.2.9. Phytochemical Properties (Tannin, Phytate and Saponin) Determination

The tannin content was determined by Folin-Denis calorimetric method described by AOAC (2010). The phytate content was determined by the method described by AOAC (2010) and saponin content was determined by Brunner (1984).

2.2.10. Sensory Evaluation

Sensory evaluation was carried out on the samples using 20 panelists (semi trained consumers) to test on the sensory attributes of the *agidi* from blends of maize and pigeon pea. The panelists were asked to indicate their preference using a 9-point Hedonic scale for colour, taste, mouthfeel, aftertaste, flavour, texture, firmness, smoothness, consistency, appearance and overall acceptability. This was used to determine the sensory acceptability of the sample (Iwe, 2002).

2.2.11. Statistical Analysis and Experimental Design

Data obtained was subjected to one-way analysis of variance (ANOVA) using completely randomized design. Means were separated using Duncan's new multiple range test (DNMRT). Significance was accepted at ($p< 0.05$) as described by Steel and Torrie (1980).

3. Results and discussions

3.1. Proximate composition and energy value of *Agidi*

The proximate composition and energy value of *agidi* samples were presented in Table 1. The moisture content increased with the substitution of 25% maize with pigeon pea to give moisture content of 14.05 % in sample B. Further addition of the pigeon pea in samples C, D and E led to decrease in the moisture contents to 13.70, 10.15 and 9.55 % respectively. Similar decrease in moisture content values was reported by Oguche *et al*. (2017) on soy-fortified *agidi* with moisture content of 9.26 % for 100% maize *agidi* and 8.83 – 8.65 % for the soy-fortified *agidi*. High moisture content of *agidi* is due to its processing method involving soaking and cooking. From the result the moisture content of *agidi* samples predispose them to rapid spoilage as moisture content is an important factor in determining the shelf-life of foods. (Oguche *et al*., 2017). Hence the need for quick consumption of *agidi* as soon as possible (Kolawole *et al*., 2020).

Protein content ranged from 8.755 to 19.50 % with sample E (100% pigeon pea) having the highest ($p<0.05$) protein content (19.50 %) and the control (100% maize) had the least protein content (8.75%) which increased subsequently with the addition of pigeon pea. Conversely, the carbohydrate content of the *agidi* blends decreased considerably from 68 % in the control (100% maize) to 68, 60.25, 57.75, 60.25 and 55.30 % for B, C, D and E respectively due to the addition of pigeon pea.The increase in protein, content of the *agidi* samples was due to the high level of protein, in pigeon pea. Pigeon pea is a legume known for its rich protein value and is incorporated into cereal products to improve their protein quality (Obizoba and Oganah, 2008). This shows the superior nutritional properties of pigeon pea over maize for the production of *agidi* and also their mutual supplementation effect. This increase in the protein value compared favorably with the report by Ikya *et al*., 2013).

A little increase in protein content made micro-structure become more homogenous and had reduced moisture loss, but continuous addition of protein weakens the structure and water vapour permeability is increased (Basiak *et al*., 2016). The ash, crude fibre and fat contents of the *agidi* ranged from (0.27 - 0.75 %), (10.20 - 13.70 %) and (0.65 - 1.20 %) respectively. This increase with addition of pigeon pea is due to the fact that pigeon pea is a rich source of fibre and minerals (Staughton, 2020).

Table 1. Proximate composition and energy value of *Agidi* samples from blends of maize and pigeon

Proximate Parameters	A	B	C	D	E
Moisture %)	$11.34^{b}\pm0.21$	$14.05^{a}\pm0.21$	$13.70^{a}\pm0.28$	$10.15^{c}\pm0.21$	$9.55^{d}\pm0.07$
Ash (%)	$0.25^{c}\pm0.07$	$0.35^{bc}\pm0.07$	$0.35^{bc}\pm0.07$	$0.45^{b}\pm0.07$	$0.75^{a}\pm0.07$
Crude Fibre (%)	$10.20^{d}\pm0.14$	$10.60^{d}\pm0.14$	$11.50^{c}\pm0.14$	$12.35^{b}\pm0.21$	$13.70^{a}\pm0.14$
Fat (%)	$0.65^{d}\pm0.07$	$0.75^{cd}\pm0.07$	$0.95^{bc}\pm0.07$	$1.05^{ab}\pm0.07$	$1.20^{a}\pm0.14$
Crude Protein (%)	$8.75^{b}\pm2.47$	$14.00^{ab}\pm0.00$	$15.75^{a}\pm2.47$	$15.75^{a}\pm2.47$	$19.50^{a}\pm2.82$
Carbohydrate (%)	$68.80^{a}\pm2.86$	$60.25^{b}\pm0.21$	$57.75^{b}\pm2.91$	$60.25^{b}\pm1.90$	$55.30^{b}\pm2.54$
Energy Value (kcal)	$315.45^{a}\pm0.63$	$303.75^{c}\pm0.21$	$302.55^{c}\pm0.49$	$313.45^{a}\pm1.62$	$310.00^{b}\pm0.14$

Values are mean ± standard deviation of duplicate readings. Values on the same column with different superscripts are significantly different at $p<0.05$.

A = 100% Maize (Control),B = 75% Maize and 25% Pigeon pea, C = 50% Maize and 50% Pigeon pea, D = 25% Maize and 75% Pigeon pea, E = 100% Pigeon pea

The steady increase in ash, fibre and fat contents with inclusion of pigeon pea is in agreement with Ikya *et al.* (2013) and Kolawole *et al*. (2020) who also reported a steady increase in the ash, fibre and fat contents due to fortification of *agidi* with a legume. Presence of ash is an indication of mineral content in the food. Minerals are required for proper composition and maintenance of body fluids including blood, nerves, tissues, bones, teeth and muscles. Fiber maintain healthy weight, reduce risk of Type-2 diabetes, lower the chances of heart disease, maintain healthy gut/digestive system, and reduce risk of certain cancers and aid detoxification (Dreisbach, 2021). A small amount of fat is an essential part of a healthy and balanced diet. Fat is a source of essential fatty acids which the body cannot make, by itself and it helps the body absorb vitamin A, D and E (NHS, 2020).

The caloric value of the *agidi* samples ranged from 305.55 to 315.45 kcal with the control sample (A: 100% maize) having the highest caloric value of 315.45 kcal as compared to other sample blends 303.75, 302.55, and 310.00 kcal for B, C and E respectively. The control (100% maize) varied significantly ($p<0.05$) with the sample blends except for sample D. Higher energy or caloric value in the *agidi* samples are expected because energy is a function of protein, fat and carbohydrate contents (Oguche *et al*., 2017). The *agidi* samples have high protein (i.e blends with more pigeon pea) and carbohydrate content (blends with more maize). This is an indication that *agidi* produced from blends of pigeon pea or only pigeon pea is a good source of energy just like the control (A: 100% maize).

3.2. Micronutrient composition of *Agidi*from blends of maize and pigeon pea

The mineral contents of *agidi* made from maize and pigeon pea were represented in Table 2 and it showed that there were significant differences ($p<0.05$) between the blends and the control.

Table 2. Mineral Content of *Agidi* Samples from Blends of Maize and Pigeon pea

Sample	Calcium (mg/100g)	Potassium (mg/100g)	Iron (mg/g)
A	$122.50^{e}\pm3.53$	$202.00^{e}\pm2.82$	$0.94^{d}\pm0.01$
B	$147.50^{d}\pm3.53$	$215.50^{d}\pm0.70$	$0.98^{c}\pm0.00$
C	$180.00^{c}\pm0.00$	$240.00^{c}\pm0.00$	$1.04^{b}\pm0.00$
D	$197.50^{b}\pm3.53$	$271.50^{b}\pm2.12$	1.14a±0.00
E	$212.50^{a}\pm3.53$	$285.50^{a}\pm0.70$	$1.16^{a}\pm0.01$

Values are mean ± standard deviation of duplicate readings. Values on the same column with different superscripts are significantly different at $p<0.05$.
A = 100% Maize (Control), B = 75% Maize and 25% Pigeon pea, C = 50% Maize and 50% Pigeon pea, D = 25% Maize and 75% Pigeon pea, E = 100% Pigeon pea

The calcium content of the *agidi* ranged between 122.50 to 212.50 mg/100g and it varied significantly ($p<0.05$). The control sample (A: 100% maize) has the least calcium content of 122.50 mg/100g which increased with the addition of pigeon pea. Pigeon pea contain appreciable amount of calcium (Saxena *et al.*, 2010). Calcium plays a significant role in blood clotting, nerve transmission, muscle contraction and also in bone health (Peters and Martini, 2010; Elinge *et al*., 2012). According to Sexana *et al*. (2010), pigeon pea contains appreciable amount of iron which explains why sample E have the highest iron content.

Potassium content ranged between 202 to 285.50 mg/100g with the control (A: 100% maize) having the least potassium content of 202 mg/100g but increased moderately with the addition of pigeon pea (215.50, 240.00, 271.50, 285.50 mg/100g for B, C, D and E respectively). Sufficient amounts of potassium in the body can increase iron utilization and control hypertension through diuretics and for individuals who experience uncontrolled potassium excretion via body fluids (Elinge *et al.*, 2012).

The iron content of the *agidi* samples ranged between 0.94 to 1.16 mg/g. The control (A: 100% maize) had the least iron content of 0.94 mg/g which slightly increased with the addition of pigeon pea. The high potassium content is due to the fact that pigeon is a rich source of potassium (Staughton, 2020). Iron plays a significant role in producing red blood cells in all body organs, including in the brain, and supporting haemoglobin synthesis in developing foetuses and young children (Georgieff *et al*., 2019).

3.3. Physicochemical properties of *Agidi* from blends of maize and pigeon pea

The physicochemical properties for the blends of maize and pigeon pea slurry and *agidi* sample texture was represented in Table 3. The pH values of all the slurries samples were low and acidic. It ranged between 3.57 to 4.36 with the control (A: 100% maize) having the least pH (3.57) which increased slightly with the addition of pigeon pea to 4.04, 3.87, 4.29, 4.36 for B, C, D and E respectively. The low acidic pH value obtained was as a result of fermentation process involved in *agidi* slurry production and is responsible for reduction or elimination of bacterial pathogens under fermentation conditions (Adegbehingbe *et al*., 2017). It is also attributed to the proliferation of microbial biomass particularly lactic acid bacteria and yeast capable of utilizing free sugar to produce organic acid.

The *agidi* slurry samples had low titratable acidity (TTA) ranging between 0.023 to 0.071 g/100g and varied significantly ($p<0.05$). Titratable acidity decreased with the addition of pigeon pea to 0.023, 0.038, 0.038, 0.038 g/100g for B, C, D and E respectively. The higher the titratable acidity, the stronger the fermentation flavor (Cauvain, 2015). It also indicates that the product will have better keeping quality because acidity can prevent or delay quick growth of spoilage microbes while low titratable acidity ensures proper absorption of mineral elements (Kuyunya *et al.*, 2011). Similar increase in the pH values and decrease in the titratable acidity values compared favourably with that reported by Zakari *et al*., (2010) during the addition of a legume *agidi* production.

The viscosity of the slurry prepared from the various proportion of the blends varied significantly ($p < 0.05$). The viscosity ranged within 150-300 cps with the sample E (100% pigeon pea) having the least viscosity of 150 cps. The viscosity of the *agidi* decreased with the increasing addition of pigeon pea. Viscosity affected the texture, firmness, smoothness, consistency and appearance of the *agidi* which are very importance qualities as they influence its acceptance by the consumers. The difference observed in the viscosities of the *agidi* sample blends slurry may be attributed to the different rate of water absorption capacity of the starch granules of the maize and pigeon pea (Ragaee and Abdel-Aal, 2006). Also maize cereal contains more starch granules than pigeon pea legume.

The texture of the *agidi* samples varied significantly ($p<0.05$) with sample C (50% maize and 50% pigeon pea) ranking the highest in texture (240.75mm) while other samples had 240.00, 239.75, 238.50 and 238.25mm for B, D, A, and E respectively. Texture is a very important quality factor in *agidi* production as it influences the consumers' acceptance of the food. Fermentation processes play important role in the textural properties of *agidi* or ogi. The addition of some materials or fortification during *agidi* production influences its rheological properties such as viscosity, swelling/gelation capacity, texture, etc. It may either increase or decrease the rheological properties (Barbradozier, 2013).

Table 3. Physicochemical properties of *Agidi* samples from blends of maize and pigeon pea

Sample	pH	TTA(g/100g)	Viscosity (cps)	Texture (mm)
A	$3.57^{c}\pm0.00$	$0.071^{a}\pm0.00$	$300^{a}\pm0.00$	$238.50^{b}\pm1.41$
B	$4.04^{b}\pm0.07$	$0.023^{c}\pm0.00$	$195^{b}\pm7.07$	$240.00^{ab}\pm0.00$
C	$3.87^{c}\pm0.01$	$0.038^{b}\pm0.00$	$175^{bc}\pm21.21$	$240.75^{a}\pm0.35$
D	$4.29^{a}\pm0.02$	$0.038^{b}\pm0.00$	$160^{c}\pm14.14$	$239.75^{ab}\pm0.35$
E	$4.36^{a}\pm0.00$	$0.038^{b}\pm0.00$	$150^{c}\pm0.00$	$238.25^{b}\pm1.06$

Values are mean ± standard deviation of duplicate readings. Values on the same column with different superscripts are significantly different at p<0.05.
A = 100% Maize (Control), B = 75% Maize and 25% Pigeon pea, C = 50% Maize and 50% Pigeon pea, D = 25% Maize and 75% Pigeon pea, E = 100% Pigeon pea

3.4. Phytochemical composition of *Agidi* from blends of maize and pigeon pea

Phytochemicals are anti-nutrients which have the capacity of decreasing the digestibility and palatability of protein because they form insoluble complex with them. They also cause deleterious effect on human health (Mbata *et al*., 2009). The phytochemical composition of *agidi*from blends of maize and pigeon pea are represented in Table 4. For all the *agidi* samples analyzed, there was low phytochemical contents which differed significantly (p<0.05) in all the parameters. Naturally, legumes including pigeon pea are said to contain some anti-nutrients (e.g.; tannin, polyphenols, phytate, oxalate, etc.) which limits their use and have deleterious effect on human health although most of these anti-nutrients are reduced or eliminate during some processing techniques like soaking, dehulling, sprouting, cooking, fermentation, etc (Sheel *et al.*, 2011). Soaking and fermentation are processing steps in *agidi* production which accounts for the massive reduction in the phytochemical contents of *agidi* as compared to the raw pigeon pea legume which has up to 6.88 mg/g of tannin. Tannin content ranged between 0.074 mg/g and 0.178 mg/g it slightly increased with the addition of pigeon pea to 0.088, 0.112, 0.155 and 0.178 mg/g for B, C, D and E respectively. Tannins are naturally occurring plant polyphenols. Their main characteristics is to bind and precipitate protein thereby interfering in its digestion and absorption. The lethal dose of tannin is 0.7-0.9 mg/100g (Pikuda and Illelaboye, 2013) and the tannin contents of the *agidi* sample blends gotten are far lower than the lethal dose. The tannin values compared favorably with those reported by Uchechukwu *et al*. (2017).

Table 4. Phytochemical composition of the *Agidi* samples made from blends of maize and pigeon pea

Samples	Tannin (mg/g)	Phytate (mg/g)	Saponin (mg/g)
A	$0.074^{e}\pm0.00$	$0.133^{e}\pm0.00$	$0.137^{e}\pm0.00$
B	$0.088^{d}\pm0.00$	$0.151^{d}\pm0.00$	$0.148^{d}\pm0.00$
C	$0.112^{c}\pm0.00$	$0.185^{c}\pm0.00$	$0.170^{c}\pm0.00$
D	$0.155^{b}\pm0.00$	$0.237^{b}\pm0.00$	$0.192^{b}\pm0.00$
E	$0.178^{a}\pm0.00$	$0.251^{a}\pm0.00$	$0.207^{a}\pm0.00$

Values are mean ± standard deviation of duplicate readings. Values on the same column with different superscripts are significantly different at p<0.05.A = 100% Maize (Control), B = 75% Maize and 25% Pigeon pea, C = 50% Maize and 50% Pigeon pea, D = 25% Maize and 75% Pigeon pea, E = 100% Pigeon pea

The phytate content ranged between 0.133 mg/g and 0.251 mg/g and varied significantly ($p<0.05$) between the control and the other sample blends. It increased slightly with the addition of pigeon pea to 0.151, 0.185, 0.237, and 0.251 mg/g for B, C, D and E respectively. The increase in the phytate content based on the addition of pigeon pea is as a result of its high content of phytate in pigeon pea of about 5.01 and 12.7 mg/g (Sheel *et al*., 2011). Saponin contents, varied significantly ($p<0.05$) the control (A: 100% maize) had the least saponin content (0.137 mg/g) as compares to the rest sample blends B, C, D and E for 0.148, 0.170, 0.192 and 0.207 mg/g respectively which later increased slightly with the addition of pigeon pea.

The increase in the phytate content based on the addition of pigeon pea is as a result of its high content in pigeon pea of about 5.01 and 12.7 mg/g (Sheel *et al*., 2011). Phytate is one of the anti-nutrients present in pigeon pea and which is known to form complexes with iron, zinc, calcium and magnesium thereby making them less available and thus inadequate in food samples especially for children. It is known that 10-50mg phytate per 100g will not cause a negative effect on the absorption of zinc and iron (Pikuda and Illelaboye, 2013). Although the phytate level increased with the addition of pigeon pea, it also decreased mainly due to the processing steps involved in *agidi* production (such as soaking, fermentation, cooking) and the values gotten are below the safe consumption range above. The phytate values also compared favorably with those reported by Uchechukwu *et al*. (2017).

Pigeon pea is a rich source of saponin up to 21.6 - 34.9 mg/g (Sexana *et al*., 2010). Saponins are good sources of antioxidants which are beneficial to human in the functioning of several organs and in treating various diseases. Ingestion of saponin has been linked with a decrease in the overall blood cholesterol (Owheruo *et al*., 2018).

3.5. Sensory characteristics

The results from the sensory evaluation for the *agidi* made from blends of maize and pigeon pea are represented in Figure 1. It showed the responses of 20 panelists that carried out the sensory evaluation. The results as shown in Table 5 indicated that all the samples were not rejected by the panelists as revealed by the rating of the mean scores. Significant differences at ($p<0.05$) were found to exist between the control (Sample A) and the other blends of the *agidi* samples in all the parameters tested.

Based on the appearance and color on the spider plot (Figure1), the control differed significantly and it was most preferred compared to the other sample blends. Both control and 25% inclusion of pigeon pea gave the same white color. But the inclusion of about 50% of pigeon pea resulted in the development of a grayish color while the use of only pigeon pea resulted in a brownish color. *Agidi* is normally known to be white or off-white in colour depending on the grain color, e.g.; *agidi* prepared from yellow maize gives a yellow colour and that prepared from white maize gives a white or off white color. Therefore, the color of the grain used generally affected the color and appearance of the *agidi.*

For the texture, firmness, smoothness and consistency, the control (A: 100% maize) was most preferred and it differed significantly from the other samples based on the rating of the mean scores. The control (A: 100% maize) had a firm and smooth texture with a thick consistency even at the inclusion of 25% pigeon pea (sample B), but at the inclusion of pigeon pea from about 50% and above (for sample C, D and E), it gave a smooth and moderately thick texture with a slightly watery consistency which needed not much pressure to break. Texture is of an important quality factor in *agidi* production as it influences the consumers' acceptance of the food. The addition of some materials for fortification during *agidi* production influences its texture and consistency either by decreasing or increasing it. Fermentation process and duration also affect the texture of *agidi*, the longer the fermentation process the lesser or weaker the textural properties (Barbradozier, 2013). Similar effect in the texture and consistency was also reported by Kolawole *et al.* (2020) due to the addition of soybean and orange fleshed sweet potato in the production of *agidi*.

Agidi samples generally had a sour taste. The flavor, mouth-feel and aftertaste of the control (100% maize) were most preferred among the sample blends. The sour taste, flavor and mouth-feel however slightly decreased in intensity with the addition of pigeon pea. *Agidi* generally had a sour taste and flavor which is very common in fermented foods. Also, the higher the acidity during the fermentation process the stronger the fermentation flavor and sour taste (Cauvain, 2015). The least accepted were D and C because of their firmness and aftertaste.

In terms of overall acceptance, the control (Sample A) ranked the highest based on the parameters surveyed, followed by B and E based on the appearance, taste, flavor and aftertaste.

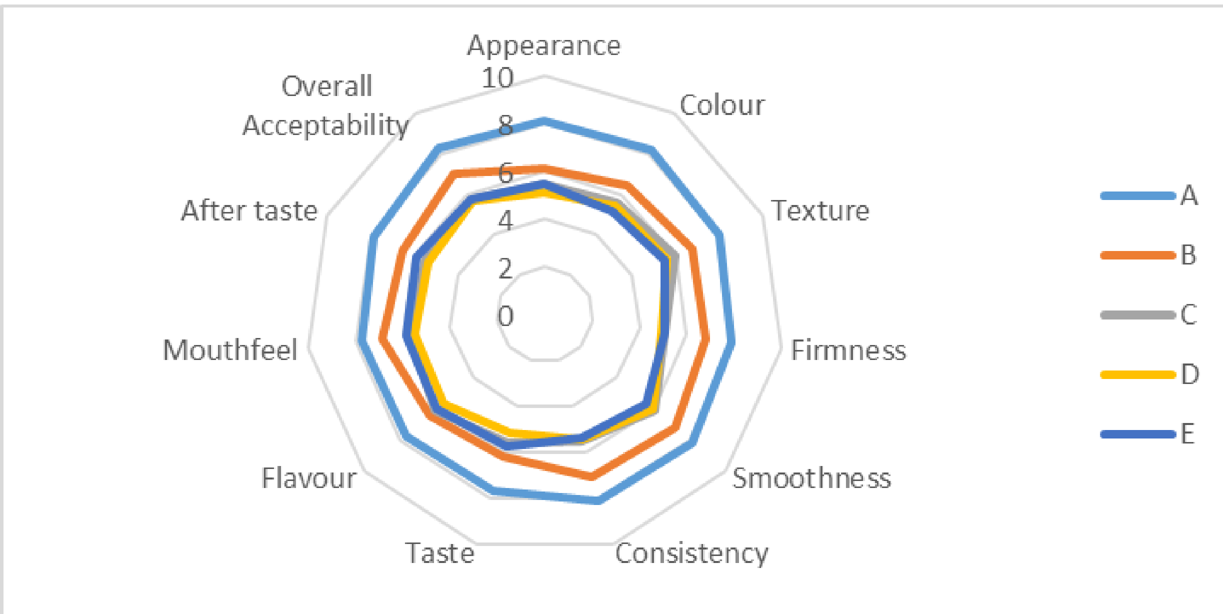

Figure 1. Spider diagram of sensory evaluation of *agidi* made from blends of maize and pigeon pea (The spider plot represents mean sensory analysis scores for the five treatment of *agidi* made from blends of maize and pigeon pea. Scores are based on 9- point hedonic scale like extremely, 9; like very much, 8; like moderately, 7; like; slightly, 6; neither like or dislike, 5; dislike slightly, 4; dislike moderately, 3; dislike very much, 2; dislike extremely, 1.; number of panelists (n)=20. A = 100% Maize (Control), B = 75% Maize and 25% Pigeon pea, C = 50% Maize and 50% Pigeon pea, D = 25% Maize and 75% Pigeon pea, E = 100% Pigeon pea)

4. Conclusions

The result of this study has shown that *agidi* made from 100% maize is of a low nutritional value although it gave a better texture and appearance which are important quality factors that influences consumers' acceptance.

The protein, crude fibre, ash and fat contents increased with the addition of pigeon pea. Similar increment was also noticed for the mineral (Ca, K, Fe) contents based on the addition of pigeon pea. Therefore, the combination of maize and pigeon pea in the production of *agidi* resulted in a product of higher nutritional status although, its viscosity and acidity decreased with the addition of pigeon pea.

Hence, combining pigeon pea with maize in the processing of 'agidi' at the substitution level up to 25% did not vary much from the control

(100% maize) and was highly accepted by the consumers.

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APPENDIX

Plate 1. 'Agidi' Sample A (100% maize)

Plate 2. 'Agidi' Sample B (75% Maize and 25% Pigeon pea)

Plate 3. 'Agidi' Sample C (25% Maize and 75% Pigeon pea)

Plate 4. 'Agidi' Sample D (50% Maize and 50% Pigeon pea)

Plate 5. 'Agidi Sample E (100% Pigeon pea)