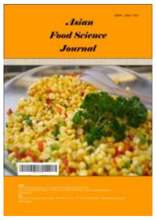

Asian Food Science Journal

18(2): 1-10, 2020; Article no.AFSJ.60603
ISSN: 2581-7752

Effects of Blend Formulation on Quality Characteristics of *Mordum* (A Nigerian Multi-Grain Breakfast Cereal) Fortified with Grain Legume or Powdered Milk

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Authors' contributions

This work was carried out in collaboration among all authors. Author AIG conceptualized, designed the study, performed the statistical analysis and produced the manuscript draft. Authors GKF and AZR jointly carried out the physicochemical and sensory analysis. Author BUH examined the microbial profile of the samples. Authors individually searched the literature, proof read the manuscript draft and endorsed it for publication.

Article Information

DOI: 10.9734/AFSJ/2020/v18i230210
Editor(s):
(1) Dr. Uttara Singh, Panjab University, India.
Reviewers:
(1) Dyego da Costa Santos, Federal Institute of Education, Science and Technology, Brazil.
(2) Gabrielli Nunes Clímaco, University of Campinas, Brazil.
(3) Tatianne Ferreira de Oliveira, Federal University of Goiás, Brazil.
Complete Peer review History: http://www.sdiarticle4.com/review-history/60603

Original Research Article

Received 25 June 2020
Accepted 31 August 2020
Published 18 September 2020

ABSTRACT

In this present study, *mordum* a millet-rice based Nigerian breakfast meal was produced from blends consisted of rice, millet or rice, maize, each fortified with cowpea, soybean or powdered milk(cereal$_1$:cereal$_2$:legume/milk or cereal$_2$:cereal$_1$:llegume/milk) in the ratios of 50:30:20 or 30:50:20. Nine spiced multigrain blends were produced and subjected to physicochemical and sensory evaluations. Percentage retentions on sieves revealed that the main mass fraction of the blends was 224-300 µm, however blends containing powdered milk were finer. Solubility (4.85-8.95%) and swelling power (2.71-3.27%) of the blends were generally low while water absorption capacity (159%-221%) and bulk density (0.7895-0.9181 g/ml) were moderately high. Moisture, crude protein, crude fat, total ash, crude fiber and carbohydrate varied significantly ($p<0.05$): 5.03-

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10.30%, 10.46-20.15%, 7.01-12.08%, 2.45-4.20%, 1.52-3.38%, and 52.57-68.50% respectively. In order of dominance, the mineral elements were (mg/100g): 226.08-356.68 K, 220.69-360.34 Ca, 13.32-40.00 Mg, 5.34-9.21 P, 3.67-8.14 Fe, and 3.32-8.34 Zn. Bacterial and fungal populations of the blends were satisfactorily low, less than10^4cfu/g and 10^3cfu/g respectively, perhaps due to relatively low moisture contents of the blends. The overall sensory attributes of the gruel containing milk and maize were the best. Although the nutritive value of the blends were generally enhanced, however the study concluded by recommending commercial production of ready-to-cook blends containing rice and maize and fortified with either soybean or milk for improved nutritional status of the mordum consumers.

Keywords: Multigrain blends; breakfast cereal; indigenous food; grain legumes; fortification.

1. INTRODUCTION

Indigenous foods consists of a wide range of food products that have evolved within a locality overtime due to availability of some food crops, they are usually prepared using unwritten rules deeply influenced by cultural taboos and beliefs and which have resisted modernization even though technological-driven production process are needed for better packaging, nutritional and sensory quality, however the need to preserve and protect indigenous methods of food processing has been stressed by Asogwa et al.[1], a worthy heritage that reminds people of their past and their current level in the scheme of things.

Fermented foods dominate the collection of indigenous foods in Africa [2] which are mainly based on spontaneous fermentation by motley of microorganisms. Like most indigenous foods, the origin of Mordum is lost in the mistiness of history because it was never documented like many others, however it has been the main breakfast meal for most tribes in northeastern Nigeria notably the Kanuri and Shuwa Arab tribes, dating back to pre-colonial Nigeria. Traditionally, it is prepared by pouring pre-cooked pearl millet with the gruel unto a flour blend of rice and millet, followed by mixing after which it is left to stand for 25-30 min before it is sweetened with sugar and for the well-to-do milk is added in order to enhance its nutritional and sensory properties. Consumption of Mordum cuts across all the age groups and social classes and like most indigenous foods, laborious preparation methods, storage instability and improper packaging have gradually led to loss of interest in its preparation and consumption especially by on-the-move urban dwellers and this trend has been exacerbated by urbanized life style with the attendant love for ready-to-eat or cook foods [3], therefore the urgent need to modify its processing and preparation by introducing nutritious, cheap pulses and use of ready-to-cook blends, thereby reduce the number of unit operations involved before it is placed on the table. Currently, there are unwritten process or product specifications as well as manufacturing and hygienic practices which usually characterize indigenous food preparations like mordum, consequently such food products do not receive wide acceptance due to poor quality and limited distribution, therefore hardly are they known outside the enclave of origin.

Mordum is cereal-based, and cereals are known providers of calories, protein, mineral and vitamins to greater part of the world population [4]. Commonest cereal grains in semi-arid environment of northeastern Nigeria are millet and sorghum, while maize and rice receive ubiquitous cultivation in all ecologies of Nigeria. These cereals are mostly used for the preparation of indigenous foods mostly in form of thin, thick or stiff porridge. Cereals in general are bedeviled by low levels of lysine and tryptophan, two essential amino acids, moreover flour extraction process in order to obtain refined flour further depletes the health giving dietary fibre, minerals and vitamins and non-nutrient nutriceutical contents through removal of the outer fibrous layers although their removal increases the bioavailability of minerals through the reduction of anti- nutrients like phytate and tannin.

In an environment where income level is low, the affordability of nutritionally superior foods usually of animal origin becomes the preserve of the rich therefore vegetable proteins obtainable from grain legumes such as cowpea, soybean etc. come to the rescue. The protein content of the grain legumes surpass that of rice by 3 to 4 times, those of millet, wheat, maize 2-3 times, additionally the quality of the protein is high, which naturally complement the lysine and tryptophan deficient cereal grain proteins and are high in dietary fibre, minerals and vitamins [5] (Cowpea (Vigna unquiculata) a hot weather crop is the top most grain legume in Nigeria, and incidentally Nigeria is the leading producer [6]. Cowpea is a good source of calorie (59-65% carbohydrate), provides significant amount of lysine rich protein (22-26%) (Khalid et al., 2012; Nwosu et al.,2014) [7,8] Soybeans on the other hand is the wonder crop of the world, both a cash and a food crop used extensively in the fabrication of functional foods, its protein quality is high, moreover its isoflavones, phenolics and saponins have health promoting functions as immune-stimulatory, antiviral, hepato-protective and anti-tumorigenic properties (Anderson et al.[9]; Lasztity et al. [10].

The dependence on single starchy crop for protein and energy is the root cause of protein-energy malnutrition in low income economies of the world, therefore the thrust of this present study was to produce Mordum using a multigrain blend of different ratios of rice, millet, maize fortified with either cowpea, soybean or powdered milk thereafter evaluate the physicochemical and sensory properties of the modified Mordum.

2. MATERIALS AND METHODS

2.1 Materials

Rice (milled Dikwa long grain) Pearl millet, maize (white flint), blacked-eyed cowpea, cream colored soybeans and spices (clove, red and black pepper, ginger) and other ingredients such as powdered milk (full cream) were purchased at Maiduguri Monday market and taken to the Food Process Laboratory of the Department of Food Science and Technology, University of Maiduguri, Nigeria for product development.

2.2 Material Preparation

2.2.1 Millet/maize flour

The seeds were sorted to remove impurities, sprinkled with water to condition, taken to a local mill for dehulling. The dehulled seeds were washed, oven-dried (3 h, 80°C) milled in a laboratory hammer mill and sieved with 400µm mesh screen, the millet and maize flour were separately bagged in LDPE bags.

2.2.2 Rice flour

Rice seeds were washed and soaked for 30 min in water, the soaked seeds were oven-dried (80°C, 3 h) milled and sieved with 400 µm mesh and bagged.

2.2.3 Soybean and cowpea flour

Cleaned seeds were soaked in warm water for 2-3 h then manually dehulled, washed and oven-dried (80°C, 5 h), the dried seeds were given mild roasting (120°C 20 min), milled, sieved with 400 µm mesh and bagged.

2.2.4 Spice mix

Dried clove, ginger, black and red pepper were separately ground and mixed in the ratio of clove: ginger: black pepper: red pepper (2:2:1:1), 1 gram was added to each flour blend.

2.3 Blend Formulation for Mordum Preparation

The blends were formulated in the ratios of 50:30:20 or 30:50:20, they all contained rice with either millet or maize and constant proportion of spice milk (1%) of cowpea or soybean or milk (20%). Each blend was mixed in kitchen blender and stored in LDPE bags prior to use.

2.4 Preparation of Mordum Gruel from the Blends

The recipe consisted of 100 g of each blend, 500 ml of water and 10 g of sugar. Slurry (10%) made with the blend was placed on fire to gelatinize, the remaining water and blend were added while stirring and cooked for 30mins. It was brought down, sweetened and allowed to cool before serving the test panelists in transparent cups bearing sample codes.

Table 1a. Formulation of the blends for mordum preparation

S/No	Formulation	R	Mt	Mz	Ss	Cp	Mk	Sm
i.	RMtSsSm (50:30:20)	50	30	-	20	-	-	1
ii.	RMzSsSm (50:30:20)	50	-	30	20	-	-	1
iii.	MtRMkSm (30:50:20)	30	50	-	-	-	20	1
Iv	MtRCpSm (30:50:20)	30	50	-	-	20	-	1
v.	MtRSbSm (30:50:20)	30	50	-	20	-	-	1
vi.	RMtMkSm (50:30:20)	50	-	-	-	-	-	1
vii.	RMzMkSm (50:30:20)	50	-	30	-	-	-	1
viii.	RMtCPSm (50:30:20)	50	30	-	-	-	20	1
ix.	RMzCpSm (50:30:20)	50	-	30	-	-	20	1

R= Rice flour, Mt= Millet flour, Sb= Soybean flour, Sm= Spice mix, Mk= Milk powder, Cp= Cowpea flour, Mz= Maize flour

3. PHYSICOCHEMICAL ANALYSIS OF THE BLENDS

3.1 Functional Properties

Bulk density was determined by the method of Onwuka [11] and results expressed in g/ml. Solubility and swelling power were determined by the method of Leach et al. [12]: One gram (1 g) of blend was placed in pre-weighed centrifuge tube, 10 ml of distilled water was added and mixed. The mixture in the tube was placed in a water bath maintained at 85°Cwith continuous stirring for 30 min. It was removed, cooled and centrifuged at 2200 rpm for 15 min. The supernatant was poured in a pre-weighed crucible and caused to evaporate in an oven (105°C, 1h). The mass of the residue left behind expressed as percentage of the weight of the sample was regarded as the solubility in percentage. The weight of the sediment expressed as the percentage of the weight of the sample was taken as the swelling power. The method of Beuchat et al. [13] was used to determine the water absorption capacity (WAC). It involved 1g of the blend mixed with 10ml of water in a centrifuge tube, rested for 30mins and centrifuged at 5000× g for 30 min. The volume of free water was read on the graduated centrifuge tube and expressed as a percentage of water absorbed per gram of sample.

3.2 Proximate Composition of the Blends

The moisture, crude protein (N×6.25), crude fat, total ash, crude fibre contents of the blends were determined using the established procedures of AOAC (2000). Moisture determined by oven drying 5 g of blend at 105°C for 1hr; protein determined using micro-Kjeldahl method using 200 mg of blend; fat determined by solvent extraction of 1g of the blend in a soxhlet extractor using petroleum ether; ash was determined by placing 5 g of blend in a muffle furnace at 550°C for 5 hr; crude fiber was determined by alternate digestion of 1g of the blend with dilute H_2SO_4 and dilute NaOH, washing, oven drying and finally incinerating a muffle furnace at 550°C 3 h. Carbohydrate contents were obtained by ‘difference. Mean results of the proximate determination were expressed in g/100 g of the blend (%).

3.3 Mineral Contents of the Blends

The mineral contents of the blend were determined according to the procedures of AOAC [14]. Five (5) gram of each blend was dry-ashed in a muffle furnace, dissolved in 20 ml of hydrochloric acid boiled and filtered, the filtrate made up to 100 ml in a volumetric flask with de-ionized water. Sodium (Na) and Potassium were determined using flame photometer (Model 405, Corning UK) and the other elements Calcium (Ca), Iron (Fe), Zn (Zinc), Magnesium (Mg) were determined using Atomic Absorption Spectrophotometer (Model 703 Perkin-Elmer, USA). Phosphorous was determined colometrically using ammonium molybdate method.

3.4 Microbiological Status of the Blends

Aerobic mesophilic bacteria were determined by the procedures of APHA [15]. One gram (1 g)of each blend was serially diluted with 0.1% peptone water to the level of 10^{-5}, 1ml of the dilution was pour plated on nutrient agar, incubated at 37°C 48 h, another 1 ml pour plated on antibiotic treated potato dextrose agar, inverted and incubated at 27±2°C for 3-5days, control plates contained no samples. Colonies on selected plates were enumerated using digital colony counter (GalenKamp, UK). Results were expressed in colony forming unit per gram (cfu/g).

3.5 Sensory Evaluation

A semi trained panel consisting of 7 males and 9 females drawn from staff and students of the Department of Food and Technology, University of Maiduguri Nigeria, assessed the sensory attributes of the different Mordum samples such as appearance, taste, consistency, mouth feel and overall acceptability on a 9-point hedonic scale where 1 represents extremely disliked, 9 extremely liked, 5 neither liked nor disliked. Coded Mordum samples contained in transparent cups were presented to panelists in a randomized manner. Warm water was provided for mouth gaggling prior to testing a given sample.

3.6 Statistical Analysis

Determinations were replicated unless otherwise stated. Data obtained were subjected to one-way analysis of variance (ANOVA) using SSPS version 16, means were separated using the Duncan multiple range test and significance was accepted at 5% probability ($p<0.05$). Results were presented as mean of duplicate or triplicate measurements.

4. RESULTS AND DISCUSSION

4.1 Particle Size Distribution of the Blends

Blends containing powdered milk devoid of millet flour such as RMtMk had the finest particles with highest % retentions on 150-180 um sieves and for those containing soybean or cowpea flour, higher retentions (28.42-40.88%) were observed on 300um sieve indicating coarser granulation; however all the blends had equivalent retentions (25.79-33.74%) on 224um sieve except RMzMk (15.60%), therefore the main mass fraction of the blends as indicated by % retentions was 224-300 um, Table 1. Negligible retentions were observed on 500 um sieve for all the blends. Blends with finer granulation would likely have better consistency and mouth-feel. The grinding process leads to the existence of particles of different sizes that have strong bearing on the physicochemical and sensory properties of flour/blends [16]. Blends with finer particles do not suit breakfast cereals but those with coarser particles (224-300 μm), still they are suitable for complementary feeding where paste thickness and viscous gruel are not needed.

4.2 Functional Properties of the Blends for Mordum Preparation

The functional properties of the blends are presented in Table 2. There were significant variations ($p<0.05$) in the solubility, water absorption capacity (WAC) and bulk density of the blends. The bulk density (BD) varied from 0.7971 to 0.9181 g/ml, the cowpea containing blends were observed to be bulkier indicating higher fibre content, followed by powdered milk containing blends, and the soybean containing blends had the least bulk density. Bulk density is an indication of the porosity of the material, it also indicates the quantity of nutrient/matter in unit volume, its knowledge is essential in food formulation as well as handling, packaging and storage operations. Blends with lower bulk density are recommended for complementary feeding. Bulk density values are influenced by flour particle size (the finer the smaller the BD), processing method such as grinding regimen and material treatment. WAC of the blends varied significantly ($P<0.05$) from 159% (RMzMk) to 221% (RMzSb). Blends containing pulse flour had significant higher WAC and lower in milk containing blends. WAC indicates the ability to absorb and retain moisture/water, the blends containing soybean had the highest WAC, followed by cowpea supplemented blends while blends with powdered milk had the least WAC. As observed here higher WAC is an indicator of which of the blends would have higher protein content, a desirable quality factor for a breakfast meal that most often resemble a viscous beverage. Mordum is consumed as gruel, therefore higher WAC of the blends is desirable in addition to higher swelling power and solubility. The solubility of the blends varied from 4.85% (RMtCp) to 8.95% (RMzMk), three milk containing blends had the highest solubility, cowpea containing blends had the least solubility of the blends. Extent of solubility of each blend determines its hydration properties such as WAC, swelling power, viscosity etc. Swelling power of the blends were generally low and varied from 2.71 to 3.27 g/g, soybeans and cowpea supplemented blends had higher swelling power and milk supplemented blends the least swelling power and WAC. Both swelling power and solubility observed in this study were lower than the values reported by Asaam et al [17] for yellow maize-soybean-pumpkin composite flours. Swelling power reveals the

Table 1. Particle size distribution (% retentions on sieves) of the blends for mordum preparation

Blend	530μm	300μm	224μm	180μm	150μm
RMtSb (50:30:20)	4.81	40.88	29.70	13.72	10.89
RMzSb (50:30:20)	6.59	40.19	30.84	11.47	10.94
MtRMk (30:50:20)	2.83	28.42	32.14	20.83	15.77
MtRCp (30:50:20)	4.25	29.36	26.34	18.66	21.40
MtRSb (30:50:20)	4.2	32.5	25.79	12.63	24.87
RMtMk (50:30:20)	3.65	36.79	33.74	17.63	8.36
RMzMk (50:30:20)	3.90	11.14	15.60	33.98	35.38
RMtCp (50:30:20)	3.90	38.32	31.91	14.35	11.15
RMzCp (50:30:20)	4.64	38.70	31.74	14.20	10.73

R= Rice flour, Mt= Millet flour, Sb= Soybean flour, Mk= Milk powder, Cp= Cowpea flour, Mz= Maize flour; the blends in the ratios of 50:30:20

Table 2. Functional Properties of blends for mordum Preparation

Mordum blend	Solubility (%)	Swelling power(g/g)	Water absorption capacity (%)	Packed bulk density (gml^{-1})
RMtSb (50:30:20)	8.15^{a}	3.02^{ab}	189.95^{b}	0.7971^{d}
RMzSb (50:30:20)	5.10^{bc}	3.26^{a}	221.60^{a}	0.8536^{bc}
MtRMk (30:50:20)	8.00^{a}	3.06^{ab}	172.65^{bc}	0.7984^{d}
MtRCp (30:50:20)	7.00^{ab}	3.06^{ab}	194.60^{ab}	0.8700^{b}
MtRSb (30:50:20)	8.00^{a}	3.27^{a}	212.10^{a}	0.7895^{e}
RMtMk (50:30:20)	8.20^{a}	2.76^{b}	163.40^{c}	0.8374^{c}
RMzMk (50:30:20)	8.95^{a}	2.71^{b}	159.30^{c}	0.8280^{c}
RMtCp (50:30:20)	4.85^{c}	3.02^{ab}	197.50^{ab}	0.9181^{a}
RMzCp (50:30:20)	5.65^{b}	3.04^{ab}	195.80^{ab}	0.9155^{a}

Mean values in the same column bearing different superscripts are significantly different (p<0.05)
R= Rice flour, Mt= Millet flour, Sb= Soybean flour, Mk= Milk powder, Cp= Cowpea flour, Mz= Maize flour. All blends in the ratio of 50:30:20

strength of associative forces within starch granules [18], moreover water uptake leads to volume expansion for higher protein, fibre and starch containing blends [19]. Higher swelling power is desirable for breakfast cereals such as *Ogi*, the commonest cereal gruel in Nigeria but for infant feeding viscous gruels with less calorie and protein are not desirable because it will easily fill up the small stomach of infants leading to under-nutrition.

4.3 Proximate Compositions of the Formulated Blends for Mordum Preparation

Significant differences were observed in the proximate composition of the various blends as shown in Table 3. Moisture contents of the blends varied significantly (P<0.05) from 5.03% to7.80%. This low level of moisture contents will ensure storage stability. The blends containing supplemented cowpea and soybean had higher moisture contents than blends with powdered milk. The fat contents of the blend ranged from 8.21% to 12.08 with the blends fortified with soybean had the highest, cowpea supplemented blend the least. Fats are flavourants or flavour carrier, however the possibility of developing rancidity during storage, decreased dispersibility and starch granule swelling are drawbacks for blends with higher fat contents. Protein contents of the blends varied significantly (P<0.05) from 9.37-22.81% comparable to 15-20% for multigrain composite flour reported by Hmeeda et al. [20]. The blends containing 20% soybean had the highest protein level, those containing 20% milk the least, less than blends containing 20% cowpea. Soybean the wonder crop of the world is known to contain higher levels of protein, fat, fibre and ash in addition to minerals and vitamins than many other crop. In recent times, it is applied for fabrication of novel or modification of existing traditional food products for enhanced nutritional and functional properties. Ash represents the inorganic elements available in a biological material. Ash contents of the blend varied from 2.45% to 4.20%, the blends containing 20% powdered milk had greater ash contents not significantly different from soybean containing blends but higher than ash contents of cowpea supplemented blends. Crude fibre contents of the blends ranged from 1.52%-3.38% higher in cowpea than soybean containing blends. RMtSb, RMzSb and MtRMk had the least crude fibre content. It has been stressed that crude fibre is important not only for blood sugar and bowel regulation but also an indispensable nutrient for healthy living. Ash and crude fibre contents of multigrain blends reported by Edet et al. [21] and Zakari et al. [22] are comparable to values obtained in this study. Proximate composition of blends are dependent on the degree of milling and sieving apart from geographical origin of the crops and the associated agronomic practices the crops were exposed to, as well as handling and storage conditions. Cereal grains are good sources of fibre, ash and vitamin B-complex but as a result of flour extraction, these nutrients are depleted. Carbohydrate contents of the blends clustered around 52.57 and 68.5%, most did not differ significantly (p<0.05).

4.4 Mineral Profile of the Blends

The order of the mineral elements in the blends was K>Ca>Mg>P>Fe>Zn, with the following significant variations: 226.08-356.68 mg/100 g, 220.69-360.34 mg/100 g, 13.32-40.00 mg/100 g, 5.34-9.21mg/100g, 3.67-8.14 mg/100 g and 3.32-8.34 mg/100 g for K, Ca, Mg, P, Fe and Zn respectively. The mean levels of these elements in the blends were (mg/100 g): Fe 5.27, Zn 6.11, Ca 279.33, Mg 24.43, K 281.72 and P 6.84. More

Calcium, Iron and Phosphorous were observed in the blends containing powdered milk especially blends RMtMk and RMzMk. The concentrations of P and Mg in wheat-acha-soybean blends reported by Edet et al. [21] are higher and the calcium levels lower than the values observed in this study but values reported by Zakari et al. [22] for complementary food made from blends of millet, soybean and African locust bean flours are comparable to the mineral contents of the blends in this study as well as results reported by Solomon [23] for complementary diets used in Jos, Nigeria. Phosphorus (a major element) contents of the blends in particular were very low apart from Mg, Fe and Zn, it could be due to dehulling and sieving process that accompanied flour extraction. The pericarp of cereal grains are rich sources of mineral, vitamins and non-nutrient phytochemicals [4].

4.5 Microbial Load (cfu/g) of the Blends for Mordum Preparation

Fungal (0.8×10^3-5.3×10^3) and bacterial populations (2.4×10^3-6.3×10^3) were satisfactorily low, bacterial load in the blends did not exceed permissible limit of 10^5 cfu/g for food stuff [24], bacteria and fungi present must have originated from the raw materials, from post processing contaminations, from food container surfaces or from the environment. The blends are not in ready-to-eat form, therefore applications of heat during preparation will further eliminate existing bacterial and fungal populations. Possible bacterial and fungal contaminants of low moisture foods include *Staphylococcus aureus*, *Salmonella* spp, *Baccilus* spp, toxigenic *Escherichia coli* and mould [25]. Micro-organisms especially bacteria cannot grow in low-moisture foods and ingredients nonetheless the vegetative cells of certain genera of bacterial and fungal spores cannot survive for long period in such low water activity food stuffs [25].

4.6 Sensory Properties of the Modified Mordom Gruel

The overall picture of the sensory attributes of mordum gruel indicated that presence of milk, maize and rice had positive influence on the sensory attributes and cowpea and pearl millet negative influence, therefore RMtMk RMzMk and others containing milk and maize had the best score of all the attributes of the mordum gruel examined, on the other hand millet and cowpea containing blends had the poorest sensory attributes especially appearance and taste. Beany favour of cowpea in particular (MtRCp and RMtCp) affected negatively the taste and the aroma of the modified mordum meal. Nice appearance of food products stimulates appetite and commercial patronage, the outer layers of millet that escaped into the flour gave rise to poor appearance which negatively influenced the scoring of other attributes. The consistency scores were generally high (5.24-8.56) but better in blends containing soybean flour and powdered milk indicating influence of protein in maintaining a homogenous aqueous mixture.

Table 3. Proximate composition (%) of the blends for mordum preparation

Mordum	Moisture	Fat	Protein	Ash	Fibre	Carbohydrate
RMtSb (50:30:20)	7.47 ± 0.24^{b}	11.36 ± 0.73^{a}	20.15 ± 0.66^{b}	3.21 ± 0.41^{cd}	1.68 ± 0.02^{d}	57.80 ± 0.24^{b}
RMzSb (50:30:20)	7.42 ± 0.02^{b}	11.82 ± 0.14^{a}	19.68 ± 2.12^{b}	3.20 ± 0.16^{bcd}	1.58 ± 0.02^{d}	56.86 ± 0.04^{b}
MtRMk (30:50:20)	5.03 ± 0.74^{d}	7.01 ± 0.07^{d}	11.407 ± 0.66^{e}	4.58 ± 0.96^{bc}	1.52 ± 0.02^{d}	68.16 ± 0.25^{a}
MtRCp (30:50:20)	10.3 ± 0.19^{a}	8.65 ± 0.24^{c}	16.87 ± 0.88^{c}	2.45 ± 0.60^{d}	2.40 ± 0.28^{c}	65.01 ± 0.10^{ab}
MtRSb (30:50:20)	6.61 ± 0.18^{c}	12.08 ± 0.08^{a}	22.81 ± 1.32^{a}	4.63 ± 0.35^{ab}	2.43 ± 0.01^{c}	52.57 ± 1.44^{c}
RMtMk (50:30:20)	6.33 ± 0.15^{c}	8.86 ± 0.14^{c}	10.46 ± 0.66^{f}	5.20 ± 2.09^{a}	2.23 ± 0.01^{c}	67.14 ± 2.74^{a}
RMzMk (50:30:20)	6.38 ± 0.35^{c}	9.82 ± 0.31^{b}	9.37 ± 1.59^{g}	4.62 ± 0.87^{bc}	3.38 ± 0.08^{a}	68.5 ± 1.71^{a}
RMtCp (50:30:20)	7.34 ± 0.06^{b}	8.21 ± 0.09^{c}	13.43 ± 0.44^{d}	4.03 ± 0.97^{cd}	3.12 ± 0.5^{b}	66.98 ± 1.59^{a}
RMzCp (50:30:20)	7.80 ± 0.19^{b}	8.21 ± 0.04^{c}	13.12 ± 0.00^{de}	4.29 ± 0.69^{bcd}	3.22 ± 0.02^{ab}	66.57 ± 0.45^{a}

Mean values in the same column bearing different superscripts are significantly different (p<0.05)
R= Rice flour, Mt= Millet flour, Sb= Soybean flour, Mk= Milk powder, Cp= Cowpea flour, Mz= Maize flour. All blends are in the ratio of 50:30:20

Table 4. Concentrations (mg/100 g) of the elements in the various blends for mordum preparation

Mordum	Fe	Zn	Ca	Mg	K	P
RMtSb (50:30:20)	4.44^{e}	3.32^{f}	290.72^{bc}	13.32^{g}	356.68^{a}	7.42^{c}
RMzSb (50:30:20)	5.92^{c}	5.00^{d}	220.69^{e}	16.66^{f}	287.49^{d}	5.84^{g}
MtRMk (30:50:20)	3.79^{f}	5.84^{c}	250.15^{d}	23.34^{d}	321.70^{b}	7.87^{b}
MtRCp (30:50:20)	5.18^{d}	4.16^{e}	310.26^{b}	26.63^{c}	347.76^{ab}	6.52^{e}
MiRSb (30:50:20)	4.46^{e}	6.66^{b}	280.09^{c}	20.00^{e}	252.20^{e}	5.34^{h}
RMtMk (50:30:20)	8.14^{a}	8.34^{a}	360.34^{a}	40.00^{a}	295.66^{d}	9.21^{a}
RMzMk (50:30:20)	6.66^{b}	5.84^{c}	270.60^{c}	26.60^{c}	304.40^{c}	6.97^{d}
RMtCp (50:30:20)	3.67^{f}	8.34^{a}	230.22^{e}	30.00^{b}	243.48^{e}	6.07^{f}
RMzCp (50:30:20)	5.18^{d}	7.51^{b}	300.91^{b}	23.34^{d}	226.08^{f}	6.29^{ef}

Mean values in the same column bearing different superscripts are significantly different ($p<0.05$)
R= Rice flour, Mt= Millet flour, Sb= Soybean flour, Mk= Milk powder, Cp= Cowpea flour, Mz= Maize flour. All blends in the ratio of 50:30:20

Table 5. Microbial load (cfu/g) of the blends for mordum preparation

Mordum	Bacterial count (cfu/g)	Fungal count (cfu/g)
RMtSbSm (50:30:20)	6.3×10^{3a}	1.2×10^{2c}
RMzSbSm (50:30:20)	3.6×10^{3d}	0.9×10^{2d}
MtRMkSb (30:50:20)	5.0×10^{3b}	5.3×10^{2b}
MtRCp (30:50:20)	2.4×10^{3e}	1.2×10^{2c}
MtRSb (30:50:20)	3.3×10^{3d}	1.2×10^{2c}
RMtMk (50:30:20)	2.7×10^{3e}	0.8×10^{2d}
RMzMk (50:30:20)	3.2×10^{3d}	4.2×10^{2b}
RMtCp (50:30:20)	4.1×10^{3c}	9.2×10^{2a}
RMzCp (50:30:20)	2.9×10^{3}	0.8×10^{2d}

Mean values in the same column bearing different superscripts are significantly different ($p<0.05$)
R= Rice flour, Mt= Millet flour, Sb= Soybean floour Mk= Milk powder, Cp= Cowpea flour, Mz= Maize flour. All blends in the ratio of 50:30:20

Table 6. Result of sensory evaluation of mordom gruel prepared from the blends

Mordum	Appearance	Aroma	Taste	Consistency
RMtSb (50:30:20)	5.52^{e}	5.39^{c}	6.56^{ab}	7.06^{c}
RMzSb (50:30:20)	6.48^{e}	5.81^{cd}	7.31^{ab}	6.23^{e}
MtRMk (30:50:20)	6.27^{d}	5.81^{cd}	7.72^{ab}	6.66^{d}
MtRCp (30:50:20)	3.81^{h}	4.63^{e}	4.29^{c}	5.24^{g}
MtRSb (30:50:20)	5.15^{f}	5.39^{d}	6.31^{b}	5.82^{f}
RMtMk (50:30:20)	7.04^{b}	7.39^{ab}	7.48^{ab}	7.74^{b}
RMzMk (50:30:20)	8.39^{a}	8.39^{a}	8.14^{a}	8.56^{a}
RMtCp (50:30:20)	4.81^{g}	5.62^{cd}	4.56^{c}	6.15^{e}
RMzCp (50:30:20)	6.31^{d}	6.66^{d}	4.32^{c}	5.79^{f}

Mean values in the same column bearing different superscripts are significantly different ($p<0.05$)
R= Rice flour, Mt= Millet flour, Sb= Soybean floour Mk= Milk powder, Cp= Cowpea flour, Mz= Maize flour. All blends in the ratio of 50:30:20

5. CONCLUSION

Mordum is a cereal-based breakfast meal popular among the main tribes of northeastern Nigeria. In this work, mordum were prepared from multigrain blends instead from of rice-millet freshly prepared every morning. Particle size distribution analysis indicated the main mass fraction of the blends was in the range of 224-300um as indicated by percent retentions on the sieves. Solubility and swelling power of the blends were generally low while the bulk density and water absorption capacity relatively high. Moisture contents of the blends were low therefore bacterial and fungal population of the blends were satisfactorily low. Sensory attributes of the blends containing maize and milk were better than those containing cowpea and millet. Proximate and mineral compositions of the multigrain blends were enhanced, higher than it would have been with a single grain. The study has succeeded not only in improving the nutrient density of the mordum but also reduced the long unit operations involved in its preparation through provision of ready-to-cook, storage stable and nutritious blends.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/60603