Functional Properties of Tigernut and Cowpea Flour Blends

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Abstract — **The pH and functional properties: water and oil absorption capacity, bulk density, solubility, swelling power and foaming capacity of tigernut and cowpea flour blends were determined. The flour blends were coded with the letters B, C, D, E, F, G and H for cowpea flour substitutions of 5, 10, 15, 20, 30, 40 and 50 % respectively. For comparison sample A1, A2 and A3 representing 100 % of wheat, tigernut and cowpea respectively, were also evaluated. Standard methods were used for all the analysis. pH of the flour samples varied significantly ($P \leq 0.05$) from 5.60-6.23 for sample B (5 % cowpea flour substitution) and A2 (100% tiger nut flour) respectively. Water and oil absorption capacity varied significantly ($P \leq 0.05$) from 1.00-2.90 ml/g and 0.39-1.38 ml/g respectively. Sample A1 (100% wheat flour) and Sample B (5% Cowpea: 95% tigernut flour) was significantly ($P \leq 0.05$) the highest in water absorption capacity while sample A1 (% wheat flour) had the highest oil absorption capacity. Bulk density varied from 0.58 - 0.84 g/cm³. Although Cowpea flour (sample A3) had the highest bulk density, there was significant ($P \leq 0.05$) decrease with increase in cowpea substitution. Swelling power and solubility ranged from 0.08-6.74 g/g and 8.00–67.35 % respectively. Sample A1 (% wheat flour) had significantly ($P \leq 0.05$) the highest solubility and swelling power while Sample A3 (% cowpea flour) had the least. The functional properties of the tigernut-cowpea composite flour were comparable with that of the wheat flour, except for the swelling power that was significantly ($P \leq 0.05$) higher for the wheat flour. The result showed that the composite tigernut-cowpea flour can be good alternative in the production of bakery products that would not require much swelling.**

Index Terms — **Cowpea, flour, functional properties, tigernut.**

I. INTRODUCTION

Tigernut (*Cyperus esculentus*) is a tuber crop that belong to the Division Magnoliophyta, Class-Liliopsida, Order-Cyperales and Family Cyperaceae [1]. It is usually cultivated as a result of its rhizomes which grow into tubers for human consumption. There are three varieties of tigernut tubers easily identified based on the colour of the tubers. They are the yellow, brown and black variety. The yellow and brown are commonly seen in most local markets in Nigeria. The yellow variety has the large and the small tuber variety [2]. The bigger variety has a bigger size, fleshier body and attractive colour. The principal component of tigernut is carbohydrates mainly starch and fibre. The starch content is almost twice the quantity in potato tubers while the moisture content is lower than those of true tubers [3]-[5]. Tigernut has been reported to confer different health benefits: reduction of the risk of colon cancer, prevention of heart disease and thrombosis, activation of blood circulation [6], [7]. The tuber is also considered to be suitable for diabetics and for weight loss as it is rich in starch, fat, sugar, protein, minerals (mainly phosphorus and potassium), and vitamins E and C [8], [9]. Tigernut can be eaten raw after thorough washing [10]. It is mostly processed into milk like beverage known as *horchata de chufa* in Spain and by other names in different parts of the world. It has also been processed into flour and used in bakery products [1]. Cantatejo, [11] reported that the flour does not lose any of its nutritious properties in the milling process and it gives a smooth, creamy texture with a distinctive taste which fish love when incorporated into fish feed and baits. These qualities can be explored for bakery products by incorporating tigernut flour.

Cowpea is a leguminous plant belonging to the family of *fabaceae*. It is also referred to as black eye peas depending on the colouration around the helium. It plays a critical role in the lives of millions of people in Africa and other parts of the developing words, where it's a major source of dietary protein and nutritionally complements staple low-protein cereal and tuber crops and is available and dependable commodity that produces income for farmers and traders [12]. It is also a rich source of micro-nutrients: mineral (iron and zinc) and vitamins (folic acid and B vitamins which are necessary for health [13], [14]. Cowpea is an important legume in the tropics and has many uses: in fresh form the young braves, immature pods and pea are used as vegetables while several snacks and main meal dishes are prepared from the grains [15]. It can be consumed whole with stew after boiling while different other products such as *akara* and *moimoi* can be made based on wet milled paste [16]. It can also be processed into flour for bakery products such as cookies and bread as well as in comminuted meat products such as chicken nugget [17], [18]. Cowpea flour can offer a versatile food ingredient for use in making of different food products depending on the effect of the ingredient on the functional properties of the food

Functional properties are those vital physical and chemical properties that reflect the complex interaction between the composition, structure, and molecular conformation of food components together with the nature of environment in which these are measured [19]. They give a description of the behaviour of food ingredients during preparation and processing and reflects how they affect the finished food products in terms of its sensory attributes. Some examples of functional properties include Water absorption capacity, oil absorption capacity, swelling capacity, foam capacity, foam stability, bulk density, emulsion activity and stability, gelatinization etc. The components of the food ingredients such as moisture, proteins, carbohydrates, fat, fibre and ash

can influence the functional properties of the food, which can be used to evaluate how new food components will behave in specific systems [19], [20]. According to Chandra et al. [19] a mixture of different vegetables flours rich in starch or protein, with or without wheat flour, for certain groups of bakery products are referred to as Composite flours. Protein and starch are the major macro molecules that contribute towards the functionality of flour. This implies that flour from tubers rich in starch such as tigernut and flour from legumes rich in protein such as cowpea can be blended for the production of bakery products. This study was therefore designed to determine the functional properties of tigernut-cowpea composite flour for suitability in bakery products.

II. MATERIALS AND METHODS

A. Tigernut and Cowpea Samples

Yellow variety of tiger nut (fresh) and cowpea were purchased from Mile III market in Port Harcourt Rivers State, Nigeria.

B. Preparation of Cowpea Flour

Cowpea flour was prepared according to the method of Madode et al. [21]. Briefly, the cowpea seeds were sorted and cleaned to remove extraneous matter (stones, chaff, broken seeds, and insect), soaked in water and dehulled. The dehulled beans were oven dried at 60 °C for 24 h in an air oven (Gallenkamp, UK) and then milled with an attrition mill. The milled samples were sieved through a net with mesh size of 75 μm to obtain a fine flour that were packaged in low density polyethylene bags, sealed, and stored in refrigerators till required for analysis.

C. Preparation of Tiger Nut Flour

The method by Adejuyitan, [22] was used in the production of the tiger nut flour. Fresh tubers were sorted to remove unwanted matter (organic matters and damaged tubers), washed in water and oven dried at 60 °C for 24 h in an air oven (Gallenkamp, UK). The dried tubers were milled with an attrition mill and sieved through a net with mesh size of 75 μm to obtain a fine flour. The flour was packaged in low density polyethylene bags, sealed and store in refrigerators till required for analysis.

D. Tigernut-cowpea Flour Blends

Flour blends used in the production of tiger nut – cowpea pancakes.

TABLE I: FORMULATION OF THE TIGERNUT-COWPEA FLOUR BLENDS

Flour	Sample code									
	A1*	A2	A3	B	C	D	E	F	G	H
Tigernut	0	100	0	95	90	85	80	70	50	60
Cowpea	0	0	100	5	10	15	20	30	50	40

* Sample A1 is 100% wheat flour.

E. Determination of pH

The standard AOAC, [23] method was used to determine the pH of the flour samples. The pH of 1 g of the sample in 10 ml of distilled water in a glass beaker was determined using a digital pH meter (PHs - 2f Harris England) after calibration with standard buffer of pH 4.0 and 7.0.

F. Determination of Water and Oil Absorption Capacity

The method by Mbofung et al. [24] was adopted in the determination of the water and oil absorption capacity. About 0.5 g of sample was added to 10 ml of distilled water and oil respectively, for water and oil absorption in a pre-weighed centrifuge tube. The centrifuge tube and content were agitated on a start scientific orbital shaker for 5 min and centrifuged at 3000 rpm for 10 min in a centrifuge (L. 600, China). The ml of the clear supernatant was subtracted from 10 ml of distilled water and the result expressed as ml/g.

G. Determination of Bulk Density

Bulk density was determined according to the standard method of AOAC, [23]. Briefly, 5 g of the flour was added to a 20 mL graduated measuring cylinder. The cylinder was tap gently until the samples was closely packed. The volume occupied by the sample was noted and the bulk density (g/cm^3) was expressed as weight of flour (g) divided by flour volume (cm^3).

H. Determination of Solubility and Swelling Power

The method described by Ayo et al. [25] was adopted in the determination of the solubility and swelling power of the tigernut-cowpea flour blends. The flour (1 g) was mixed with 10 ml of distilled water in a centrifuge tube and heated to 80 °C and held for 30 min with continuous shaking. The heated suspension was centrifuged at 1000 x g for 15 min. The weight of the supernatant and the sediment was taken. Swelling capacity (g/g) was expressed as weight of sediment divided by the weight of the sample while solubility index (%) was expressed as weight of supernatant divided by weight of the sample multiplied by 100.

I. Determination of Foaming Capacity

Foaming capacity was determined using the method Narayana and Narasinga, [26]. The flour sample (2 g) was added to 50 ml distilled water at 30 °C in a 100 ml measuring cylinder. The suspension was thoroughly mixed and properly shaken to foam and the volume of the foam was recorded after 30 s. The forming capacity (5) was expressed as a percentage increase in volume.

J. Statistical Analysis

Minitab (Release 18.0) Statistical Software (Minitab Ltd., Coventry, UK) was used for the analysis of the data obtained. Statistical differences were obtained using analysis of variance (ANOVA) under the general linear model and Fisher pairwise comparison at 95% confidence level. Statistical differences among the sensory attributes was established using the non-parametric Friedman test.

III. RESULTS AND DISCUSSION

A. pH of Tiger Nut-cowpea Flour Blends Used in the Production of Pancakes

The pH of the flour samples varied significantly ($P \leq 0.05$) as shown in Fig. 1. The values ranged from 5.60-6.23 for sample B (5 % cowpea flour substitution) and AB (100% tiger nut flour) respectively. The pH of the tiger nut-cowpea flour was comparable with the pH values reported by Bolarinwa et al. [27] and Ade-Omowaye et al. [28] for malted

sorghum-soy and tigernut-wheat composite flour. not acidic. The composite flours can therefore be used to produce acceptable products for people suffering from stomach or pectic ulcer.
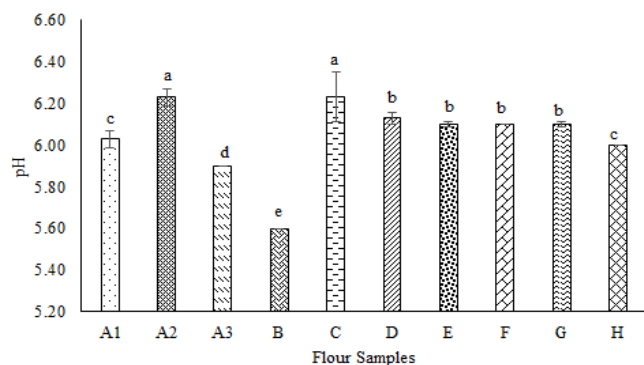

Fig. 1. pH of tiger nut-cowpea flour blends.
Columns and error bars represent the mean and standard deviation of duplicate determination.
Means with the same alphabets are not significantly ($P \geq 0.05$) different.
A1 = 100% Wheat flour; A2 = 100% Tiger nut flour; A3 = 100 % Cowpea flour; B = 95 % Tigernut: 5 % Cowpea flour; C = 90 % Tigernut: 10 % Cowpea flour; D = 85 % Tigernut: 15 % Cowpea flour; E = 80 % Tigernut: 20 % Cowpea flour; F = 70 % Tiger nut: 30 % Cowpea flour; G = 60 % Tigernut: 40 % Cowpea flour; H =5 0 % Tigernut: 50 % Cowpea flour.

B. Water and Oil Absorption Capacity (ml/g) of the Tigernut-cowpea Flour Blends

Table 2 showed the water and oil absorption capacities of the different tigernut-cowpea flour blends. The water absorption capacity of the flour samples varied significantly ($P \leq 0.05$) from 1.00 - 2.90 ml/g for sample A1 (100% wheat flour) and sample B (5% Cowpea: 95% tigernut flour) respectively. Water absorption capacity is a description of flour to water association ability with limited water supply [29]. The water absorption capacity of the cowpea flour and its 5 and 15% substitution (sample A3-C) were comparable with the report by Appiah et al. [30] and Moutaleb et al. [31] for cowpea flour. The others were comparable with the report by Chandra et al. [19] but higher than the report by Ade-Omowaye et al. [28]. Carbohydrate and protein concentration can influence water absorption capacity [30]. High water absorption capacity indicates that such flour will be useful in the formulation of some foods such as sausage, dough, processed cheese, and bakery products [19]. The result of the tigernut-cowpea flour suggests that they may find application in baked products.

Oil absorption capacity ranged from 0.39-1.38 ml/g. The wheat flour (sample A1) had significantly ($P \leq 0.05$) the highest oil absorption capacity while the cowpea flour (sample A3) was significantly ($P \leq 0.05$) the least. There was significant ($P \leq 0.05$) decrease in the result for the tigernut-cowpea flour blends with increase in cowpea flour substitution. The result for tigernut and wheat flour were comparable with other reports [29], [19]. The lower oil absorption capacity of cowpea flour may be attributed to its high protein content. Protein is a major chemical component that affects oil absorption capacity as it is composed of both hydrophilic and hydrophobic parts [19].

TABLE 2: WATER AND OIL ABSORPTION CAPACITY OF TIGERNUT-COWPEA FLOUR BLENDS

Sample code	Flour (Tigernut: Cowpea)	Oil Absorption capacity	Water Absorption capacity
A1	100% Wheat flour	1.38±0.13[a]	1.00±0.03[d]
A2	100% Tiger nut flour	1.35±0.14[a]	1.35±0.08[cd]
A3	100 % Cowpea flour	0.97±0.00[b]	1.42±0.28[c]
B	95:5	0.39±0.15[b]	2.90±0.00[a]
C	90:10	0.99±0.14[b]	2.00±0.00[b]
D	85:15	0.79±0.00[b]	1.22±0.28[cd]
E	80:20	0.78±0.00[b]	1.00±0.03[d]
F	70:30	0.79±0.00[b]	1.00±0.03[d]
G	60:40	0.79±0.00[b]	1.00±0.03d
H	50:50	0.99±0.16[b]	1.22±0.28[cd]

Values are mean ± standard deviation of duplicate determination.
Means with the same superscript along the same column are not significantly ($P \geq 0.05$) different.

C. Bulk Density (g/cm³) of the Tigernut-cowpea Flour Blends

Bulk density of the tigernut-cowpea flour blends is shown in Fig. 2. The bulk density varied from 0.58-0.84 g/cm³. Sample A3 (100% cowpea flour) had significantly ($P \leq 0.05$) the highest bulk density while sample H (50% Cowpea: 50% tiger nut flour) had least. There was significant ($P \leq 0.05$) decrease in bulk density with increase in cowpea substitution although cowpea flour had significantly the highest bulk density. The bulk density of sample B and C with 5 and 10 % cowpea substitution was not significantly ($P \geq 0.05$) different from that of wheat flour. The bulk densities of samples D – H were comparable with those of wheat-tigernut flour reported by Ade-Omowaye et al. [28], while sample A1–C were higher and comparable to the report by Chandra et al. [19]. The bulk density of the yellow tigernut flour (A2) was similar to the report by Oladele and Aina, [29], while that of the cowpea flour was similar to the report of Moutaleb et al. [31]. High bulk density of flour suggests their suitability for use in food preparations [19].
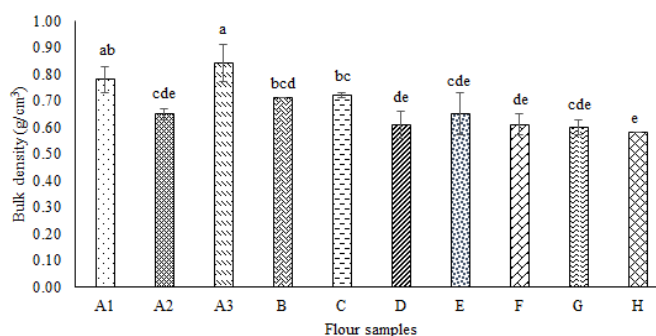

Fig. 2. Bulk density of tigernut-cowpea flour blends.
Columns and error bars represent the mean and standard deviation of duplicate determination.
Means with the same alphabets are not significantly ($P \geq 0.05$) different.
A1 = 100% Wheat flour; A2 = 100% Tiger nut flour; A3 = 100 % Cowpea flour; B = 95 % Tigernut: 5 % Cowpea flour; C = 90 % Tigernut: 10 % Cowpea flour; D = 85 % Tigernut: 15 % Cowpea flour; E = 80 % Tigernut: 20 % Cowpea flour; F = 70 % Tiger nut: 30 % Cowpea flour; G = 60 % Tigernut: 40 % Cowpea flour; H =5 0 % Tigernut: 50 % Cowpea flour.

D. Swelling Power and Solubility of the Tigernut-cowpea Flour Blends

The swelling power (g/g) and solubility (%) of the different blends of the tigernut-cowpea flour are shown in Table 3. The swelling power and solubility of the flour samples varied significantly ($P \leq 0.05$) from 0.08 - 6.74 g/g and 8.00–67.35% respectively. Wheat flour (Sample A1) had significantly ($P \leq 0.05$) the highest solubility and swelling power while cowpea had the least. The swelling power of the cowpea flour was lower than the report by Moutaleb et al. [31]. The swelling power of the tigernut-cowpea flour was influenced by the low swelling power of the cowpea flour. The swelling power of the tigernut-cowpea flour blends were comparable with the report by Ayo et al. [25] for tigernut flour. Swelling power is an indication of the cumulative effects of starch quality, specifically amylose/amylopectin ratio as reflected by the volume of gel produced when flour is heated with an excess of water [32]. The starch quality of wheat could have influenced its high swelling power. Flour with low swelling power and solubility will influence the quality of bakery product as the product will not raise [33].

TABLE 3: SWELLING POWER AND SOLUBILITY OF TIGERNUT-COWPEA FLOUR BLENDS

Sample code	Flour (Tigernut: Cowpea)	Swelling power (g/g)	Solubility (%)
A1	100% Wheat flour	6.74±0.30[a]	67.35±30.41[a]
A2	100% Tiger nut flour	0.78±0.00[b]	7.80±0.00[b]
A3	100 % Cowpea flour	0.08±0.00[g]	8.00±0.00[g]
B	95:5	0.43±0.15[c]	42.50±1.85[c]
C	90:10	0.35±0.06[de]	35.00±0.57[de]
D	85:15	0.28±0.06[e]	28.00±0.66[e]
E	80:20	0.40±0.11[cd]	39.50±1.06[cd]
F	70:30	0.46±0.02[c]	45.50±2.12[c]
G	60:40	0.17±0.04[f]	16.50±1.30[f]
H	50:50	0.30±0.05[e]	29.50±1.95[e]

Values are mean ± standard deviation of duplicate determination.
Means with the same superscript along the same column are not significantly ($P \geq 0.05$) different.

E. Foaming Capacity of the Tigernut-cowpea Flour Blends

Foaming capacity of the flour samples are shown in Fig. 3. It varied from 22.00 - 71.50 %. The foaming capacity of the wheat flour was lower than the report by Chandra et al. [19]. The result for tigernut flour was Cowpea flour had significantly ($P \leq 0.05$) the highest foaming capacity. This can be attributed to the protein content of cowpea. According to Adebowale et al. [34] good foaming capacity is dependent on the ability of protein to adsorb rapidly at air - water interface during bubbling and undergo rapid conformational change and re-arrangement at the interface.
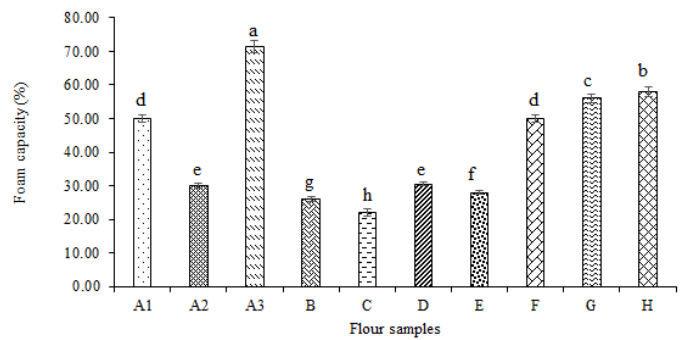

Fig. 3. Foaming capacity of tiger nut-cowpea flour blends.
Columns and error bars represent the mean and standard deviation of duplicate determination.
Means with the same alphabets are not significantly ($P \geq 0.05$) different.
A1 = 100% Wheat flour; A2 = 100% Tiger nut flour; A3 = 100 % Cowpea flour; B = 95 % Tigernut: 5 % Cowpea flour; C = 90 % Tigernut: 10 % Cowpea flour; D = 85 % Tigernut: 15 % Cowpea flour; E = 80 % Tigernut: 20 % Cowpea flour; F = 70 % Tiger nut: 30 % Cowpea flour; G = 60 % Tigernut: 40 % Cowpea flour; H =5 0 % Tigernut: 50 % Cowpea flour.

IV. CONCLUSION

The functional properties of the tigernut-cowpea composite flour were comparable with that of the wheat flour, except for the swelling power that was significantly ($P \leq 0.05$) higher for the wheat flour. The result suggests that the composite tigernut-cowpea flour can be good alternative in the production of gluten free bakery products that would not require much swelling. It is therefore recommended that these flour blends should be used in the production of bakery products and the qualities of such products be evaluated and consumer acceptability ascertained.

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