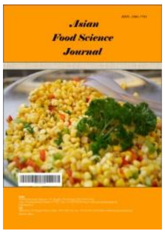

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Evaluation of the Functional, Proximate and Sensory Properties of Cowpea/Soybean Fortified *Dabuwa* (A Nigerian Dried Stiff Porridge) Produced from Different Cereals

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Authors' contributions

This work was a collaboration between authors MAJ and GIA. Author MAJ produced dabuwa, carried out the functional, chemical and sensory analyses. Author GIA designed the experiment, statistically analyzed tthe data and discussed the same. Both Authors collectively sought the relevant literature and proof read the manuscript draft and authorized it's publication. The returned reviewed manuscript or galley proof was revisited by GIA and reverted back.

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ABSTRACT

Dabuwa is a dried stiff porridge made from fonio and maize in the ratio of 1:3, beef fat and spiced with fresh onion and caraway (black) seeds. It is a popular food indigenous to the Shuwa Arab nomads of North-eastern Nigeria. An attempt was made to modify *dabuwa* not only from maize but also from millet and rice. The cereal flours were supplemented with legume flours, the beef fat content was reduced, fresh onion and caraway seeds were replaced with a dried spice-mix of onion, ginger and cardamom. A 3×2×2×2 full factorial design was scaled down to a fractional factorial design of 3×2×2 which generated 12 runs. Supplementation (cowpea and soybean) was done at a constant level of 30%. Fonio was incorporated at either 12.5% (F_1) or 22.5% (F_2). Each formulation had the other cereal (maize, millet or rice) added at 57.5% (Ma_1, Mi_1, R_1) or 47.5% (Ma_2, Mi_2, R_2); while traditional *dabuwa* comprising of 25% fonio and 75% maize served as the Control. The blends and *dabuwa* were evaluated for functional and sensory properties, and proximate composition. Results indicated a general increase on water absorption capacity

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(216.76% to 270.34% of the blends) unlike oil absorption capacity (0.97ml/g to 1.09ml/g), and an enhanced bulk densities (0.74-0.86g/ml). *Dabuwa* samples enriched with soybean were shown to be denser in nutrients than those supplemented with cowpea, though no particular trend was observed. Moisture, ash, crude protein, crude fiber, fat, carbohydrate (by difference) and calorific contents of the blends varied significantly (p≤0.05) from 7.38 to 12.18%, 1.80 to 2.96%, 4.33 to 16. 29%, 1.62 to 6.59%, 2.45 to 9.57%, 53.66 to 82.90%, and 337.12-393.37kcal/100g respectively. Proximate composition of modified *dabuwa* varied thus:4.86-10.85%, 0.92-2.48%, 10.11-16.38%, 0.96-4.65%, 2.02-10.60%, 58.55-86.54%, and 351.03-421.17kcal/100g for moisture, ash, crude protein, crude fiber, fat, carbohydrate contents and calorific value respectively. Sensory scores revealed that rice- and maize-containing *dabuwa* were liked moderately, but millet containing *dabuwa* were neither liked nor disliked by the panelists. It was concluded that dabuwa could be prepared not only from maize, but also from rice or millet with legume fortification for enhanced nutrient density without affecting negatively the well known traditional sensory properties of the *dabuwa.*. Therefore, production and consumption of *dabuwa* should be re-popularized and its consumption patronized so as to provide macro and micro nutrients to the consumers and avoid the disappearance of a worthy age-old food product.

Keywords: Maize; millet; rice; fonio; cowpea; soybean; flour; dabuwa; proximate composition; functional properties; sensory properties.

1. INTRODUCTION

Cereals and grain legumes are the major providers of dietary energy worldwide [1] and their consumption gives these crops an important position in International Nutrition [2]. Cereals fill many nutritional needs, however, they lack two important amino acids; lysine and tryptophan which are higher in grain legumes. Grain legumes are low-cost sources of vegetable proteins and micronutrients when compared to animal-based protein, which is very expensive [3]. still they are deficient in the sulphur-containing amino acids: methionine and cysteine. Thus, legume proteins are a natural complement to cereal grain proteins in providing an overall essential amino acid balance [4,5]. Improvement in standards of living, knowledge about natural foods, and rise in the cost of medicine, have all led to an increased trend in consumption of healthy foods which are provided by multigrain flour blends which are excellent source of functional ingredients from natural sources in the diet [6].

Dabuwa, a dried stiff porridge (*tuwo*) is traditionally produced from fonio and maize, spiced and flavoured with onions, caraway (black) seeds and beef fat (*man shanu*). It is indigenous to the shuwa Arab nomads of northeastern Nigeria. *Dabuwa* can be referred to as a “five-in-one” food item as it is consumed in any of the following forms: reconstituted into the fresh porridge (*tuwo)* and eaten with stew or soup; as breakfast cereal soaked in boiled milk; or soaked in boiled water with added salt, pepper and beef fat; reconstituted and prepared as the popular jollof rice; it can also be eaten as a snack without reconstitution. *Dabuwa*, being a cereal-based food provide better nourishment to well to do consumers who can afford to consume it when reconstituted with milk or soup containing meat or fish. However, milk, meat and fish are sources of animal proteins that are expensive and therefore unaffordable to resource poor families. Moreover, taking *dabuwa* alone as a snack will not meet the recommended protein and micro nutrient requirements. Cowpea (Vigna unguicalata), probably due to its place in the socio-economic lives of the people, is the most suitable crop that is employed in enrichment of indigenous cereal-based foods and it is heavily cultivated in semi-arid climates of northeastern Nigeria where *dabuwa* is commonly produced and consumed at the household level.

Soyabean (*Glycine max*), the wonder crop of the world, serves both as an industrial raw material and a food crop. Borno state remains the largest producer of pearl millet in Nigeria [7] and millet is the commonest cereal of the poorest households providing energy to cater for the laborious life style of resource poor populations justifying the saying that “pearl millet is the powerhouse of nutrients” with unlimited health benefits ([8]. Asian rice (*Oryza sativum*), a gluten-free cereal, is widely cultivated in all regions of Nigeria and consumed mainly when cooked. Fonio (*Digitaria exilis*), on the other hand is an easy to digest, tasty cereal with high amino acid profile, good texture and appearance, low bulk and high caloric density [9], and low glycemic index [10]; it is equally produced in Nigeria and is a compulsory ingredient in *dabuwa* preparation. The traditional preparation of *dabuwa* is too labourous for the teaming health- and time-conscious urban dwellers, and beef fat, a saturated fat, is profusely applied in its preparation. It became necessary to improve the nutritional and sensory properties of *dabuwa* through fortification with grain legume flours and use of other cereals such as rice and millet in its preparation which has not been attempted.

Therefore, in this present study, *dabuwa* was prepared from blends consisting of fonio with either maize, millet or rice flour each fortified with cowpea or soyabean flour, spiced and flavoured with beef fat and a spice mix, and thereafter the proximate composition and functional and sensory properties of the modified *dabuwa* as well as the blends were evaluated.

2. MATERIALS AND METHODS

2.1 Raw Material Collection

The raw materials were purchased from Gamboru market, Jere Local Government Area of Borno State. The grains were maize, pearl millet, rice, fonio, cowpea, soyabean. Other ingredients were onions, caraway (black) seeds, ginger, cardamom and beef fat (*man shanu*). Samples were processed at the Nutrition unit of the Department of Food Science and Technology, Ramat Polytechnic, Maiduguri where Sensory evaluation was conducted also. Functional properties and Proximate Composition of the flour blends and *dabuwa* were analysed at National Agency for Food and Drug Administration Control (NAFDAC), Maiduguri Area Laboratory.

2.2 Preparation of the Cereal Flours

Maize, millet and rice were separately sorted to remove foreign materials, soaked overnight, decorticated, winnowed, washed thoroughly, and then dried. All grains were milled before complete drying (which yielded finer flours). Milled grains were sieved with a 300µm sieve mesh and packaged inside plastic buckets with air-tight fitting covers for further use. Fig. 1 represents a flow chart for preparation of the cereal flours.

2.3 Preparation of the Legume Flours

The method of Nkama [7] was used for both cowpea and soybean flour production with a slight modification. The cowpea and soybean after sorting and cleaning were soaked for 2 hours, de-hulled manually (by lightly pounding in a mortar with a pestle), sundried slightly and the brans removed by winnowing. These were then washed, dried and toasted mildly to reduce their beany flavor and also destroy some anti-nutritional factors. The grains were allowed to cool and then milled in attrition mill. The flours obtained were sieved with a 300µm mesh and then packaged inside plastic buckets and covered with tight-fitting lids. This process is shown in Fig. 2.

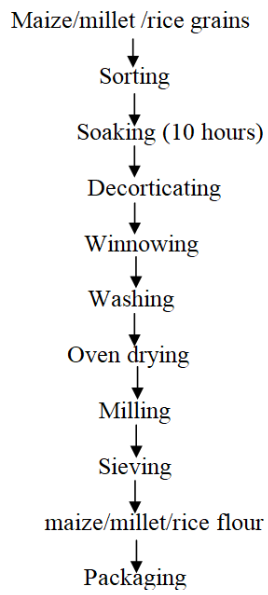

Fig.1 Flow chart for processing of maize, millet and rice flours

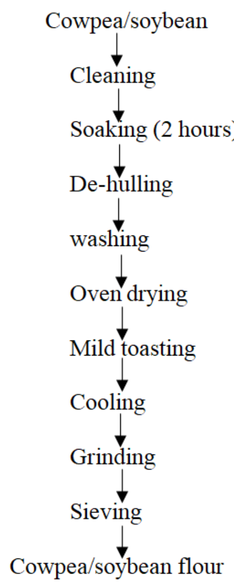

Fig. 2. Cowpea/soybean flour production

2.4 Preparation of Spice-mix and other Ingredients

A spice-mix of onions, ginger and cardamom in the ratio of 3:1:1 respectively was prepared for the modified *dabuwa*. Onions were peeled, washed, chopped and sundried. Ginger and cardamom seeds were sorted for extraneous materials and then washed and sundried. Dried spices were then milled and sieved to obtain a coarse flour.

Caraway seeds were sorted to remove foreign materials, washed and dried. Fonio grains were sorted for extraneous materials, de-hulled manually in a mortar with the use of pestle with the addition of hulls (from previously dehulled grains) to aid loosening and separation of hulls, dried slightly, winnowed to get rid of the hulls, washed severally the local way using a calabash (until all sand must have been removed), and then finally dried. Beef fat (*manshanu)* was fried with chopped onions inside till the onions turned golden brown in colour.

2.5 Formulation and Coding of Samples

Dabuwa, usually produced from a blend of 25% fonio and 75% maize was modified by using two levels (1=57.5%, 2=47.5%) each of maize (Ma_1, Ma_2), millet (Mi_1, Mi_2) and rice (R_1, R_2) and two levels (1=12.5%, 2=22.5%) of fonio (F_1, F_2) with constant level of cowpea (C) and soybean (S) leading to a 3×2×2×2 full factorial design but reduced to a fractional factorial design of 3×2×2 by manipulating the order of cereal addition while keeping the level of legume supplementation at a constant level of 30%. A total of 12 experimental runs and the Control (traditional *dabuwa*) were obtained and coded as follows: **F_1Ma_1C, F_2Ma_2C, F_1Mi_1C, F_2Mi_2C, F_1R_1C, F_2R_2C, F_1Ma_1S, F_2Ma_2S, F_1Mi_1S, F_2Mi_2S, F_1R_1S, F_2R_2S** and the Control **(FMa).**

2.6 Preparation of Traditional and Modified *dabuwa*

Traditional *dabuwa* was prepared as shown in Fig.3. Water, onions and blackseeds were brought to boil in a pot. Fonio grains were sprinkled while stirring, some part of the *manshanu* (beef fat) was added and the pot covered and allowed to cook for 10 minutes. Maize flour was mixed with water to obtain a thick slurry. This was poured into the pot while stirring. The remaining part of the *manshanu* was added then stirred continuously until a stiff and smooth porridge was obtained. This was covered and allowed to cook for another 8 minutes under low heat. The porridge was scooped out with the use of a small plastic plate unto lightly fat-greased trays and allowed to cool. This was cut manually into thin small pieces and oven-dried.

Fortified *dabuwa* using the new spice mix combination were processed the same way as traditional *dabuwa* was, but the spice mix was added much later, after the addition of slurry of flour blend. Drying was done in an oven at 55 – 65 ℃ for 4 - 5 hours, as required by different samples. This process is shown in Fig. 4.

Table 1. The formulations indicating proportion of each ingredient

Formulation	Fonio (g)	Maize (g)	Millet (g)	Rice (g)	Cowpea (g)	Soyabean (g)	Spicemix (g)	Fat (ml)
F_1Ma_1C	12.5	57.5	-	-	30	-	5	10
F_2Ma_2C	22.5	47.5	-	-	30	-	5	10
F_1Mi_1C	12.5	-	57.5	-	30	-	5	10
F_2Mi_2C	22.5	-	47.5	-	30	-	5	10
F_1R_1C	12.5	-	-	57.5	30	-	5	10
F_2R_2C	22.5	-	-	47.5	30	-	5	10
F_1Ma_1S	12.5	57.5	-	-	-	30	5	10
F_2Ma_2S	22.5	47.5	-	-	-	30	5	10
F_1Mi_1S	12.5	-	57.5	-	-	30	5	10
F_2Mi_2S	22.5	-	47.5	-	-	30	5	10
F_1R_1S	12.5	-	-	57.5	-	30	5	10
F_2R_2S	22.5	-	-	47.5	-	30	5	10
FMa	25	75	-	-	-	-	10	20

Key: F= Fonio, Ma = Maize, Mi = Millet, R = Rice, C = Cowpea, S = Soybean. The subscripts 1 and 2 of F denote 12.5% and 22.5% respectively while those of Ma, Mi and R denotes 57.5% and 47.5% respectively

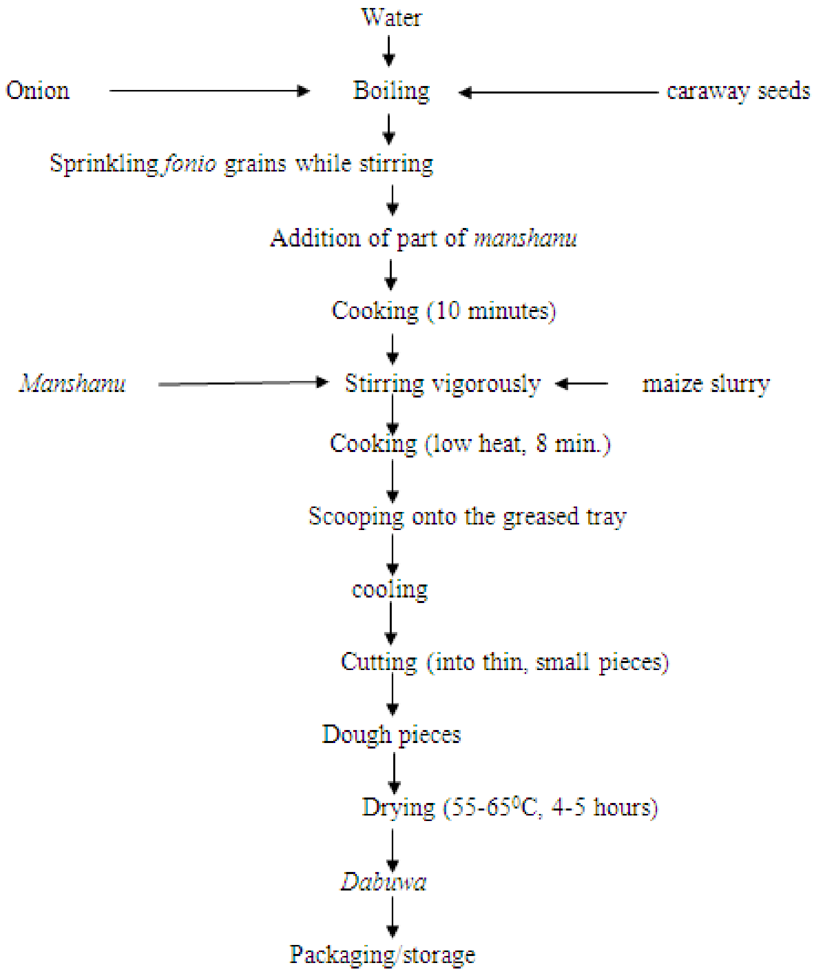

Fig. 3. Flow chart for preparation of traditional *dabuwa*

3. PHYSICAL AND CHEMICAL ANALYSIS

The flour blends were evaluated for functional properties and proximate composition. Flour blends and *dabuwa* were analyzed for proximate composition. All *dabuwa* were subjected to sensory evaluation test.

3.1 Functional Properties

Bulk density (BD) of the blends were determined using the method described by Onwuka [11]. Swelling capacity (SC) and solubility (S) of the blends were determined using the method of Leach et al. [12] with slight modification, whereas water absorption capacity (WAC) was determined using the Beuchat [13] method and oil absorption capacity (OAC) as described by Solsulski [14] were determined using the flour blends.

3.2 Proximate Composition

The various flour blends, as well as the *dabuwa* were analyzed for moisture, total ash, crude fat, and crude protein by the established procedures of the Association of Official Analytical Chemist, AOAC [15] while carbohydrate contents were obtained by "difference" i.e. 100-(%protein+%fat+%ash+%moisture+%fiber).

3.3 Sensory Evaluation

Sensory evaluation test was conducted by a team of 15 panelist drawn from people conversant with *dabuwa*. Samples were rated for appearance, aroma, taste, mouthfeel and overall acceptability using the nine-point hedonic scale rating (9-like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither like nor dislike, 4-dislike slightly, 3-dislike moderately, 2-dislike very much and 1-dislike extremely) as described by Ihekoronye and Ngoddy [16]

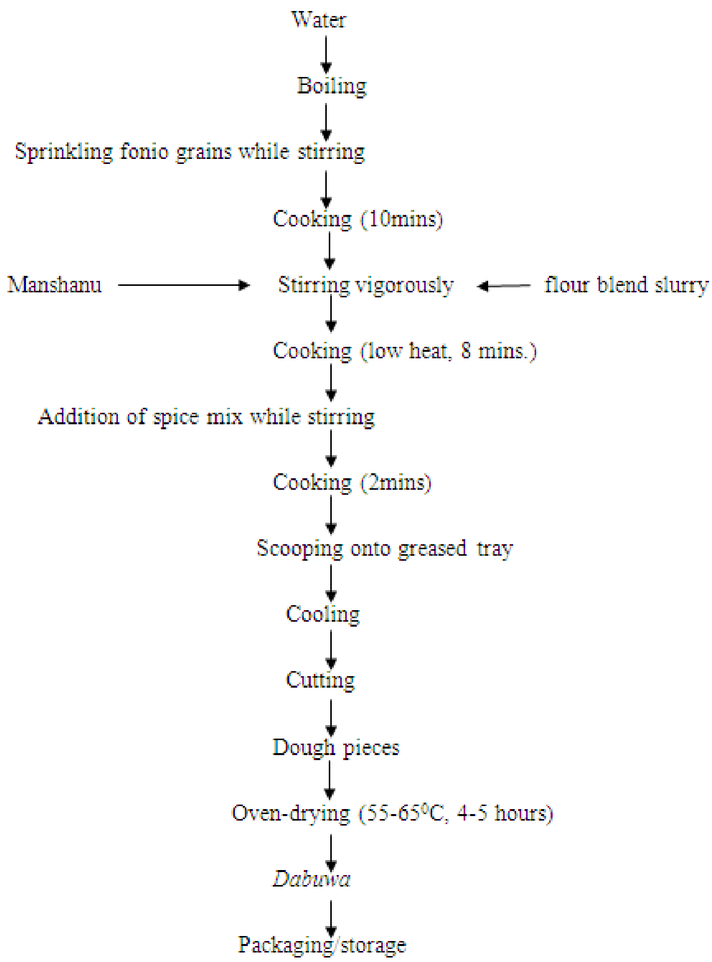

Fig. 4. Flow diagram for preparation of fortified *dabuwa*

3.4 Statistical Analysis

Data were expressed as Means ± Standard Deviation. The statistical analysis was performed using the Statistical Tool for Agricultural Research (STAR) software version 2.0.1 (IRRI). New Duncan's Multiple Range Test (nDMRT) was used to separate the means. Significance was accepted at 5% level of probability (p<0.05)

4. RESULTS AND DISCUSSION

4.1 Functional Properties of Flour Blends Used for the Production of *dabuwa*

Functional properties of flour blends are shown in Table 2. Water absorption capacity (WAC) varied significantly (P≤0.05) from 216.76% to 270.34% and were generally high and needed for higher yield of *dabuwa* and improved textural characteristics. Many factors such as higher protein and fiber content, and lower flour particle sizes might be responsible for higher WACs of the blends. F_1R_1C and F_1Mi_1S had the lowest values of WAC indicating that higher level of fonio (22.5%) had positive influence on WAC perhaps due to higher presence of pentosans in fonio flour. Solubility (S) influences other functional properties in addition to digestibility of the blends. Solubility level of the Control (FMa) was the least (4.03%) and was enhanced in the legume-supplemented blends. However, the range recorded (6.74-13.98%) for the blends was still low, perhaps mild toasting of the de-hulled legumes caused protein denaturation leading to limited solubility. The highest solubility value was observed in blends containing maize and soyabeans such as F_1Ma_1S and F_2Ma_2S which recorded 13.98% and 12.98% respectively. Bulk density (BD) of the blends varied significantly from 0.74g/ml (F_1Mi_1S) to 0.86g/ml (F_2Ma_2C and F_1R_1C). BD indirectly indicates nutrient density and is dependent on flour particle size, therefore, BD of blends influenced the textural properties of the *dabuwa* apart from handling, packaging and storage requirements [17,18,19].

The swelling power of blends were low including the Control. Swelling capacities (SC) ranged from 1.21ml/g (F_1Mi_1S) to 2.17ml/g (F_2R_2C). SC was highest in the rice-containing blends, and rice starch is known for high swelling capacity which is related to starch granule size and the ratio of amylose to amylopectin. Millet-containing blends had the least swelling power. Both WAC and SC are desireable flour attributes for dough formation and handling for most cereal flour based products. High level of fat in blends limit swelling of starch granules, and soyabean containing blends had higher level of fat which restricted swelling in aqueos medium. Generally, OAC was low, lowest in the Control FMa (0.97ml/g) and highest in F_2Ma_2C (1.09ml/g). Observed values were significantly not different ($p \geq 0.05$) from that of the Control. High OAC is needed in *dabuwa* preparation because traditionally beef fat is needed in its preparation for softness, flavor retention ([20,18,21] palatability [22] and higher calorific values.

4.2 Proximate Composition of Flour Blends Used to Produce *dabuwa*

The moisture, ash, protein, fat, fiber, carbohydrate contents and calorific values of the flour blends used for *dabuwa* production varied significantly ($p \leq 0.05$) from 7.38% -12.18%, 1.80% -2.96%, 4.33%-16.95%, 2.45-9.57%, 1.62-6.59%, 53.66-82.90% and 337.12-393.37kcal/100g respectively (Table 3). There was enhancement of protein, fat and ash contents of multi grain blends as a result of legume supplementation of the fonio- containing maize, millet, and rice flours. Malik et al. [6] Kumar et al. [23] and Radhika et al. [24] reported a similar increase in protein, ash and fibre contents of multigrain flours. The influence of soybean flour was more prominent in enhancing the nutritive value (with the exception of crude fiber) of the blends than cowpea flour as the results revealed. Soybean is known to contain high level of protein (40%), fat (20%) and ash (4.9%) [25]. Protein content of 38-44% was reported by Synder and Kwon [26] and 47.5% by Stein et al. [27] in soyabean. The Control (FMa) recorded the least protein content of 4.33% while the highest value of 16.95% was observed in F_1R_1S. Protein values observed were higher than values reported by Abdulrahman and Omoniyi [28] for single cereal flour from maize, millet and rice but lower than 14.00 to 16.49% for multigrain flour reported by Ijarotimi et al. [3] for a multigrain blend consisting of maize, cassava starch, defatted soybean and moringa. Moisture contents of the blends were low and this is good for shelf stability. A range of 7.38%-12.18% was observed. Blends containing rice flour had greater moisture content, especially cowpea-treated blends. A moisture content of less than 13% will ensure storage stability of well packaged and stored white flours [29] and at moisture contents higher than 13%, mustiness due to mould growth may develop [30]. Results for moisture content in this investigation all fall below 13%, an indication that these blends for *dabuwa* preparation can be kept for longer periods without quality deterioration.

The ash content represents the inorganic material present, and was enhanced with supplementation with legume flours when compared with the Control. The untreated Control (FMa) had the least ash content of 1.96%, a value not significantly different ($P \geq 0.05$) from 1.97% for F_1R_1C and 1.98% for F_2Ma_2S. The ash content ranged from 1.96% (FMa) to 2.96% (F_2R_2S). Higher ash content values were observed in soybean treated blends than cowpea treated expectedly.

Cereal grains are rich sources of dietary fiber which represent the indigestible material of the blends. Dietary fiber varied significantly ($p \leq 0.05$) from 1.62% (F_1Ma_1C) to 6.59% (F_2Mi_2S). Higher values of dietary fibre (6.59% and 6.26%) were observed in F_2Mi_2S and F_1Mi_1C respectively.

Blends containing soybean flour had lower levels of carbohydrate expectedly since carbohydrate contents were determined by “difference”. The overall mean for carbohydrate contents was 67.88% and ranged from 53.66% (F_2Mi_2S) to 82.90% (FMa). Ash, fiber, protein, fat and carbohydrates were higher in blends with higher level (57.5%) of cereal flour and fortified with 30% soyabean flour.

Calorific values of soybean supplemented cereal blends were also higher than the cowpea supplemented ones, the highest was 393.37kcal/100g (F_2Mi_2S) which is significantly different ($p \leq 0.05$) from 355.50 kcal/100g (F_1R_1C). This might be as a result of high fat contents of soybean compared to cowpea in the blends.

Table 2. Effect of cowpea and soybean supplementation on the functional properties of *dabuwa* composite blends produced from three different cereal grains

Formulations	Water absorption capacity (%)	Solubility (%)	Bulk density (g/ml)	Swelling capacity (g/g)	Oil absorption capacity (ml/g)
Cowpea supplementation					
F_1Ma_1C (12.5:57.5:30)	249.75±0.36[c]	9.70±0.28[de]	0.85±0.01[ab]	1.51±0.01[c]	1.05±0.00[c]
F_2Ma_2C (22.5:47.5:30)	270.34±0.48[a]	10.02±0.03[d]	0.86±0.03[a]	1.60±0.01[bc]	1.39±0.01[a]
F_1Mi_1C (12.5:57.5:30)	239.29±0.33[f]	6.77±0.13[g]	0.80±0.01[abcde]	1.49±0.01[cde]	1.02±0.01[cde]
F_2Mi_2C (22.5:47.5:30)	241.18±0.24[e]	6.74±0.01[g]	0.78±0.02[bcde]	1.30±0.00[ef]	1.10±0.01[b]
F_1R_1C (12.5:57.5:30)	216.76±0.36[k]	8.40±0.21[f]	0.86±0.01[a]	2.15±0.07[a]	0.98±0.01[f]
F_2R_2C (22.5:47.5):30)	234.12±0.20[h]	6.81±0.04[g]	0.85±0.01[ab]	2.17±0.18[a]	0.98±0.01[f]
Soybean supplementation					
F_1Ma_1S (12.5:57.5:30)	240.06±0.08[ef]	12.98±0.02[b]	0.77±0.03[cde]	1.50±0.00[cde]	1.01±0.01[def]
F_2Ma_2S (22.5:47.5:30)	236.31±0.46[g]	13.98±0.17[a]	0.84±0.01[abc]	1.79±0.01[b]	1.04±0.01[cd]
F_1Mi_1S (12.5:57.5:30)	221.09±0.31[j]	9.32±0.01[e]	0.74±0.01[e]	1.29±0.01[ef]	1.07±0.01[bc]
F_2Mi_2S (22.5:47.5:30)	223.98±0.31[i]	9.96±0.08[d]	0.75±0.01[de]	1.21±0.01[f]	1.02±0.02[cde]
F_1R_1S (12.5:57.5:30)	265.03±0.03[b]	11.68±0.04[c]	0.81±0.01[abcd]	1.50±0.00[cde]	1.07±0.01[bc]
F_2R_2S (22.5:47.5):30)	234.17±0.08[h]	11.74±0.04[c]	0.74±0.01[e]	1.79±0.01[b]	0.99±0.01[f]
Control FMa (25:75)	245.99±0.13[d]	4.03±0.16[h]	0.82±0.03[abc]	1.52±0.02[c]	0.97±0.01[f]
Mean	239.85±15.27	9.39±2.77	0.81±0.05	1.60±0.30	1.05±0.11
CV (%)	0.123	1.35	2.14	3.35	1.48

Values are mean ± standard deviation of duplicate determinations. Means in the same column with different letters are significantly different ($p\leq0.05$)
Key: F= Fonio, Ma = Maize, Mi = Millet, R = Rice, C = Cowpea, S = Soybean. The subscripts 1 and 2 of F denotes 12.5% and 22.5% respectively while those after Ma, Mi and R denotes 57.5% and 47.5% respectively

Table 3. Effect of cowpea and soybean supplementation on the proximate composition of composite blends for *dabuwa* produced from three different cereal grains

Formulations	**Proximate composition (%)**						**Calorie (kcal/100g)**
	Moisture	**Ash**	**Protein**	**Fat**	**Fibre**	**Carbohydrate**	
Cowpea supplementation							
F_1Ma_1C (12.5:57.5:30)	8.20±0.01[g]	1.80±0.06[d]	6.12±0.01[gh]	2.49±0.01[ef]	1.65±0.01[ef]	82.32±0.10[ab]	358.24±0.30[e]
F_2Ma_2C (22.5:47.5:30)	8.62±0.06[f]	2.50±0.03[b]	7.29±0.01[g]	2.88±0.01[e]	1.62±0.04[ef]	70.52±9.43[cd]	337.12±0.61[j]

F_1Mi_1C (12.5:57.5:30)	9.12±0.01[e]	2.50±0.06[b]	14.21±0.01[cd]	2.45±0.01[ef]	6.26±0.21[ab]	65.47±0.27[cde]	340.77±0.89[i]
F_2Mi_2C (22.5:47.5:30)	9.09±0.06[e]	2.00±0.01[c]	13.66±0.01[d]	4.82±0.02[d]	4.20±0.05[b]	66.23±0.15[cde]	362.99±0.37[d]
F_1R_1C (12.5:57.5:30)	12.18±0.04[a]	1.97±0.02[c]	9.82±0.02[e]	2.95±0.02[e]	1.65±0.01[ef]	72.44±0.09[bc]	355.50±0.22[f]
F_2R_2C (22.5:47.5):30)	12.14±0.04[a]	2.04±0.01[c]	9.87±0.02[e]	2.91±0.02[e]	3.62±0.01[bc]	69.42±0.02[cde]	343.31±0.19[h]
Soybean supplementation							
F_1Ma_1S (12.5:57.5:30)	7.79±0.01[h]	2.49±0.01[b]	16.29±0.05[ab]	7.08±0.01[b]	2.44±0.01[d]	64.99±0.00[cde]	388.77±0.26[b]
F_2Ma_2S (22.5:47.5:30)	7.38±0.01[i]	1.98±0.01[c]	8.66±0.01[f]	6.28±0.04[bc]	2.60±0.02[cd]	74.09±0.08[abc]	387.51±0.04[bc]
F_1Mi_1S (12.5:57.5:30)	8.26±0.04[g]	2.93±0.03[a]	14.82±0.01[c]	9.57±0.01[a]	4.33±0.02[b]	60.08±0.12[ef]	385.77±0.39[c]
F_2Mi_2S (22.5:47.5:30)	9.20±0.02[e]	2.00±0.01[c]	15.68±0.01[b]	8.89±0.01[ab]	6.59±0.01[a]	53.66±0.06[f]	393.37±0.23[a]
F_1R_1S (12.5:57.5:30)	10.99±0.01[b]	2.01±0.01[c]	16.95±0.01[a]	5.52±0.02[c]	3.77±0.01[bc]	60.77±0.06d[ef]	360.48±0.04[de]
F_2R_2S (22.5:47.5):30)	10.62±0.04[c]	2.96±0.01[a]	15.48±0.01[bc]	8.54±0.02[ab]	2.87±0.02[c]	59.54±0.07[ef]	376.88±0.06[cd]
Control FMa (25:75)	9.51±0.01[d]	1.96±0.01[c]	4.33±0.011[h]	2.49±0.02[ef]	1.77±0.02[e]	82.90±0.08[a]	353.38±0.09[g]
Mean	9.47±0.036	1.99±0.030	11.79±0.018	5.14±0.017	3.31±1.67	67.88±2.62	364.93±20.57
CV (%)	0.382	1.48	0.149	0.339	1.89	3.85	2.86

Values are mean ± standard deviation of duplicate determinations. Means in the same column with different letters are significantly different ($p \le 0.05$)
Key: F= Fonio, Ma = Maize, Mi = Millet, R = Rice, C = Cowpea, S = Soybean. The subscripts 1 and 2 of F denotes 12.5% and 22.5% respectively while those after Ma, Mi and R denotes 57.5% and 47.5% respectively

Table 4. Effect of cowpea and soybean supplementation on the proximate composition of *dabuwa* produced from three different cereal grains

Formulations	**Proximate composition (%)**						**Calorie (kcal/100g)**
	Moisture	**Ash**	**Protein**	**Fat**	**Fibre**	**Carbohydrate**	
Cowpea supplementation							
F_1Ma_1C (12.5:57.5:30)	$6.76±0.35^{f}$	$0.94±0.01^{f}$	$11.89±0.01^{d}$	$4.44±0.01^{ef}$	$1.21±0.01^{e}$	$77.75±0.37^{c}$	$371.54±1.44^{f}$
F_2Ma_2C (22.5:47.5:30)	$4.86±0.35^{h}$	$1.41±0.01^{de}$	$11.04±0.22^{e}$	$8.34±0.04^{bc}$	$1.12±0.02^{e}$	$73.22±0.54^{d}$	$412.12±1.65^{b}$
F_1Mi_1C (12.5:57.5:30)	$8.37±0.05^{cd}$	$2.48±0.04^{a}$	$16.38±0.39^{a}$	$7.88±0.02^{c}$	$4.63±0.07^{a}$	$60.25±0.46^{f}$	$377.49±0.09^{e}$
F_2Mi_2C (22.5:47.5:30)	7.61±0.06e	$0.92±0.03^{f}$	$12.29±0.02^{d}$	$2.30±0.04^{g}$	$3.30±0.28^{bc}$	$73.59±0.30^{d}$	$364.23±1.45^{g}$
F_1R_1C (12.5:57.5:30)	$7.41±0.01^{ef}$	$1.50±0.07^{d}$	$11.50±0.01^{g}$	$2.54±0.23^{g}$	$0.96±0.01^{e}$	$82.11±0.29^{b}$	$373.21±0.97^{f}$
F_2R_2C (22.5:47.5):30)	$5.22±0.01^{h}$	$1.44±0.01^{de}$	$11.44±0.01^{i}$	$2.02±0.05^{gh}$	$3.32±0.01^{bc}$	$86.54±0.07^{a}$	$370.16±0.19^{f}$
Soybean supplementation							
F_1Ma_1S (12.5:57.5:30)	$8.57±0.02^{cd}$	$1.33±0.01^{e}$	$14.77±0.34^{b}$	$8.75±0.03^{b}$	$2.00±0.05^{d}$	$59.58±0.40^{fg}$	$421.17±0.00^{a}$
F_2Ma_2S (22.5:47.5:30)	$6.01±0.07^{g}$	$1.33±0.04^{e}$	$13.63±0.34^{c}$	$6.07±0.06^{d}$	$2.00±0.04^{d}$	$70.97±0.33^{e}$	$393.01±0.54^{c}$
F_1Mi_1S (12.5:57.5:30)	$7.96±0.06^{de}$	$1.85±0.04^{c}$	$10.12±0.02^{f}$	$8.44±0.03^{bc}$	$3.63±0.07^{b}$	$73.00±0.03^{d}$	$363.42±0.06^{gh}$
F_2Mi_2S (22.5:47.5:30)	$8.81±0.20^{bc}$	$1.92±0.03^{c}$	$15.43±0.09^{b}$	$10.60 ±0.08^{a}$	$4.65±0.33^{a}$	$58.55±0.06^{g}$	$391.32±0.88^{c}$
F_1R_1S (12.5:57.5:30)	$9.28±0.04^{b}$	$2.26±0.06^{b}$	$12.26±0.06^{h}$	$4.81±0.04^{e}$	$2.96±0.04^{c}$	$81.42±0.06^{b}$	$351.03±0.41^{i}$
F_2R_2S (22.5:47.5):30)	$10.85±0.04^{a}$	$0.94±0.01^{f}$	$10.94±0.01^{i}$	$3.17±0.03^{h}$	$2.02±0.01^{d}$	$82.06±0.09^{b}$	$360.57±0.08^{h}$
Control FMa (25:75)	$6.05±0.02^{g}$	$1.51±0.01^{d}$	$10.11±0.01^{f}$	$4.16±0.25^{ef}$	$1.18±0.03^{e}$	$76.99±0.48^{c}$	$385.81±0.28^{d}$
Mean	7.52+0.16	1.53±0.033	9.68±0.185	5.19±0.102	2.54±0.124	73.54±0.321	379.62±0.84
CV (%)	2.16	2.12	1.91	1.97	4.88	0.44	0.222

Values are mean ± standard deviation of duplicate determinations. Means in the same column with different letters are significantly different (p≤0.05)
Key: F= Fonio, Ma = Maize, Mi = Millet, R = Rice, C = Cowpea, S = Soybean. The subscripts 1 and 2 of F denotes 12.5% and 22.5% respectively while those after Ma, Mi and R denotes 57.5% and 47.5% respectively

Table 5. Effect of cowpea and soybean supplementation on sensory characteristics of *dabuwa* produced from three different cereal grains

Formulation	Sensory Attributes				Overall acceptability
	Appearance	Taste	Mouth feel	Aroma	
Cowpea supplementation					
F_1Ma_1C (12.5:57.5:30)	8.47±0.74[a]	8.13±1.13[a]	6.80±0.86[bcd]	7.27±1.03[ab]	7.87±0.74[ab]
F_2Ma_2C (22.5:47.5:30)	8.40±0.74[a]	8.13±0.13[a]	7.00±0.93[bcd]	7.27±1.03[ab]	7.67±0.62[ab]
F_1Mi_1C (12.5:57.5:30)	5.07±1.44[b]	4.47±0.92[b]	3.00±1.20[e]	6.53±0.92[b]	5.40±0.83[c]
F_2Mi_2C (22.5:47.5:30)	5.13±0.99[b]	4.67±0.62[b]	2.87±0.99[e]	6.60±0.74[b]	5.87±0.64[c]
F_1R_1C (12.5:57.5:30)	8.53±0.52[a]	8.20±1.01[a]	6.20±0.68[d]	7.13±0.74[ab]	7.40±0.51[b]
F_2R_2C (22.5:47.5):30)	8.60±0.51[a]	8.47±0.52[a]	6.40±0.83[cd]	7.27±0.46[ab]	7.67±0.49[ab]
Soybean supplementation					
F_1Ma_1S (12.5:57.5:30)	8.47±0.74[a]	8.27±0.88[a]	7.33±0.72[bc]	7.40±0.99[ab]	7.80±0.68[ab]
F_2Ma_2S (22.5:47.5:30)	8.47±0.74[a]	8.27±0.88[a]	7.53±0.83[ab]	7.33±1.11[ab]	7.80±0.56[ab]
F_1Mi_1S (12.5:57.5:30)	4.93±1.10[b]	4.60±0.91[b]	3.60±0.83[e]	6.53±0.99[b]	5.53±0.74[c]
F_2Mi_2S (12.5:47.5:30)	5.00±1.07[b]	4.93±0.88[b]	3.67±0.73[e]	6.67±0.72[b]	5.80±0.41[c]
F_1R_1S (12.5:57.5:30)	8.60±0.51[a]	8.33±0.90[a]	6.87±0.92[bcd]	7.20±0.56[ab]	7.60±0.51[b]
F_2R_2S (22.5:47.5):30)	8.60±0.51[a]	8.53±0.52[a]	7.00±0.93[bcd]	7.47±0.83[ab]	8.00±0.65[ab]
Control FMa (25:75)	8.80±0.56[a]	8.53±0.74[a]	8.40±0.63[a]	8.20±1.15[a]	8.40±0.74[a]
Mean	7.47±1.82	7.19±1.89	5.90±2.01	7.14±0.97	7.14±1.20
CV	11.11	12.10	14.63	12.47	8.90

Values are mean ± standard deviation of duplicate determinations. Means in the same column with different letters are significantly different (p≤0.05)

Key: F= Fonio, Ma = Maize, Mi = Millet, R = Rice, C = Cowpea, S = Soybean. The subscripts 1 and 2 of F denotes 12.5% and 22.5% respectively while those after Ma, Mi and R denotes 57.5% and 47.5% respectively

4.3 Proximate Composition of Modified *dabuwa* and Control

As shown in Table 4, moisture, ash, protein, fat, fiber, carbohydrate and calories content of *dabuwa* ranged from 4.86-10.85%, 0.92-2.48%, 10.11-16.38%, 2.02-10.60%, 0.96-4.65%, 58.55-86.54%, and 351.00-421.17kcal/100g respectively. There was a general enhancement of nutrients in the enriched dabuwa, the preparation process might be responsible for the slight reduction. Results indicated an enhancement of protein and fat, and consequently, calorific contents of the enriched dabuwa. Fiber content was enhanced not in any particular trend while ash contents were lower compared to those of flour blends. Malik et al. [6] Kumar et al. [23] and Radhika et al. [24] reported an enhancement of nutrients in products obtained from multigrain blend compared to flour from a single grain.

Generally, moisture contents of *dabuwa* were low; a range of 4.86% to 10.85%, and this is an indication of storage stability and longer shelf life, however, not different from those of the blends. *Dabuwa* with soybean treated blends had greater moisture contents than their cowpea treated counterparts. This may be due to high presence of hydrophobic substances in soybean treated *dabuwa*.

Results indicate a reduction in both ash and fiber contents of dabuwa compared to the flour blends, even though a significant difference ($p \le 0.05$) existed between the values of the Control and those of enriched dabuwa. Ash contents ranged from 0.92 to 2.48%, these values are lower than 4.07 to 5.01% reported by Radhika et al. [24]

Fiber contents varied significantly ($P \le 0.05$) from 0.96% (F_1R_1C) to 4.63% (F_1Mi_1C). Millet grain is a good source of fiber and ash as shown by dabuwa containing millet, a desirable quality improvement compared with fiber and ash contents of the control and the legume-treated maize and rice products.

Protein content of the untreated Control FMa (25:75) was the least (10.11%) significantly not different ($P \ge 0.05$) from 10.12% (F_1Mi_1S). The overall mean for protein content was 9.68% and it ranged from 10.11% to 16.38%. Dabuwa produced from F_1Mi_1C and F_2Mi_2S had the highest protein contents of 16.38% and 15.43% respectively. Devi et al. [31] reported millets as distinctive among cereals because of their abundance in protein along with Ca, dietary fiber and polyphenol.

Fat contents varied significantly ($p \le 0.05$) from 2.02% to 10.60% with a mean value of 5.19%. These values are higher than 1.64 – 6.72% reported by Radhika et al. [24] this was expected since beef fat was part of the formulation for dabuwa preparation. Low moisture contents that would guarantee storage stability for dabuwa would not be of value if rancidity is encouraged by higher fat contents.

Values for carbohydrate and calories of dabuwa were generally higher than the Control. Carbohydrate values ranged from 58.55% (F_2Mi_2S) to 86.54% (F_2R_2C). Dietary calories ranged from 351.03kcal/100g (F_1R_1S) to 421.17 kcal/100g (F_1Ma_1S). Calorific contents were enhanced in soybean treated dabuwa expectedly compared to the cowpea treated products, especially dabuwa with higher amounts of cereal flours (57.5%).

4.4 Sensory Properties of dabuwa

Sensory scores as shown in Table 5 were significantly different ($p \le 0.05$). The Control (FMa) had the highest and the millet containing dabuwa scored the least. The variations were as follows: appearance: 4.93 (F_1Mi_1S) to 8.80 (FMa), taste: 4.47 (F_1Mi_1C) to 8.53 (FMa), mouthfeel: 2.87 (F_2Mi_2C) to 8.40 (FMa), aroma: 6.53 (F_1Mi_1C and F_1Mi_1S) to 8.20 (FMa), and overall acceptability: 5.40 (F_1Mi_1C) to 8.40 (FMa). The overall mean scores were appearance 7.47, taste 7.19, mouthfeel 5.90, aroma 7.14, and overall acceptability 7.14. The sensory attributes were influenced positively by the presence of rice and maize flours mainly and the influence of legume flours were masked by the cereal flours and the presence of the spice mix. Radhika et al. [24] observed lower sensory scores for millet-containing multigrain products. Products prepared from millet flour have low consumer appeal due to presence of the fibrous seed coat which renders the flour coarse in texture and imparts a greyish color that gives a bitter taste [32]. McDonough et al. [33] blamed higher presence of polyphenolic pigments in the pericarp, aleurone and endosperm regions of millet to be responsible for off colour and off taste as observed for dabuwa. Rice containing dabuwa had the highest scores for appearance (8.53, 8.60, 8.60 and 8.60) and taste (8.20, 8.47, 8.33 and 8.53), values that were not significantly different ($p \ge 0.05$) from maize containing *dabuwa*.

On the overall, FMa i.e. the Control outscored all other samples in all attributes but taste, the Control and F_2R_2S scored 8.53 for taste, making them the most preferred. However, the coefficient of variation for overall acceptability was the least (8.90) indicating that the various *dabuwa* were generally accepted and none was rejected.

CONCLUSION

Within multigrain flour blends, there was enhancement of water absorption capacity which is necessary for *dabuwa* production; and equally enhanced was the nutrient density of the modified flour blends and *dabuwa* in terms of enhanced ash, protein, fiber, fat but slightly decreased carbohydrate. *Dabuwa* containing maize or rice competed favorably with traditional *dabuwa* in terms of all the tested sensory attributes however, sensory quality of millet-containing *dabuwa* was marred by their dull color, bitter taste and coarse texture.

It is concluded that ready-to-use multigrain flour blends have lessened the labor involved in the production of *dabuwa. M*oreover*,* the nutritional profile of *dabuwa*, a traditional cereal based food of the Shuwa-Arabs of Northern Nigeria was equally enhanced without undermining its well-known sensory properties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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