Research Journal of Food Science and Quality Control (RJFSQC) E-ISSN 2756-5483
P-ISSN 2695-2459 Vol 9. No. 1 2023 DOI: 10.56201/rjfsqc www.iiardjournals.org

Nutritional Evaluation and Glycemic Indices of Agidi Produced From Maize (*Zea mays*) Starch and Cowpea (*Vigna unguiculata*) Flour Blends

***Ohwesiri M. Akusu, David B. Kiin-Kabari, Olaoluwa Jolaoso & Bariwere S. Chibor**
Department of Food Science and Technology,
Rivers State University, Port Harcourt, Nigeria
Email address: akusumonday22@gmail.com
*Corresponding author sbsambary93@gmail.com

DOI: 10.56201/rjfsqc.v9.no1.2023.pg21.37

Abstract

The main objective of this work was to evaluate the nutritional properties and glycemic indices of "Agidi" produced from the blends of maize starch and cowpea flour. Starch was extracted from maize after fermenting for 72h and blended with cowpea flour in the ratio of 100:0, 95:5, 90:10, 85:15 and 80:20, respectively (maize: cowpea) and labelled sample A, B, C, D and E, respectively. Agidi samples were produced from these blends by cooking and continuous stirring, and labelled accordingly. Percentage moisture, Ash and fat content of the starch and flour blends ranged from 3.27 – 4.13, 0.17 – 1.07 and 1.59 – 4.67, crude fiber, protein and carbohydrate ranged from 1.14- 5.17, 5.74- 23.28 and 62.56 – 87.23, respectively. Percentage Ash, fat, fiber and protein content of the starch/flour blends and the prepared Agidi increased significantly as the percentage substitution of cowpea flour increases. Carbohydrate content reduced as percentage substitution of cowpea increases, with sample A showing significantly higher value of 52.84 %. Energy value of sample E was significantly higher (257.61 kcal/100g). Water absorption capacity, bulk density and least gelation capacity of each sample were not significantly different. pH and viscosity of the Agidi samples ranged from 3.37 – 3.78 and 1.185 – 1.340 pas, respectively, with higher values seen in samples D and E. Glycemic indices of the Agidi samples ranged from 54.20 – 66.23, with low value of 54.20 presented in sample E. Percentage invitro protein digestibility (IVPD) increased with increase substitution of cowpea flour, with sample E given significantly higher value of 17.74 %. IVPD of samples B, C and D were not significantly different. The colour score ranged from 7.45 – 7.10, Aroma ranged from 7.20 - 6.25, these mean scores were not significantly different. Appearance, Aroma and sogginess scores ranged from 6.85 – 7.35, 6.25 – 7.20 and 6.35 – 7.05, The mean scores for Taste, Texture and Overall acceptability were shown ranging from 6.45 – 6.95, 6.85 – 7.05 and 6.73 – 7.12, respectively. There was significant difference in the sensory variables for the Agidi samples, showing that Agidi enriched with cowpea flour received equal acceptability with the conventional Corn starch Agidi. Blending of cowpea flour at 20 % substitution with 80 % fermented maize starch for Agidi preparation, is highly recommended, to enhance nutritional potentials.

Keywords*: Nutritional, Glycemic Indices, Maize, Cowpea, Agidi*

1. Introduction

Cereals such as Maize, rice, wheat, sorghum, millet, are among members of the grass family *Graminae* and are particularly important because of their role as staple food crops in many areas of the world (Murtaugh*et al*., 2003: Pereira *et al.*, 2002. They form an important human diet as they provide starch, carbohydrate and dietary fibre. Thus, enabling consumers to meet their demand of energy and nutrient intake. Verma and Patel (2013) presented cereal as the most stable food for many countries because of their good organoleptic properties and their low cost which make them accessible to the under-privilege populations. Among the cereals; the most commonly used in production of fermented products such as "agidi", is maize. Although "agidi" is however usually rich in carbohydrates but low in protein (Stadimayi *et al*., 2012).

Maize has a high carbohydrate content of 72-73% (Lag *et al.*, 2012). Protein content ranging from 10 to 11.25%. ash content ranging from 3.3-4.17% and fat content ranging from 4.17-5.0% (Ujabaderigi and Adedu, 2005). Maize is an important cereal and can be fermented to give various products important to the diet of many countries in Africa. Fermentation improves the products quality by producing lactic acid which causes souring and improvement in its taste, flavour and texture (Mohiedeen *et al.*, 2001)**.**

Cowpea (*Vignaunguiculata*) is an edible legume belonging to the family *Fabaceae* (Appiah *et al*., 2011). It is popularly known by various names such as Southern pea, China pea, Black-eyed bean or cow grain. It originated in Africa and is widely distributed in tropical and temperate climate and differs in shape, size and colour of seed coat (Ashogbon and Akintayo, 2013). Nigeria, the largest producer of cowpea, where about 2.l billion tones are produced for annum accounts for 61% of production in Africa and 58% worldwide (IITA, 2007). It is a nutritious crop which provides protein-rich diet at comparatively lower costs than animal proteins and hence is a choice crop in developing countries. Legumes, particularly cowpeas, are good sources of nutrients (protein, carbohydrate, fiber, vitamins and minerals). Recently, beans have been shown to be a low glycemic index (GI) food. They therefore have positive health benefits which include hypocholesterolemia, mitigation of diabetes and weight control. Cowpea *(Vigna unguinculata)* is a grain legume consumed in Nigeria (Onuorah *et al.*, 1989). They serve as a cheap source of proteins and other nutrients (EneObang and Carnovole, 1992).

Agidi is gel-like traditional fermented starch food item produced from maize *(Zea mays)*, although millet and sorghum can also serve as raw materials (Ogiehor, 2005). Its colour depends on the cereals used. It is cream to glassy white from maize, light brown from sorghum and grey to greenish colour from millet. It is known by different names in different localities such as "eko" (Yoruba), akason (Benue), Kamu (Hausa), and Agidi (Ibo). It can be consumed with stew, beans cake, or with moi-moi and can also be consumed alone. According to Oguche *et al.*, (2017), agidi has a moisture content of 9.26%, protein 8.92%, fat 4.85%, Ash 0.99%, crude fibre 1.92%, carbohydrate 74.06% and energy of 375.57 kcal. Agidi produced from fermented maize flour is inherently deficient in nutrients, especially lysine while some nutrients are leached out because of the poor processing techniques involved in its traditional production (Adeyemi *et al.*, 1987). Such deficiencies may result in protein malnutrition among consumers of "agidi" particularly the young children who are fed with the product as weaning food (Onyeka and Dibia, 2002; Plahar *et al.*, 2003). Process modification of "agidi" is a way of improving nutritional qualities of it and also, cereal variety selection and protein supplementation

(Akpapunan *et al.,* 1997; Tsatsu, 2009); Adeniyi and Porter, 1978; Aminigo and Akingbala, 2004). Incorporation of legumes such as cowpea to fermented maize starch is supposed to provide a nutritionally improved food because of the excepted increase in protein quality and high energy value of the blends. However, very little has been reported about the nutritive value of "agidi" especially those supplemented like legumes.

2. Materials and Methods

Maize *(Zea mays),* and cowpea (*Vigna unguiculata)* were purchased from mile 3 market in Port Harcourt, Rives State, Nigeria.

2.1 Production of Maize Starch

The method described by Ogiehor *et al.*, (2005) was used, as shown in Figure 1. Maize grains were sorted and cleaned; one kg of the maize grain was steeped in potable water (4L) for 72h at room temperature ($29 \pm 2^{o}C$). The steeped water was decanted and the grains will be washed thoroughly with potable water. The grain was milled with water using attrition mill. The slurry was sieved with excess potable water using a muslin cloth. The filtrate was allowed to settle for 12h and the supernatant decanted. The sediment was place in a cheese cloth and squeezed to remove excess water

Maize grain
↓
Sorting and cleaning
↓
Steeping for 72h / $28\pm2^{0}C$
↓
Draining
↓
Wet milling
↓
Sieving using muslin cloth
↓
Leave to sediment for 12h
↓
Draining
↓
Squeezing using cheese cloth
↓
Maize starch

Fig 1: Flow diagram for the production of maize starch (Source: Ogiehor *et al.*, 2005)

2.2 Production of Cowpea flour

Cowpea seeds were sorted and cleaned to get rid of foreign and adhering soil matters. The cleaned seeds Fluted pumpkin seed was dehulled, cleaned and oven dried at 60°C for 12h (Kiin-Kabari *et al*., 2020) in a hot air oven (model QUB 305010G, Gallenkamp, UK), milled using a laboratory mill (model MXAC2105, Panasonic, Japan) and sieved to obtain uniform particle size; then packaged in an airtight container for further analytical use.

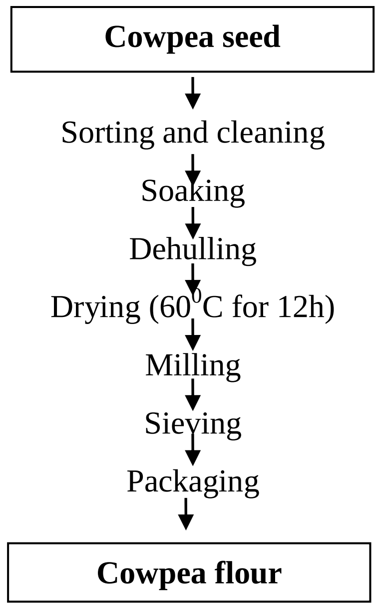

Figure 2: **Flow diagram for production of cowpea flour from cowpea seed (**Source**:** Ndgoddy *et al*., 1996)

2.3 Preparation of Agidi from the blends of Maize Starch and Cowpea flour

Agidi was prepared using the procedure of Akusu *et al*. (2019), as shown in fig. 3. Five formulations designated composites., A, B, C, D and E were prepared by mixing various proportion of starch and flour recipes. The reconstituted blends were cooked with continuous stirring until a stiff gel was obtained

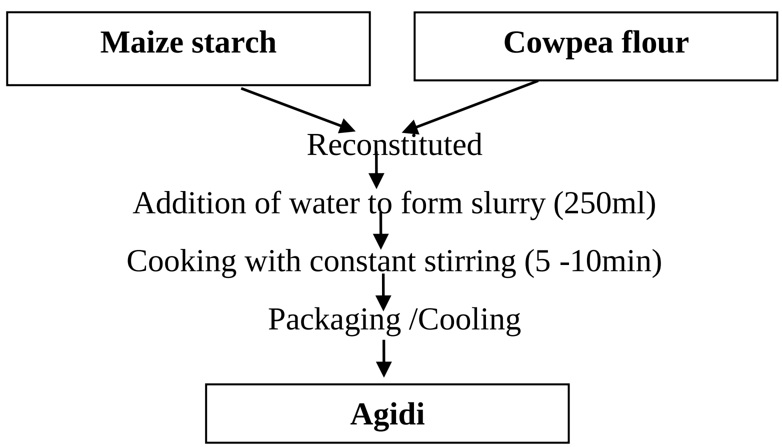

Figure 3: Flow diagram for the preparation of Agidi from the blends of maize starch and cowpea flour

Table 1: Formulation Table of Flour Blends for Agidi

Sample	Maize starch (%)	Cowpea flour (%)	Quantity (g)
A	100	0	200
B	95	5	190.10
C	90	10	180:20
D	85	15	170:30
E	80	20	160:40

2.4 Proximate Composition

Percentage moisture, Ash, fat, protein and crude fiber were determined using AOAC (2012) standard method, while Carbohydrate content was determined by difference; % available carbohydrate = 100 – (%moisture + % Ash + % Fat + % crude protein + % crude fibre).

2.5 Energy value

Energy value (kcal per 100 g) was estimated using the Atwater conversion factor (Kiin-Kabari and Giami, 2015). Energy (kcal per 100 g) = [9 × Lipids% + 4 × Proteins% + 4 × Carbohydrates%].

2.6 Functional Properties

Functional properties of the wheat/fish composite flour; bulk density, swelling index, water absorption capacity and oil absorption capacity were determined according to the standard procedures;

2.6.1 Bulk Density

The method of Akpapunam and Markakis (1981) was used. A 10 ml-graduated cylinder was gently filled to mark with the sample. The filled cylinder was gently tapped on a laboratory bench about 10 times until there was no further diminution of the sample level after filling to the 10 ml mark. The procedure was adopted for each of the sample and the bulk density was calculated using the formula:

$$\text{Bulk density (g/ml)} = \frac{\text{packed weight of sample}}{\text{volume of material after tapping}}$$

2.6.2 Least Gelation concentration capacity

The methods of Sathe and Salunkhe, (1981) will be used. Samples were prepared at 2-20% W/ with water inside test tubes. The test-tubes will be heated in a water bath for 1h at temperatures above 65^{O}c. The tubes were brought out and cooled for 2h in a refrigerator (4^{0}C) and inverted. Least gelation concentration was determined at that concentration when the samples from the inverted test tubes does not slip or fall.

2.6.3 Water Absorption Capacity

The method described by Elkhalifa *et al*. (2005) was used to determine the water absorption capacity of the flour samples. Five millilitres of water/oil were added to 1.0 g of the sample in a centrifuge tube. The mixture was sonicated for 1 min to disperse the sample and the suspension was allowed to stand for 30 min. The suspension was then centrifuged after standing at 3500 rpm for 30 min and the water absorbed was calculated using the formula:

Water absorbed (ml/g) = $\frac{a-b}{a}$

where a = initial volume of water

b = final volume of water

2.7 Physiochemical Properties of the Agidi Slurry

pH and Viscosity were determined using AOAC (2012) standard method. pH was measured with Jenco 6177 pH meter**.** Viscosity of the agidi slurry was determined using rotary viscometer (model NDI-185, China). Dynamic Viscosity was read with Rotor 4# at 30rpm.

2.8 **In Vitro Protein Digestibility**

The in-vitro protein digestibility of Agidi samples was determined using the procedure of Mertz *et al*. (1984) and modified by Monsour and Yusuf (2002). Sample was homogenized and 200mg of cookie was weighed into a flask and suspended in 15ml of 0.1M HCl containing 1mg of porcein pepsin and incubated at 37oC for 3 hr. The pepsin hydrolyzed suspension was then neutralized with 0.5M NaOH and incubated with 6mg of pancreatin in 7.5ml of phosphate buffer (pH 8.0) for 24hr at 37^{o}C. After the incubation, the sample was treated with 15ml of 10% TCA. The mixture was filtered through Whatman No 1 filter paper. The TCA soluble fraction was assayed for nitrogen estimation using micro Kjedahl method. A blank sample was also determined. The protein digestibility was calculated by the following formula:

$$\text{Protein Digestibility \%} = \frac{\text{Nitrogen in Supernatant} - \text{Nitrogen in Blank}}{\text{Nitrogen in Sample}} \times 100$$

2.8 Starch Hydrolysis/Glycemic Index Prediction

The starch hydrolysis and predicted glycemic index was carried out using the modified Goni *et al.*, (1997) method as described by Kiin-Kabari and Giami (2016). Fifty milligrams of sample was weighed and ten ml of Hcl-Kcl buffer was added to bring the pH to 1.5, this was followed by the addition of 0.2ml pepsin (Cat no: P6887) enzyme solution to the sample and was incubated for one hour at 40^{0}C using a digital control incubator (Model 9053A, England). The volume was made up to twenty-five ml by the addition of phosphate buffer (pH 6.9) and 2.5ml of α-amylase solution was added and incubated at 37^{0}C. Aliquots of one ml was taken from each flask at intervals of 30min from zero time to 3h. The α-amylase was inactivated by heating the tubes in a boiling water bath for 5min. The content of the flask was allowed to cool and followed by the addition of three ml of 0.2M sodium acetate buffer (pH4.5) and 0.06ml (1 drop) of amyloglucosidase enzyme. The content of the flask was further incubated for 45min at 60^{0}C. The glucose concentration was determined by using the DNS method. 0.5ml aliquot of the hydrolyzed starch was taken in duplicate, 1ml of Dinitrosalicyclic reagent (DNS) was added to the test tubes, heated for 5min followed by the addition of 3.5ml of Distilled water. The absorbance was read at 540nm using a spectrophotometer (CE 1011, UK). A glucose standard curve was prepared. The rate of starch digestion was expressed as a percentage of total starch hydrolysed at different times (30, 60,90 120, 150, 180min).

The area under hydrolysis curve for each sample and the reference sample were calculated using the trapezoid method. Hydrolysis index (HI) was obtained by dividing the area under the curve of each sample by the area under the curve of the reference sample (glucose)

$$\text{H.I} = \frac{\text{Area under curve of sample}}{\text{Area under curve of reference sample}} \times 100$$

Glyceamic Index (GI) was estimated using the equation:
GI = 3971 + (0.549 x H.I)

2.9 Sensory Evaluation

Sensory evaluation was performed on "Agidi" using the method of Iwe, (2010). The samples were evaluated by selected semi-trained panelists on the 9point Hedonic scale. The team consisted of 20 randomly selected tasters, from the Department of Food Science, Rivers State University, Port Harcourt. Evaluation was on how they liked or disliked each treatment/blend levels with respect to colour, appearance, sogginess, flavour, aroma, texture, taste and overall acceptability. All evaluations were conducted at room temperature on the same day.

2.10 Statistical Analysis

All experiments and analysis were carried out in triplicates. The mean and standard deviation values were calculated. Data were subjected to Analysis of Variance (ANOVA). Means were separated using Tukey's multiple comparison test, and significance accepted at $P<0.05$ level. The statistical package in Minitab 20 computer program was used.

3. Results and Discussion

3.1 Functional Properties of Maize Starch and Cowpea Flour Blends

Result for the functional properties of Agidi prepared from maize starch and cowpea flour blends (Table 2) showed the Water absorption capacity ranging from 0.15 - 0.25 g/ml. Differences noticed in these values were not statistically significant ($p>0.05$). Water absorption capacity is important in bulking and consistency of products (Akusu *et al*., 2019). Water absorption capacity (WAC) is the ability of the starch or flour to absorb water, swell for improved consistency and texture (Akinsola *et al*., 2017). Water absorption capacity also influences the viscosity of the product (Niba *et al*., 2001). The capability of food materials to absorb water to a large extent is associated to its protein content (Kiin-Kabari *et al*., 2015).

The bulk density of flour blends ranged from 1.82 - 1.87 g/g. The bulk density increased with increase in substitution levels of cowpea. However, there was no significant difference ($p>0.05$) in the mean bulk density of the Agidi samples. These values were higher than 0.54 - 0.58g/g reported earlier for Agidi prepared from maize, millet and sorghum blends (Akusu *et al*., 2019). The bulk density is influenced by particle size and the density of the flour and is important in determining the packaging requirement and material handling (Karuna *et al*., 1996). Plaami (1997) reported that bulk density is influenced by the structure of the starch polymers and loose structure of the starch polymers could result in low bulk density.

The least gelation concentration recorded was 2% for all the samples. Functional properties of food is seen as the characteristics of food ingredients different from nutritional quality which has a great influence on its utilization (Ajatta *et al*., 2016). They are those parameters that determine the application and end use of food material for various food products (Adebayo-Oyetoro *et al*., 2017). Wijaya and Mehta (2015) stated that functional properties evaluate the roles and functions of specific component in foods or how ingredients behave during preparation and cooking. How they affect the finish food products in terms of colour, taste and texture (De-Man, 1999). It is also characterized by the structure, quality, nutritional value and acceptability of a food product. These characteristics are vital to evaluate and possibly help to predict how proteins, fat, fibre and carbohydrates may behave in specific structures (Chandra and Shamsher, 2013). It has been established that the composition and nature of macromolecules (proteins, fat, and carbohydrates) in food materials often affect their functionality (Prinyawiwatkul *et al*.,1997; Hung and Morita, 2003). The capability of food materials to absorb water to a large extent is associated to its protein content (Kiin-Kabari *et al*., 2015).

Table 2: Functional Properties of Maize Starch and Cowpea Flour Blends.

Samples	Water Absorption Capacity (g/ml)	Bulk Density (g/g)	Least Gelation (%)
A	$0.15^a \pm 0.07$	$1.83^a \pm 0.05$	$2^a \pm 0.00$
B	$0.25^a \pm 0.07$	$1.84^a \pm 0.02$	$2^a \pm 0.00$
C	$0.15^a \pm 0.07$	$1.86^a \pm 0.03$	$2^a \pm 0.00$
D	$0.15^a \pm 0.07$	$1.82^a \pm 0.00$	$2^a \pm 0.00$
E	$0.15^a \pm 0.07$	$1.87^a \pm 0.00$	$2^a \pm 0.00$

Values are means ± standard deviation of triplicate samples. Mean values bearing different superscript in the same Column differ significantly ($p < 0.05$).

Key: A = Maize 100%**,** B=Maize 95%, Cowpea 5%**,** C= Maize 90%, cowpea 10%**,** D= Maize 85%, cowpea 15%

E= Maize 80%, cowpea 20%

3.2 Proximate Composition of "Agidi" produced from blends of Maize starch and Cowpea flour

Result for proximate composition of the "Agidi" showed Moisture content ranged from 35.47 - 36.95 % with sample A and B showing significantly ($p<0.05$) higher values of 36.95% and 36.92 %, respectively (Table 3). There was no significant difference ($p>0.05$) in the moisture content of "Agidi" prepared from 85:15 and 80:20 maize starch and cowpea flour. The moisture compared favourably with 35. 44 – 36.93 % reported by earlier researchers (Balogun *et al*., 2016; Oguche *et al*., 2017; Kolawole *et al*., 2020), but higher than 15.94 - 19.08% reported by *Akusu et al*. (2019) for Agidi prepared from maize, millet and sorghum blends. High moisture content in "Agidi" could be due to the processing method since these samples were cooked pastes. Moisture content is an important indicator of the shelf-life of foods (Oguche *et al*., 2017). Thus, the high moisture contents of the samples predispose them to rapid spoilage, and hence, there may be need to consume as soon as possible or to refrigerate where this option is available (Kolawole *et al*., 2020).

Ash content ranged from 0.48 - 0.69% with sample E showing significantly ($p<0.05$) higher value of 0.69 %. Increase in Ash content was probably due to increase substitution of cowpea flour. Ikya *et al*. (2013) earlier reported increase in Ash content of maize/soy blend Agidi from 0.99 – 1.12 %, as substituted with 0 – 20 % soybean flour. Zakari *et al*. (2010) also reported increase in Ash content from 0.21 – 0.34 % for millet and Bambara blend Agidi, as the substitution of Bambara groundnut increased. Increase substitution of cowpea flour in the Agidi products thus increases the mineral potential of the products (Akpapunam *et al*., 1997).

The range for fat content of the "Agidi" was 0.50 - 2.49 %, with sample E having the highest (2.49 %). The fat content as seen in Table 4.2 increase with increased substitution of cowpea flour.

Crude fibre content ranged from 0.66 - 2.55%, with sample E showing significantly higher value (2.55%). Crude fibre content of all the Agidi samples were significantly ($p<0.05$) different. Higher fiber values found in the maize/cowpea blend Agidi could be attributed to the cowpea added. This was in line with Gondwe *et al*. (2019) who reported high fibre content for cowpea. Fibre is essential for effective gastro-intestine functions and in the treatment and prevention of many diseases and gastro intestinal disorder (Nkama, *et al*., 2000) and for risk reduction for a number of chronic diseases, including heart disease, certain cancers and diabetes (Bhartiya *et al*., 2015).

From the result, percentage protein ranged from 8.57 - 20.80 % with sample E showing significantly ($p<0.05$) higher value (20.80%). Protein content of the Agidi samples increased as the percentage of cowpea was increased. The increase in fat and protein was also observed by Ayinde and Olusegun, (2003). The variation of ash and crude fibre was also observed by Ayinde and Olusegun (2003). Minka and Buretean (2000) also observed similar changes in proximate composition. This is a reflection of the superior nutritional properties of cowpea flour over maize flour and it demonstrated their mutual supplementation effect.

Carbohydrate content range from to 38.00 – 52.84 % with sample A (100% maize starch Agidi) showing significantly ($p<0.05$) higher value of 52.84%, indicating that maize is a good source of carbohydrate. These carbohydrate values were however lower than 59.21 – 74.06 % reported by Oguche *et al*. (2017) for Agidi prepared with maize and soybean blend. Variation in carbohydrate content (as calculated by difference) was probably due to variation in the moisture content.

Table 3: Proximate Composition of "Agidi" produced from blends of Maize starch and Cowpea flour

Samples	Moisture (%)	Ash (%)	Fat (%)	Crude Fibre (%)	Protein (%)	CHO (%)
A	$36.95^{a}\pm0.06$	$0.48^{d}\pm0.00$	$0.50^{c}\pm0.09$	$0.66^{d}\pm0.04$	$8.57^{b}\pm0.41$	$52.84^{a}\pm0.21$
B	$36.92^{a}\pm0.01$	$0.51^{cd}\pm0.02$	$0.97^{bc}\pm0.62$	$1.26^{c}\pm0.01$	$9.84^{b}\pm1.65$	$50.50^{ab}\pm1.32$
C	$35.84^{b}\pm0.02$	$0.54^{bc}\pm0.02$	$1.03^{bc}\pm0.55$	$1.95^{b}\pm0.01$	$12.05^{b}\pm1.33$	$48.59^{b}\pm1.87$
D	$35.49^{c}\pm0.01$	$0.60^{b}\pm0.02$	$1.66^{ab}\pm0.17$	$2.17^{b}\pm0.12$	$19.66^{a}\pm0.55$	$40.42^{c}\pm0.05$
E	$35.47^{c}\pm0.01$	$0.69^{a}\pm0.02$	$2.49^{a}\pm0.09$	$2.55^{a}\pm0.028$	$20.80^{a}\pm0.09$	$38.00^{d}\pm1.17$

Values are means ± standard deviation of triplicate samples. Mean values bearing different superscript in the same Column differ significantly ($p < 0.05$).

Key: A = Maize 100%**,** B=Maize 95%, Cowpea 5%**,** C= Maize 90%, cowpea 10%**,** D= Maize 85%, cowpea 15%

E= Maize 80%, cowpea 20%

3.3 Energy Value (Kcal/100g) of "Agidi" produced from the blends of Maize starch and Cowpea flour blends.

The number of kilocalories (often termed "calories") needed per unit of a person's body weight expresses energy needs (Lawrence *et al*., 2005). From the result in Fig. 4, energy value of "Agidi" produced from Maize starch and Cowpea flour blends ranging from 250.09 – 257.61 kcal/100g. These values were significantly difference ($p<0.05$). However, there was no significant difference ($p>0.05$) in the energy value of samples A and B. Higher energy value was observed in sample E (Agidi prepared from 80 % Maize starch and 20 % Cowpea flour). Increase in energy value of the Agidi samples resulting from increase substitution of cowpea flour was probably due to increase fat content. The high caloric value of the blends is noteworthy. It is an indication that agidi produced from maize/cowpea blends would be a good source of energy. These values were in accordance with 252.07 – 253.91 kcal/100g reported by Kolawole *et al*. (2020) for Agidi prepared with maize, orange flesh sweet potato and soybean blends. Higher energy value of 416,60 – 423.40 kcal/100g (calculated on dry mass bases) had been reported for Agidi prepared from maize and soybean blends (Ikya *et al*., 2013).

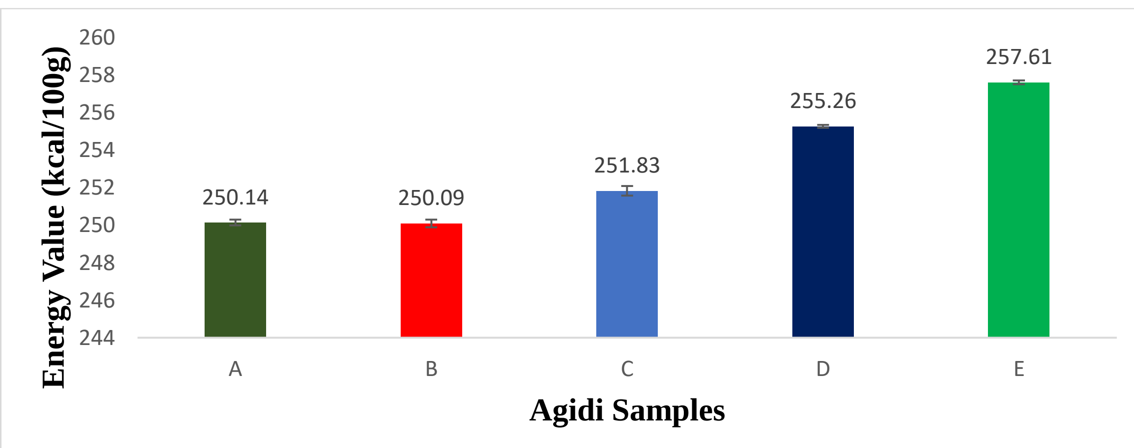

Figure 4. Energy Value (Kcal/100g) of "Agidi" produced from the blends of Maize starch and Cowpea flour blends.

3.4 Physicochemical Properties of Agidi Slurry

Physicochemical properties of the Agidi slurry as represented in Table 4. showed the pH ranging from 3.37 – 3.78 with sample E recording significantly ($p<0.05$) higher value of 3.78. There was no significant differece ($p>0.05$) in the pH of samples B, C and D. Results for pH compared favourably with pH of 3.55 – 3.90 reported earlier by Akusu *et al*. (2019) for Agidi prepared from maize, millet and sorghum flour blends, but lower than 5.30 reported earlier by Umoh and Fields (1981) for Agidi samples. Low pH is necessary for good keeping quality of any food sample (Bankole *et al*., 2013; Akusu *et al*., 2019). Viscosity of the Agidi slurry ranged from

1.340 to 1.185pas with samples D and E showing significantly (p<0.05) higher value of 1.340pas. These values also compared with the range of 0.30 – 1.95pas reported by Akusu *et al*. (2019) for maize/millet/sorghum Agidi, with maize Agidi given higher viscosity value. As supported by Esther *et al*. (2015) who reported high viscosity in maize than in millet and sorghum ogi. Viscosity of 0.845pas had been reported earlier for millet/Bambara groundnut Agidi (Zaraki *et al*., 2010). Higher viscosity seen in the present study was due to the presence of maize and increase substitution with cowpea flour which might increase the particle size of the Agidi slurry. Increase in viscosity of Agidi due to increase particle size had earlier been reported (Osingbaro, 1986).

Table 4: Physicochemical Properties of Agidi Slurry

Samples	pH	Viscosity (pas)
A	$3.37^{c}\pm0.00$	$1.185^{d}\pm4.24$
B	$3.54^{b}\pm0.06$	$1.228^{c}\pm0.00$
C	$3.59^{b}\pm0.00$	$1.284^{b}\pm5.66$
D	$3.64^{b}\pm0.04$	$1.340^{a}\pm0.00$
E	$3.78^{a}\pm0.01$	$1.340^{a}\pm0.00$

Values are means ± standard deviation of triplicate samples. Mean values bearing different superscript in the same Column differ significantly (p < 0.05).
Key: A = Maize 100%**,** B=Maize 95%, Cowpea 5%**,** C= Maize 90%, cowpea 10%**,** D= Maize 85%, cowpea 15%
E= Maize 80%, cowpea 20%

3.5 Glycemic Index of "Agidi" Prepared from the blends of Cowpea Flour and Maize Starch.

Glycemic index (GI) is a measure of the blood glucose raising potential of carbohydrate-rich foods (Ramdath, 2016). The area under the curve (AUC), hydrolytic (HI) and predicted glycemic index (GI) of 'Agidi' prepared from blends of cowpea and maize starch are presented in Table 5. AUC, HI and GI ranged from 8.40 – 15.36, 26.42 – 48.32 and 54.20 – 66.23, respectively. Mean values of the Agidi samples, in same column were all significantly different (p<0.05). AUC, HI and GI of agidi prepared with 100 % maize starch were significantly (p<0.05) higher than those of the cowpea substituted samples. AUC, HI and GI of the Agidi samples were shown to reduce significantly (p<0.05) with increase substitution of cowpea flour. According to the standard by American Society for Clinical Nutrition, foods are classified as high (GI ≥ 70), moderate (GI 56 – 69), or low (GI ≤ 55) (Foster-Powell *et al*., 2002; Huang and Miskelly, 2016). Foods with a high GI are rapidly digested and blood glucose rises rapidly after consumption (Owuno *et al*., 2021). The predicted glycaemic Index showed significant differences and the lowest value recorded in Agidi sample produced with 80 % maize starch and 20 % cowpea flour blend. This was probably due to Presence of high proportion of resistant starch and dietary fibers in cowpea flour resulting in lower GI values (Herath *et al*., 2018). Low GI of 41.4 had been reported for cowpea (Herath *et al*., 2018).

Low GI foods slow the digestion and absorption of carbohydrates and show a gradual rise in blood glucose and insulin level, which have many positive health benefits such as reducing the incidence and prevalence of heart disease, diabetes, obesity (Roberts, 2000). High GI of 85.00 - 92.30 had been reported for maize flour (Foster-Powell *et al*., 2002; Omoregie and Osagie, 2008). GI of 82.25 had also been reported for maize starch, using bread as reference sample (Mamma *et al*., 2018). GI of maize starch was reported to reduce during fermentation, to 65.49 (Mlother *et al*., 2015), this explained the relative decrease in GI of the Agidi samples in this study, which was processed through maize fermentation. Significantly ($p<0.05$) higher HI in sample A (48.32) gave higher GI (66.23). The result showed that the more cowpeaflour in the product formulations, the lower the HI which subsequently led to the reduced predicted glycemic index. This may be that cowpea contains carbohydrates whose bulk may consist of non-starch polysaccharides with a low GI. Studies have shown that a low GI diet not only improves certain metabolic consequence of insulin resistance but also reduces insulin resistances (Kiin-Kabari and Giami, 2016).

The health implications of the high GI of the processed foods are that they could cause a fast and short – lived rise in blood sugar, with the result that one is lacking in energy and hungry within a short time, thus the desire to eat will arise. If this pattern is repeated, there is the likelihood of gaining weight as a result of constantly eating. The overall effects are that the individual will gain weight and obesity might results. It could trigger diabetes in individuals that are prone to the disease, or worsen the management of the disease (Gilberston *et al.*, 2001). Reports by earlier researchers have indicated a positive correlation between high G I and risk of type II diabetes (Salmeron *et al*., 1997).

Table 5 Glycemic Index of "Agidi" Prepared from the blends of Cowpea Flour and Maize Starch.

Samples	AUC	HI	GI
A	$15.36^{a}\pm0.014$	$48.32^{a}\pm0.045$	$66.23^{a}\pm0.024$
B	$12.00^{b}\pm0.000$	$37.77^{b}\pm0.000$	$60.43^{b}\pm0.000$
C	$11.13^{c}\pm0.028$	$35.02^{c}\pm0.089$	$58.92^{c}\pm0.049$
D	$10.42^{d}\pm0.014$	$32.77^{d}\pm0.045$	$57.69^{d}\pm0.024$
E	$8.40^{e}\pm0.042$	$26.42^{e}\pm0.134$	$54.20^{e}\pm0.007$

Values are means ± standard deviation of triplicate samples. Mean values bearing different superscript in the same Column differ significantly ($p < 0.05$).

Key: A = Maize 100%**,** B=Maize 95%, Cowpea 5%**,** C= Maize 90%, cowpea 10%**,** D= Maize 85%, cowpea 15%

E= Maize 80%, cowpea 20%

3.6 Invitro Protein Digestibility of "Agidi" Prepared from the blends of Cowpea Flour and Maize Starch.

From the result in Figure 5, percentage invitro digestible protein (IVPD) ranged from 8.74 – 17.47 % for samples A – E. These mean values were significantly different ($p<0.05$), however, there was no significant difference ($p>0.05$) in the IVPD of samples B, C and D. Protein digestibility is a primary determinant of the availability of amino acids and, therefore, protein digestibility is important in evaluating the nutritive quality of a food protein (Hassan, 2011). Percentage invitro protein digestibility of Agidi produced with 80 % maize starch and 20 %

cowpea flour was significantly ($p<0.05$) higher. Increase in IVPD was probably due to increased substitution of cowpea flour in the blend. High percentage IVPD of 68.,7 – 72.0 % had been reported earlier for cowpea (Teka *et al*., 2020). The nutritional quality of any protein relates to its amino acid composition, digestibility, and ability to supply the essential amino acids in the amounts required by the species consuming the protein (Kiin-Kabari *et al*., 2021). Protein is needed as building blocks for the body, necessary for growth and for the repair of damaged tissues (Wardlaw, 2004)

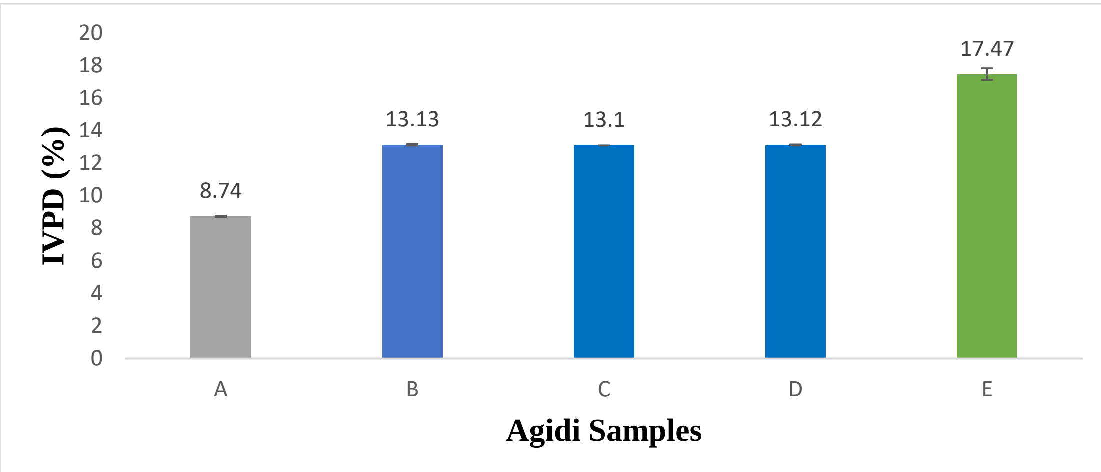

Figure 5 Invitro Protein Digestibility of "Agidi" Prepared from the blends of Cowpea Flour and Maize Starch. (IVPD = invitro protein digestibility)

3.7 Sensory Properties of "Agidi" prepared from the blends of Cowpea Flour and Maize starch.

Table 6 showed the scores for sensory properties of Agidi samples produced from blends of Maize starch and Cowpea flour. The colour score ranged from 7.10 - 7.45 with sample C (90% maize and 10% cowpea flour) scored higher while sample B (95% maize and 5% cowpea flour) scored relatively lower, however, these mean values were not significantly difference ($p>0.05$). Aroma ranged from 6.25 - 7.20, these mean scores were not significantly difference ($p>0.05$). Appearance scores for Agidi produced from 80 % maize starch and 20 % cowpea flour was seen higher, but this value was not significantly different ($p>0.05$) from the Appearance scores for other samples. Colour and appearance are important sensory attributes which affect the perception of other attributes, such as aroma, taste and flavor (Hutching, 1999). The mean scores for Taste, Texture and Overall acceptability were shown ranging from 6.45 – 6.95, 6.85 – 7.05 and 6.73 – 7.12, respectively. Agidi prepared with 100% maize had been reported to attract high sensory scores of 7.33 - 8.40 (Akusu *et al*., 2019). The mean scores for each of these responses (column wise) were not significantly different ($p>0.05$), showing that Agidi enriched with cowpea flour received equal acceptability with the conventional Corn starch Agidi.

Table 6: Sensory Properties of "Agidi" prepared from the blends of Cowpea Flour and Maize starch.

Samples	Colour	Appearance	Aroma	Sogginess	Taste	Texture	Overall

							Acceptability
A	7.30^{a}±1.53	7.05^{a}±1.40	6.95^{a}±1.15	7.05^{a}±1.28	6.85^{a}±1.57	6.85^{a}±1.42	7.01^{a}±1.01
B	7.10^{a}±1.37	6.95^{a}±1.28	7.20^{a}±1.15	6.80^{a}±1.01	6.85^{a}±1.53	7.05^{a}±1.23	6.99^{a}±0.95
C	7.45^{a}±1.57	7.30^{a}±1.42	6.95^{a}±1.43	7.05^{a}±1.00	6.95^{a}±1.73	7.00^{a}±1.38	7.12^{a}±1.10
D	7.25^{a}±1.52	7.10^{a}±1.33	6.25^{a}±2.07	6.35^{a}±1.81	6.55^{a}±2.04	6.90^{a}±1.55	6.73^{a}±1.38
E	7.25^{a}±1.48	7.35^{a}±1.53	6.90^{a}±1.83	6.40^{a}±1.85	6.45^{a}±1.85	6.95^{a}±2.08	6.88^{a}±1.47

Values are means ± standard deviation of 20 responses. Mean values bearing different superscript in the same Column differ significantly ($p < 0.05$).

Key: A = Maize 100%**,** B=Maize 95%, Cowpea 5%**,** C= Maize 90%, cowpea 10%**,** D= Maize 85%, cowpea 15%

E= Maize 80%, cowpea 20%

4 CONCLUSSION AND RECOMMENDATIONS

The results revealed that Ash, fat, crude fiber and protein content of the maize starch and cowpea flour Agidi increased with increase substitution of cowpea flour. Crude fiber and protein content of Agidi substituted with 20 % cowpea flour were significantly higher (2.55 and 20.80 %). Though carbohydrate content of the Agidi decreased as the percentage substitution of cowpea flour increased, but energy value increased due to increased fat and protein content. With higher energy value of 257.61 kcal/100g in sample E.

Water absorption capacity, bulk density and least gelation capacity of the cowpea substituted Agidi samples compared favourably with the conventional 100% maize starch Agidi. No significant difference was noticed in the functional properties for all samples. The pH ranged from 3.37 – 3.78, a good range for better shelf stability. Viscosity of Agidi substituted with 15 and 20 % cowpea flour gave 1.34 pas, in each case, good for stiff porridge stability and mouthfeel. Percentage invitro protein digestibility increased as substitution of cowpea flour increased.

Hydrolytic and glycemic index of the Agidi samples reduced significantly with increase substitution of cowpea flour. GI of samples A, B, C and D were in the moderate range of 57.69 – 66.23, while the GI of sample E (54.20) was in the low range. The mean scores for each of these responses (column wise) were not significantly different ($p>0.05$), showing that Agidi enriched with cowpea flour received equal acceptability with the conventional Corn starch Agidi. Use of cowpea flour at 20 % substitution with fermented maize starch for Agidi preparation is recommended, to enhance nutritional potentials.

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