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Effect of Added Bambara Groundnut Flour on the Quality of Acha Based Fura

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Authors' contributions

This work was carried out in collaboration between all authors. Author JAA designed, supervised, wrote the first draft of the manuscript and approve the final manuscript. Author EA managed the analysis, literature searches and statistical analysis of the study. Authors VAA and CAP managed the literature searches. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Aims: To improve the nutrient quality of fura, an acha based flour food by adding bambara groundnut flour.
Study Design: Product development approach.
Place and Duration of Study: Department of Food Science and Technology, Federal Polytechnic, Bauchi and for six months.
Methodology: Acha grain *(Digitaria exilis*) and Bambara groundnut (*Vigna subterranean*) were cleaned, dry milled and sieved to produce flour. The Bambara groundnut was substituted into acha grain flour (0-25%), mixed with spices (cloves, salt, ginger, red chilly-pepper, black pepper), conditioned (adding water), molded into balls, steamed (5min), boiled (30min), pound and molded to produce fura. The sample were analyzed for chemical (protein, fat, ash, moisture, carbohydrate), sensory (taste, colour, texture, odour) and functional (water absorption, bulk density and foam capacity).
Results: The added bambara groundnut increased the protein (6.14 – 9.30%), fat (3.01 – 4.80%), crude fibre (1.20 – 4.4%) and ash (0.50 –1.12%), but decreased the carbohydrate (88.20 – 79.21%) content of the fura with increase in quantity (0 - 25%).

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The bulk density and foam capacity increased 0.57 – 0.71% and 5.0 – 12.2%, respectively with increase in added bambara groundnut (0 -25%). There was significant increase in the foam capacity. The average means scored of the taste, texture and general acceptability increased 6.4 -7.55, 7.1 – 7.8, and 6.9 – 7.85, respectively, with increase in added Bambara groundnut up to 10% and thereafter decreased significantly.

Conclusion: The addition of Bambara groundnut increased the protein, fat, fibre and ash content significantly, p = 0.05, however, it was most acceptable at 10%. At this level of acceptance, the protein, fat and fibre content have been improved by 27.5, 37.8 and 31.5% respectively.

Keywords: Bambara groundnut; acha; fura quality.

1. INTRODUCTION

Acha (*Digitaria exilis*) also known as hungry rice is one of the indigenous African cereals which belong to the *Poaceae* (grasses) [1]. The plant is about 4.5cm high with a tiny bug ear; grow on poor sandy soil that will not support the growth of some common cereal [2,3].

The kernels of this cereal, are tiny and weighs about 0.5mg is classified as millet but on like other millet is low in protein content [4]. However acha protein is unique because its higher methionine and lysine content than other cereal [5]. Methionine and lysine which are vital to human health are deficient in common cereals, like wheat, rice, maize, sorghum, barley and rye [1]. The major traditional food from the grain are thick (*Tuwo)* and thin (*kunu*) steamed product (*Burabusko* or Couscous) and alcoholic beverages principally consumed in Nigeria, Mali, Chad and Ghana [1,3].

Enrichment of cereal based food with other protein source such as legumes has received considerable attention. The use of cereal-legume based food has long been advocated as alternative protein and energy source for infant and young children food products [6]. It is evident that when cereals and legumes are judiciously selected and combine desirable pattern of essential amino acids of high biological value is obtained [7].Cereals are deficient in essential amino acid like lysine and tryptophan [8]. Legumes are deficient in sulphur containing amino acids like methionine and cystine, but rich in tryptophan and lysine. Acha contain high water absorption capacity carbohydrate that gives it the potential to be utilized in baked foods. It also contain pentosan [9,10] which gives it the ability to form gel in the presence of oxidizing agent at room temperature with high residual protein coupled with high level of sulphur and hydrophobic amino acid residue making it useful in baking processes [11,12]. The recent finding of the unique property of acha, diminishing the blood glucose level [13] and the subsequent reduction of diabetic popuace has made this crop attractive research focus in recent time [14,13].

The use of composite flour in baked product has been studied in great details since 1904 when food and agricultural organizations (FAO) of United State sponsored composite flour programme. Most effort of researchers was centered on composite flour made from sorghum, maize, cassava, acha, yam, potatoes etc. The study of composite flour has been triggered by Food and Agricultural Organization interventions [15]. Investigation on the use of cassava in biscuit making has recently become the focus of researchers in Nigeria [13].

Bambara groundnut (*Voandzeia subterranean* (L) Thouars) is a species of Africa origin used locally as a vegetable. It was first found in West Africa [16]. Bambara groundnut is called

Gurjiya or Kwaruru in Hausa, Kwam in Geom, part of Plateau State, Okpa in Ibo and Epa-kuta in Yoruba part of Nigeria [17]. Bambara groundnut can be consumed in different forms, either at immature green stage or matured. At matured however, the seeds become very hard and therefore require boiling before any specific preparation can be carried out on it [17]. The quest for plant with nutritional properties continues to receive attention. Bambara groundnut (Vigna subterranean) which constitutes complete food stuff is reported to contain protein, carbohydrate and lipids and can be consumed at different stages of maturation [3,18]. The plant has a potential to improve malnutrition and boost food availability.

Food fortification has been defined as the addition of one or more essential nutrient to a food whether or not it's normally contained in the food for the purpose of preventing or correcting a demonstrated deficiency of one or more nutrient in a population or specific group [19]. Diet can be deficient in certain nutrient due to the soil of a region, or because of the inherent inadequacy of nutrient can be improved by fortification or enrichment. Addition of micronutrients to staples and condiment can prevent large scale deficiency disease in these cases.

Fura is a semi-solid dumpling cereal meal produced mainly from moist pearl millet (*Pennisettum glaucum*) flour, blended with spices compressed into balls and boiled for 30 minutes while still hot the cooked dough is worked in the mortar with pestle (with addition of hot water) until a smooth slightly elastic cohesive lump *fura* was formed.

The work was aimed at improving the quality of acha based fura by adding bambara groundnut flour.

2. MATERIALS AND METHODS

Acha grains (Digitaria exilis), Bambara groundnut (Vigna subterranean), cloves, salt ginger, red chilly pepper, black pepper was purchased from Muda-Lawal market Bauchi.

The Acha grain was sorted and washed with water to remove stones, dust and foreign materials, the grain was sundried, milled using hammer mill and sieved with a sieve of aperture size of 0.300m. The flour was packed in Polythene and stored in cool dry environment acha flour.

The Bambara groundnut seed was sorted, cleaned, toasted, and allowed to cool. The seed was milled with the use of hammer mill into fine flour and sieved through a sieve with aperture 0.300m, packed in a polythene bag and stored in a cool dry environment as Bambara groundnut flour

2.1 Production of Fura

The bambara groundnut flour was substituted into the acha flour(0, 5, 10, 15, 20 25) and mixed with weighed spices (ginger, cloves, black pepper and red chilly pepper) as shown in Table 1, mixed thoroughly(manually) and conditioned(adding100cm^3 water) to improve molding. The conditioned flour was weighed (20g), molded into balls, steamed (15min), boiled (30min covered with water) and pound (local mortar) until a smooth and slightly elastic consistency was achieved. The smooth and elastic dough was remolded into balls (30g), coated with wheat flour to avoid cracking, cooled and stored in dry atmosphere.

Table 1. Recipe for formulation

Sample/Ingredient						
Acha flour(%)	100	95	90	85	80	75
Bambara nut flour(%)	0	5	10	15	20	25
Ginger (g)	1.34	1.34	1.34	1.34	1.34	1.34
Black pepper(g)	0.24	0.24	0.24	0.24	0.24	0.24
Chilly pepper(g)	0.50	0.50	0.50	0.50	0.50	0.50
Cloves(g)	0.67	0.67	0.67	0.67	0.67	0.67

2.2 Sensory Quality Evaluation

The sensory evaluation of the samples were carried out for consumer acceptance, and preference using twenty (20) untrained judges randomly selected(student and staff of the Dept. of Food Science and Technology, Federal Polytechnic, Bauchi) using a nine(9) point Hedonic Scale (1 and 9, representing extremely dislike and extremely like, respectively)[20]. The quality assessed include:- colour, taste, odour, texture and overall acceptance. Coded samples of the same size at the same temperature (35ºC) were served in a colored (white) plate of the same size to judges in each panel cupboard under the florescent light. Only one sensory attribute was tested in one sitting [20].

2.3 Chemical properties

The moisture, fat, ash Moisture determination, carbohydrate and protein content were determined [22,23]. One gram of the sample was weighed into aluminum dish and dried at 103 ºC (using air oven) until a constant weight was reached and the difference in weight is taken in percentage as moisture content.

2.4 Functional Properties

Foaming capacity: Two gram of the sample of fura was blended (using Kenwood blender) with 80ml distilled water for 5min and poured into the measuring cylinder. The height of the foam was determined by taking the reading [24,25,26]

Water Absorption Capacity: The samples (2.0g) were weighed into the tubes and 25ml of water was added, shaken and allowed to stand for 1hr at room temperature (30-32ºC) with occasional shaking. The mixture was centrifuged at 16000rps for 25min. Excess water was decanted by inverting the tubes on absorbent paper. The initial and final weight (after centrifugation) of the sample was recorded. The water absorbed was calculated as difference in weight [27,13,28]

Bulk Density: The procedure of Hall and Hedicy [29] was used. Twenty gram (20g) of the sample was measured into graduated flask, tapped or dropped on a soft pad-table 30times and the volume noted (Vml). The bulk density is calculated by dividing the Vml by the weight of sample (20g).

2.5 Data Analysis

Data collected were subjected to analysis of variance and difference between the mean were separated using Duncan multiple test [30]. Unless otherwise mentioned, all the

measurements were made in triplicate and the values represent the average of the three measurement.

3. RESULTS AND DISCUSSION

3.1 Effect of Added Bambara Groundnut Flour on the Chemical Quality of Acha Based Fura

The effect of added bambara groundnut flour on the chemical composition of Acha based fura is detailed in Table 2 below;

Table 2. Chemical composition of acha based fura (%)

Acha	Bambara g/nut	Crude protein	Fat	Crude fiber	Ash	Moisture	Carbohydrate
100	0	6.14c	3.01d	1.20c	0.50c	0.99b	88.20a
95	5	7.41b	3.50c	1.31bc	0.60bc	1.00b	86.21a
90	10	7.83ab	4.25b	1.71b	0.70b	1.05ab	84.53a
85	15	8.90a	4.40ab	2.30b	0.81ab	1.10a	82.54a
80	20	9.11a	4.61a	3.90a	0.93a	1.20a	80.33a
75	25	9.30a	4.80a	4.4a	1.12a	1.22a	79.21a

**Average means scores with the same alphabet in same column are not significantly different p=05*

Moisture: The moisture content increased from 0.99 to 1.22% with increase in the added bambara nut flour (0-25%). The increase in the moisture content is relatively low which could be an advantage in the keeping quality of the product as it will not allow the growth of spoiling microorganisms and biochemical and enzymatic reactions.

Fat: The fat content increased from 3.0 – 4.8% with increase in the percentage (0 – 25%) of bambara groundnut flour. The increase in fat content could be due to the added bambara groundnut. The relative increase in fat content could improve the energy level of the consumer as it has been known that one gram of fat or oil will yield about 368kJ/gkcal of energy when oxidized in the body [12]. The relatively low level of moisture content of the products could prevent hydrolysis of the fat that could endanger its shelf life.

Crude protein: The protein content increased from 6.14 – 9.3% with increase in the percentage (0 – 25%) of bambara groundnut flour. The increase in the protein content could be due to the added bambara groundnut which have been confirmed to contain substantial high level of the same and could be an inexpensive source [17].

Ash content: The Ash content of the product increased from 0.5 – 1.1% with increased concentration (0 – 25%) in added bambara groundnut flour. The increase in the ash content could be due to the added bambara groundnut which have been noted to relatively high in the same [17]. High ash content could be an indication of increase in the principal mineral content which could be of vital importance to the body [30, 18, 32].

Crude fibre: The crude fibre of the product increased from 1.2 – 4.4% as the percentage concentration (0 – 25%) of added bambara groundnut flour increased. The increase in percentage fibre could be due to high fibre content of bambara groundnut (4.9) [31,33,34].

Relatively high fibre content could be an advantage in the ease of empty of bowel and prevention of arthritis.

Carbohydrate: The carbohydrate decreased from 88.2 – 79.2% with increase in the added bambara groundnut flour (0 – 25%). The decrease in carbohydrate content could be attributed to the substitution of acha flour for bambara groundnut which contain relatively lower carbohydrate. Carbohydrate is a macronutrient needed in the largest amount. The relative high carbohydrate that is still contained in the product could be adequate for normal supply of daily calorie for an adult.

3.2 Sensory Evaluation of the Fura

The effect of added bambara groundnut flour on the sensory quality of Acha base fura is shown in Table 3.

Table 3. Sensory evaluation of instant fura

Acha /g	Bambara-g/nut/g	Taste	Odour	Texture	Colour	Overall acceptability
100	0	6.4c	7.7a	7.1b	7.3a	6.9a
95	5	6.95b	7.2a	7.25b	6.7b	7.0a
90	10	7.55a	7.68a	7.8a	6.0c	7.85a
85	15	6.6c	6.1c	6.5c	6.6d	6.05a
80	20	6.15c	6.05c	5.8d	6.2e	6.0a
75	25	6.0c	6.55b	5.18e	6.1f	5.2a

**Average means scores with the same alphabet in the same column are not significantly different p=05*

Taste: The addition of bambara groundnut flour on the quality of acha based instant fura increased the mean score for taste from 6.4 to7.55 as the concentration of bambara groundnut flour increased (0–10%) and then decease(7.55 to 6.0) with further addition(10 to 25%). The decrease could be due to increase in concentration of some inherent compounds in bambara groundnut.

Texture: The addition of bambara groundnut flour on the quality of acha based instant fura increased 7.1 to 7.8 with increase in the added bambara groundnut flour (0 to 10%) decreased (7.8 - 5.18) with further increase (10 - 25%).

Colour: The average mean score of the instant fura colour decreased from 7.3 – 6.1 with increase in the percentage (0 – 25%) of bambara groundnut flour. The decrease could be due to increased concentration of adulterated added bambara groundnut flour. The adulteration could be due to improper removal of the seed coat prior to milling.

Odour: The average mean score of the instant Fura odour decreased from 7.7 – 6.55 with increased percentage flour. There is a significant effect at above 10% added bambara groundnut flour. The decrease in the sensory evaluation of odour at above 10% could be due to unacceptable odourous compound inherent to bambara groundnut flour particularly at higher concentration.

General acceptability: The average mean score for general acceptability increased from 6.9-7.85 with increased percentage concentration (0-10%) of bambara groundnut flour and

then decreased (7.85-5.2) with further addition. The sample with 10% bambara groundnut flour is ranked the best in terms of assessed qualities.

3.3 Effect of Added Bambara Groundnut Flour on Functional Properties of the Instant Fura

Bulk density: The bulk density increased from 0.57 to 0.71g/ml (Table 4) with increase in percentage (0 – 25%) of added bambara groundnut flour. The increase in bulk density could be an advantage in packaging of the product as it will occupy less space and could also be advantage in solubility as the particles has less tendency of floating during soaking in liquid prior to consumption which could also improve digestion.

Foam capacity: The foam capacity of the product increased from 5.7 – 12.2% with increase in percentage (0 – 25%) of added bambara groundnut flour. The increase in the foaming capacity could be due to high protein content of the added bambara groundnut as noted by Iwe [35]. The high foaming capacity could be an advantage in the solubility of the product and also ability to incorporate air resulting in the raising, consequently giving the end product a honeycomb structure as desired in bread, cake and ice cream [36].

Water absorption capacity: The water absorption capacity deceased (57-42%) with increase in the added bambara groundnut flour (0-25%). The relatively decrease in the water absorption capacity could be due to the presence of the husk or outer coat of the bambara groundnut as a result of low extraction rate during processing. The presence of the hull (cellulose and hemi-cellulose) has been observed to have low water absorption capacity [36]. Low water absorption could be an advantage in storage stability as the rate of absorption could be relatively low hence lower moisture availability for microbial growth and biochemical reactions.

Table 4. Functional properties of acha-bambara groundnut flour

Acha	Bambara g/nut	Bulk density g/ml	Water absorption capacity (%)	Foam capacity (%)
100	0	0.57b	57a	5.0d
95	5	0.59b	55a	6.8c
90	10	0.60b	54ab	8.2b
85	15	0.60b	51b	8.9ab
80	20	0.72a	42c	11.0a
75	25	0.71a	42c	12.2a

**Average means scores with the same alphabet in the same column are not significantly different, p=05*

4. CONCLUSION

The addition of bambara groundnut flour to acha based fura greatly improved the quality of the product mostly at the 10% acceptable level as indicated by the panelist. At this level of acceptance the protein, fat and fibre content has been improved by 27.5, 37.8 and 31.5% respectively, making the product highly nutritious particularly for the diabetes who have been proven to consume acha with less difficulty. The pretreatment of the bamabara groundnut prior to usage could improve the texture, color and water absorption capacity of the product.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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