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Functional, organoleptic assessment and nutritional composition of akara produced from cowpea (*Vigna unguiculata*)–fonio millet (*Digitaria exilis*) flour blends

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ABSTRACT

This study investigated the effect of supplementing cowpea flour with fonio millet flour on the functional, organoleptic, and nutritional properties of akara. Flour blends were analyzed for their pasting and functional properties, while the proximate composition, mineral content, and sensory qualities of the resulting akara were also evaluated. Pure cowpea flour (100%) served as the control and was substituted with fonio millet at varying ratios (5%, 10%, 15%, 20%, 50%, 85%, and 100%). Pasting characteristics such as peak viscosity, trough viscosity, breakdown, final viscosity, setback, peak time, and pasting temperature ranged from 181–1314 RVU, 161–1253 RVU, 8–20 RVU, 292–2905 RVU, 107–1652 RVU, 4.4–6.9 min, and 83.1–87.3°C, respectively. Functional properties, including bulk density, swelling capacity, foam stability, foam capacity, oil and water absorption capacities, and least gelation capacity, showed variation across blends. Substitution with fonio millet increased protein, fat, fiber, and mineral content, while moisture and ash contents remained relatively stable. Sensory analysis revealed high acceptability for akara, particularly from the 90:10 cowpea to fonio millet blend. The findings demonstrate the potential for producing nutritionally enhanced akara using cowpea-fonio blends, thereby promoting local crop utilization and dietary diversity.

Keywords: Akara, Organoleptic, Nutrition, Cowpea, Fonio millet, Nigeria

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Introduction

Akara (bean cake) is a widely consumed deep-fried snack in Sub-Saharan Africa, particularly Nigeria, valued for its affordability, sensory appeal, and nutritional quality (Ngoddy *et al.*, 1986; Singh *et al.*, 2004). It is traditionally prepared from a paste of dehulled cowpea (*Vigna unguiculata*). Although cowpea is rich in protein, carbohydrates, and dietary fiber, it is deficient in sulfur-containing amino acids such as methionine and cysteine (Olapade *et al.*, 2012; Ogundele *et al.*, 2014).

Fonio millet (*Digitaria exilis*), an indigenous West African cereal, is known for its high methionine and cysteine content as well as its mineral richness (Coda *et al.*, 2010). Fonio also contains beneficial levels of dietary fiber and is associated with low glycemic responses (Ibrahim and Saidu, 2017). Integrating fonio into commonly consumed foods such as akara may help address protein-quality limitations and micronutrient deficiencies while promoting the use of underutilized local crops (Adediran *et al.*, 2013).

This study examined the pasting and functional properties of cowpea–fonio flour blends and evaluated the proximate composition, mineral profile, and sensory characteristics of akara produced from these blends.

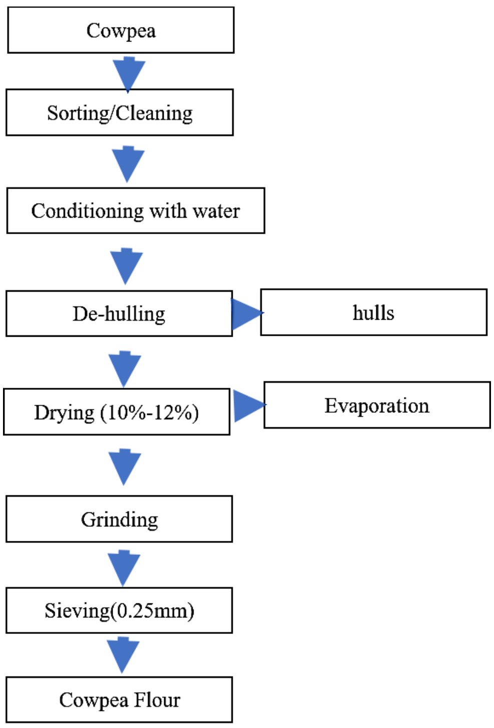
Materials and Methods

Materials, flour preparation, formulation of blends, akara preparation, sensory evaluation, chemical analyses, and statistical analysis were carried out using standard methods as described in the revised manuscript.

Cowpea (black-eyed peas) and fonio millet were purchased from Jimeta Modern Market, Adamawa State, Nigeria. Other ingredients (tatashe pepper, vegetable oil, salt, seasoning cubes, and onions) were obtained from a local market. All chemicals were of analytical grade and sourced from the Biochemistry Laboratory, Department of Food Science and Technology, Modibbo Adama University.

Preparation of cowpea flour

The protocol for cowpea flour production was adapted from Ilesanmi and Nkama (2017). After manual cleaning to remove foreign matter, the grains underwent a one-hour water soak to facilitate seed coat removal. The dehulled cotyledons were then thoroughly washed, wet-milled into a slurry and dehydrated in a forced-air oven at 70°C for two days. The resulting dry cake was pulverized into a fine powder using a hammer mill, passed through a 150-micron sieve, and stored under airtight conditions until use.

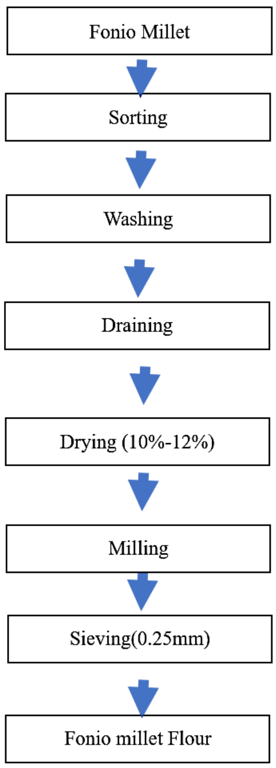


Process flow diagram of Cowpea flour preparation.

Source: Ilesanmi and Nkama (2017).

Preparation of fonio flour

The production of fonio millet flour followed established protocols with minor modifications adopted from Ibrahim and Saidu (2017). The initial step involved cleaning the raw fonio (*Digitaria exilis*) grains. This was achieved by washing under running tap water followed by decantation, effectively removing sand, stones, and other field debris. To achieve stable moisture content suitable for milling, the cleaned grains were subjected to drying in a hot-air oven maintained at 55°C (±2°C) for approximately 46 hours. The thoroughly dried grains were then comminuted using an electric mill. To obtain a flour of consistent granulation, the milled material was passed through a standard 0.30 mm sieve. The finished fonio flour was immediately transferred into high-density polyethylene containers with sealed lids to prevent moisture uptake and stored at ambient temperature until used in blend formulation.



Process flow diagram of Fonio-millet flour preparation.

Source: Ibrahim and Saidu (2017).

Formulation of flour blends

Cowpea and fonio flours were blended in the ratios 100:0, 95:5, 90:10, 85:15, 80:20, 50:50, 15:85, and 0:100 (w/w). Each 200 g blend was mixed with 40 g tatashe pepper, 6 g salt, 15 g seasoning cubes, and 40 g onions.

Preparation of akara

Each flour blend was mixed with ingredients to form a uniform batter and deep-fried in vegetable oil at moderate heat until golden brown.

Sensory evaluation

Twenty semi-trained panelists evaluated appearance, taste, sponginess, sogginess, flavor, and overall acceptability using a 9-point hedonic scale, following AOAC (2005) guidelines.

Chemical analyses

Pasting properties were determined using a Rapid Visco Analyzer (RVA). Functional properties assessed included bulk density, swelling capacity, foaming characteristics, oil absorption capacity (OAC), water absorption capacity (WAC), and least gelation concentration (LGC). Proximate composition was analyzed using AOAC (2005) methods; carbohydrate content was calculated by difference (Onwuka, 2005). Mineral elements (Cr, Cu, Fe, Mn, Zn, Na, K, Ca, Mg, P) were quantified using an atomic absorption spectrophotometer (UNICAM Model 939, UK).

Statistical analysis

Data were analyzed using one-way ANOVA, and mean separation was performed with Duncan's Multiple Range Test at $p < 0.05$ using SPSS 23.0.

Results and Discussion

Significant variations ($p<0.05$) were recorded in the pasting, functional, proximate, mineral, and sensory properties of the akara samples as the proportion of fonio millet flour increased. Blends containing moderate levels of fonio (5–15%) yielded akara that was both nutritionally superior and highly acceptable to consumers.

Pasting properties

Table 1. Pasting properties of cowpea-fonio millet flour blends.

Sample	Peak Viscosity (RVU)	Trough (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temp (°C)
AC	181.13±0.70^{h}	161.00±0.58^{h}	20.00±0.00^{d}	305.00±0.58^{h}	143.15±0.60^{h}	4.62±0.02^{e}	83.91±0.35^{e}
A1	184.00±0.58^{g}	176.00±0.26^{g}	8.00±0.00^{e}	348.77±0.34^{g}	173.07±0.64^{g}	6.48±0.27^{c}	83.23±0.50^{f}
A2	212.00±0.58^{f}	185.00±0.58^{f}	27.00±0.00^{c}	292.00±0.58^{f}	107.00±0.58^{f}	4.60±0.06^{e}	85.30±0.06^{d}
A3	252.00±0.12^{e}	244.67±0.44^{e}	8.00±0.00^{e}	491.67±1.30^{e}	247.67±0.92^{e}	6.93±0.02^{a}	87.25±0.03^{a}
A4	262.00±0.58^{d}	233.00±0.63^{d}	28.00±0.00^{b}	455.00±0.58^{d}	222.00±0.64^{d}	4.60±0.00^{e}	86.45±0.15^{b}
A5	293.00±0.58^{c}	285.00±0.58^{c}	8.00±0.00^{e}	590.00±0.58^{c}	306.00±0.58^{c}	6.88±0.01^{b}	86.35±0.00^{b}
A6	679.00±0.58^{b}	470.00±0.58^{b}	28.00±0.58^{b}	1070.00±0.68^{b}	600.00±0.57^{b}	4.60±0.00^{e}	83.15±0.58^{g}
A7	1314.00±0.58^{a}	1253.00±0.58^{a}	61.00±0.58^{a}	2905.00±0.58^{a}	1652.00±0.58^{a}	5.47±0.00^{d}	85.50±0.58^{c}

Values are means ± SD of triplicate determinations. Means in the same column with different superscripts differ significantly ($p < 0.05$).

Key:

AC = 100% cowpea flour (control sample)
A1 = 95% cowpea flour : 5% fonio millet flour
A2 = 90% cowpea flour : 10% fonio millet flour
A3 = 85% cowpea flour : 15% fonio millet flour
A4 = 80% cowpea flour : 20% fonio millet flour
A5 = 50% cowpea flour : 50% fonio millet flour
A6 = 15% cowpea flour : 85% fonio millet flour
A7 = 0% cowpea flour : 100% fonio millet flour

The pasting characteristics of the flour blends, determined by Rapid Visco Analyzer, are detailed in Table 1. All measured parameters showed significant differences among the formulations. Peak viscosity, an indicator of starch swelling power during heating, exhibited a wide range from 181.13 RVU in the 100% cowpea control (AC) to 1314.00 RVU in the 100% fonio sample (A7). This marked increase suggests that fonio starch possesses a greater capacity for gelatinization under heat and shear compared to cowpea starch.

Breakdown viscosity, which reflects the paste stability under continued heating and mechanical stress, was generally lower in blends with higher cowpea content. This trend implies that cowpea-rich pastes are more resistant to breakdown, offering better thermal stability during cooking processes like frying. Conversely, setback viscosity, associated with starch retrogradation and gel firming upon cooling, increased substantially with higher fonio inclusion. The high setback value (1652 RVU) in the 100% fonio flour points to a stronger tendency for its cooked paste to form a firm gel upon cooling, which could influence the final texture of products.

The time and temperature required for gelatinization also varied. Peak time ranged from 4.40 to 6.93 minutes, while pasting temperature spanned 83.1°C to 87.3°C. The longest peak time and highest pasting temperature were observed in the 85:15 cowpea-fonio blend (A3), indicating that this specific formulation required more thermal energy and time for its starch granules to fully swell.

Functional properties

Table 2. Functional property of cowpea-fonio millet flour blends.

Sample	Loose Bulk (g/cm³)	Packed Bulk (g/cm³)	Swelling Capacity (%)	Foam Stability (%)	Foam Capacity (%)	OAC (%)	WAC (%)	LGC (%)
AC	0.60±0.01^{b}	0.61±0.00^{d}	15.97±0.52^{a}	9.10±0.00^{d}	15.00±0.00^{d}	1.70±0.00^{c}	1.63±0.01^{b}	4.00±0.00^{d}
A1	0.62±0.00^{b}	0.62±0.00^{d}	14.10±0.06^{b}	9.10±0.00^{d}	15.13±0.03^{c}	1.65±0.03^{d}	1.80±0.05^{a}	4.10±0.06^{d}
A2	0.62±0.00^{b}	0.88±0.00^{b}	14.06±0.03^{b}	8.03±0.03^{b}	18.17±0.09^{b}	1.40±0.09^{e}	1.80±0.06^{a}	3.73±0.33^{e}
A3	0.62±0.00^{b}	0.84±0.00^{b}	12.20±0.06^{c}	10.20±0.06^{bc}	13.20±0.06^{e}	1.07±0.03^{f}	1.60±0.06^{b}	4.03±0.33^{d}
A4	0.60±0.00^{c}	0.86±0.00^{b}	9.10±0.00^{e}	10.03±0.03^{c}	15.10±0.05^{c}	1.16±0.09^{g}	1.67±0.01^{b}	5.07±0.03^{b}
A5	0.60±0.00^{c}	0.91±0.00^{ab}	10.30±0.05^{d}	18.10±0.05^{a}	21.23±0.12^{a}	1.83±0.03^{ab}	1.80±0.06^{a}	5.40±0.00^{a}
A6	0.67±0.00^{abc}	0.81±0.00^{b}	9.00±0.00^{e}	5.33±0.03^{e}	10.23±0.03^{f}	0.80±0.05^{b}	1.80±0.06^{a}	4.80±0.00^{c}
A7	0.63±0.00^{ab}	0.73±0.06^{c}	8.20±0.06^{f}	4.17±0.03^{f}	7.03±0.03^{g}	0.76±0.03^{c}	1.43±0.03^{c}	5.00±0.00^{b}

Values are means ± SD of triplicate determinations. Means in the same column with different superscripts differ significantly ($p < 0.05$).

Key:

AC = 100% cowpea flour (control sample)
A1 = 95% cowpea flour : 5% fonio millet flour
A2 = 90% cowpea flour : 10% fonio millet flour
A3 = 85% cowpea flour : 15% fonio millet flour
A4 = 80% cowpea flour : 20% fonio millet flour
A5 = 50% cowpea flour : 50% fonio millet flour
A6 = 15% cowpea flour : 85% fonio millet flour
A7 = 0% cowpea flour : 100% fonio millet flour

The functional properties crucial for food processing and product quality are presented in Table 2. Bulk density, relevant for packaging and handling, was higher in cowpea-dominant blends. Swelling capacity declined progressively as fonio levels rose, likely due to the dilution of cowpea starch and the interfering effects of other fonio components like protein and fiber on water uptake and granule expansion.

Interestingly, the 50:50 composite flour (A5) demonstrated optimal foaming characteristics, registering the highest foam capacity (21.23%) and stability (18.10%). This synergistic effect suggests that at equal proportions, the proteins and other constituents from both sources interact favorably to create and stabilize air bubbles, which is a desirable trait for achieving a spongy akara texture. Water and oil absorption capacities are vital for mouthfeel and flavor retention. Generally, blends with more cowpea exhibited higher oil absorption, whereas water absorption was more variable across formulations.

Proximate composition

Table 3. Proximate composition of *akara* from cowpea-fonio millet flour blends.

Sample	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
PC	12.19±0.49^{bc}	21.93±0.43^{d}	1.43±0.19^{d}	9.71±0.25^{e}	1.41±0.24^{c}	53.33±0.21^{a}
P1	11.85±0.45^{dc}	21.98±0.50^{d}	1.26±0.06^{e}	9.62±0.38^{e}	2.55±0.07^{b}	52.74±0.07^{b}
P2	12.03±0.03^{c}	22.91±0.43^{c}	1.42±0.08^{c}	10.60±0.32^{d}	2.57±0.22^{b}	50.47±0.11^{c}
P3	12.03±0.27^{c}	23.89±0.63^{b}	1.47±0.16^{c}	10.20±0.36^{ac}	2.46±0.23^{c}	49.95±0.42^{e}
P4	12.22±0.23^{bc}	23.59±0.34^{b}	1.58±0.01b^{c}	11.36±0.28^{b}	2.64±0.18^{abc}	48.69±0.70^{f}
P5	11.57±0.06^{d}	26.04±0.34^{a}	1.65±0.02^{abcd}	11.60±0.14^{a}	2.61±0.18b^{c}	46.53±0.05^{b}
P6	12.46±0.22^{abc}	23.49±0.26^{b}	1.40±0.04^{c}	9.56±0.06^{f}	2.44±0.27^{c}	50.65±0.01^{c}
P7	12.04±0.03^{c}	22.85±0.10^{c}	1.55±0.22^{bc}	9.35±0.11^{g}	2.45±0.23^{c}	51.76±0.23^{d}

Values are means ± SD of triplicate determinations. Means in the same column with different superscripts differ significantly ($p < 0.05$).

Key:

AC = 100% cowpea flour (control sample)
A1 = 95% cowpea flour : 5% fonio millet flour
A2 = 90% cowpea flour : 10% fonio millet flour
A3 = 85% cowpea flour : 15% fonio millet flour
A4 = 80% cowpea flour : 20% fonio millet flour
A5 = 50% cowpea flour : 50% fonio millet flour
A6 = 15% cowpea flour : 85% fonio millet flour
A7 = 0% cowpea flour : 100% fonio millet flour

The nutritional composition of the prepared akara is shown in Table 3. A key finding was the significant enhancement in protein content with fonio fortification. The crude protein level rose from 21.93% in the control to a maximum of 26.04% in the 50:50 blends (P5), demonstrating the complementary protein quality of the cowpea-fonio mixture.

Moisture content remained consistent across all samples (11.57–12.46%), indicating that the frying process was standardized. Fat content showed a slight but significant increase in some blended samples, attributable to the varying oil absorption properties of the flours during deep-frying. Dietary fiber and ash content also increased with fonio substitution, aligning with fonio's known composition and thereby enhancing the dietary fiber and mineral density of the akara.

As expected, carbohydrate content calculated by difference showed a corresponding decrease in blends with higher protein and fiber, particularly in the 50:50 samples.

Mineral composition

Table 4. Mineral composition of *akara* from cowpea-fonio millet flour blends.

Sample	Cr	Cu	Fe	Mn	Zn	Na	K	Ca	Mg	P
PC	0.03 ± 0.00^{a}	0.81 ± 0.00^{b}	10.48 ± 0.02^{e}	0.59 ± 0.00^{e}	1.45 ± 0.01^{e}	7.22 ± 0.01^{g}	109.10 ± 0.00^{c}	155.50 ± 0.03^{b}	31.61 ± 0.01^{f}	20.11 ± 0.00^{d}
P1	0.22 ± 0.00^{a}	0.89 ± 0.00^{b}	12.15 ± 0.02^{d}	0.76 ± 0.00^{d}	1.94 ± 0.01^{d}	7.59 ± 0.01^{f}	98.43 ± 0.01^{d}	142.70 ± 0.00^{c}	42.53 ± 0.00^{e}	17.21 ± 0.01^{f}
P2	0.19 ± 0.00^{a}	1.15 ± 0.01^{a}	15.56 ± 0.01^{d}	0.85 ± 0.00^{c}	2.71 ± 0.01^{b}	8.12 ± 0.00^{e}	79.22 ± 0.01^{a}	125.30 ± 0.01^{e}	45.27 ± 0.01^{d}	19.36 ± 0.00^{e}
P3	0.09 ± 0.00^{a}	0.74 ± 0.00^{b}	22.78 ± 0.01^{c}	1.33 ± 0.00^{b}	2.05 ± 0.01^{d}	8.29 ± 0.00^{d}	112.50 ± 0.02^{b}	161.72 ± 0.01^{a}	30.99 ± 0.01^{f}	21.32 ± 0.01^{d}
P4	0.82 ± 0.00^{a}	0.81 ± 0.00^{b}	30.25 ± 0.03^{b}	1.16 ± 0.00^{a}	2.25 ± 0.01^{c}	8.45 ± 0.01^{c}	100.30 ± 0.02^{c}	156.38 ± 0.03^{b}	51.61 ± 0.14^{b}	21.81 ± 0.01^{d}
P5	0.38 ± 0.00^{a}	1.34 ± 0.00^{a}	28.62 ± 0.04^{c}	0.97 ± 0.00^{c}	4.57 ± 0.01^{a}	8.44 ± 0.01^{c}	89.63 ± 0.01^{e}	143.28 ± 0.07^{c}	49.23 ± 0.12^{c}	43.63 ± 0.02^{a}
P6	0.13 ± 0.00^{a}	1.63 ± 0.01^{a}	30.25 ± 0.03^{b}	1.54 ± 0.00^{a}	2.74 ± 0.02^{b}	8.75 ± 0.01^{b}	122.28 ± 0.03^{a}	132.71 ± 0.01^{d}	57.22 ± 0.01^{a}	25.41 ± 0.01^{c}
P7	0.21 ± 0.00^{a}	0.92 ± 0.00^{b}	35.43 ± 0.01^{a}	1.70 ± 0.01^{a}	2.80 ± 0.01^{b}	10.22 ± 0.01^{a}	88.91 ± 0.01^{f}	121.71 ± 0.01^{e}	51.63 ± 0.18^{b}	41.20 ± 0.01^{b}

Values are means ± SD of triplicate determinations. Means in the same column with different superscripts differ significantly ($p < 0.05$).

Key:

AC = 100% cowpea flour (control sample)
A1 = 95% cowpea flour : 5% fonio millet flour
A2 = 90% cowpea flour : 10% fonio millet flour
A3 = 85% cowpea flour : 15% fonio millet flour
A4 = 80% cowpea flour : 20% fonio millet flour
A5 = 50% cowpea flour : 50% fonio millet flour
A6 = 15% cowpea flour : 85% fonio millet flour
A7 = 0% cowpea flour : 100% fonio millet flour

The mineral enrichment achieved through fonio inclusion is clearly demonstrated in Table 4. Fonio-fortified akara contained markedly higher levels of several essential minerals. Iron content showed a more than three-fold increase, from 10.48 ppm in the control to 35.43 ppm in the 100% fonio akara. Zinc content also improved substantially, reaching 4.57 ppm in the 50:50 blends. Notable increases were also recorded for calcium, magnesium, and potassium.

This mineral fortification is a major nutritional advantage, as iron, zinc, and calcium are commonly deficient in plant-based diets. The integration of fonio millet into a staple snack like akara presents a practical food-based strategy for combating micronutrient deficiencies in regions where it is consumed.

Sensory evaluation

Table 5. Sensory Evaluation of *akara* from cowpea-fonio millet flour blends.

Sample	Appearance	Taste	Sponginess	Sogginess	Flavour	Overall Acceptability
PC	8.20 ± 1.20^{c}	8.01 ± 1.10^{e}	7.02 ± 0.09^{e}	8.57 ± 2.10^{c}	8.50 ± 2.45^{b}	7.50 ± 2.11^{b}
P1	8.09 ± 0.80^{d}	8.82 ± 0.02^{bc}	7.93 ± 1.10^{bc}	8.89 ± 0.09^{a}	8.67 ± 1.45^{a}	8.87 ± 2.00^{a}
P2	8.56 ± 2.50^{b}	7.71 ± 1.02^{f}	8.50 ± 2.45^{a}	8.62 ± 0.07^{b}	8.69 ± 1.00^{a}	8.56 ± 2.50^{b}
P3	8.85 ± 0.05^{abc}	8.57 ± 1.10^{d}	8.50 ± 2.45^{a}	8.56 ± 1.10^{c}	8.51 ± 2.00^{b}	8.82 ± 0.02^{a}
P4	7.51 ± 1.22^{g}	8.95 ± 0.04^{ab}	7.87 ± 0.50^{c}	8.51 ± 0.54^{c}	7.52 ± 0.12^{c}	6.51 ± 0.02^{e}
P5	7.64 ± 0.09^{e}	8.74 ± 1.56^{c}	7.58 ± 0.57^{d}	7.56 ± 0.02^{d}	6.53 ± 1.24^{d}	7.02 ± 0.09^{c}
P6	7.54 ± 1.19^{f}	7.51 ± 1.01^{g}	6.86 ± 0.76^{f}	6.51 ± 0.43^{e}	7.54 ± 0.09^{c}	7.51 ± 0.00^{b}
P7	7.51 ± 0.01^{g}	6.02 ± 0.02^{h}	4.50 ± 2.30^{g}	2.00 ± 0.00^{f}	5.52 ± 1.11^{e}	6.56 ± 0.76^{d}

Values are means ± SD of triplicate determinations. Means in the same column with different superscripts differ significantly ($p < 0.05$).

Key:

AC = 100% cowpea flour (control sample)
A1 = 95% cowpea flour : 5% fonio millet flour
A2 = 90% cowpea flour : 10% fonio millet flour
A3 = 85% cowpea flour : 15% fonio millet flour
A4 = 80% cowpea flour : 20% fonio millet flour
A5 = 50% cowpea flour : 50% fonio millet flour
A6 = 15% cowpea flour : 85% fonio millet flour
A7 = 0% cowpea flour : 100% fonio millet flour

The sensory scores determining consumer acceptability are presented in Table 5. Panelists showed a strong preference for akara containing low to moderate levels of fonio. Blends with 5%, 10%, and 15% fonio (P1, P2, P3) received the highest scores for key attributes like taste, flavor, appearance, and overall acceptability, performing on par with or even exceeding the 100% cowpea control.

The 90:10 cowpea-fonio blend (P2) emerged as the most favored sample overall. However, when fonio substitution exceeded 20%, acceptability declined noticeably. Samples with 50% or more fonio were rated lower, particularly for texture-related attributes like sogginess and sponginess, and for flavor. This suggests that while fonio improves nutrition, its distinct granular texture and flavor become dominant and less preferred at higher inclusion levels, defining the practical limit for substitution in this product.

Conclusion

Akara produced from cowpea–fonio flour blends demonstrated improved nutritional quality, particularly in protein, dietary fiber, and essential minerals. The functional and pasting characteristics indicated suitability for akara production, and sensory analysis identified blends containing up to 15% fonio as most acceptable. Moderate inclusion of fonio therefore offers a feasible approach to enhancing the nutritional quality of traditional foods while promoting the utilization of indigenous crops.

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