International Journal of Food Science and Nutrition
www.foodsciencejournal.com
ISSN: 2455-4898
Received: 09-06-2021, Accepted: 25-06-2021, Published: 10-07-2021
Volume 6, Issue 4, 2021, Page No. 23-29

Mineral and amino acid profile of cowpea/soybean fortified *Dabuwa* (A Nigerian dried stiff porridge) produced from three different cereals

Maryam A Jarma[1], Gervase I Agbara[2*], Yakaka M Alkali[1]
[1] Department of Food Science and Nutrition, Ramat Polytechnic, Maiduguri, Nigeria
[2] Department of Food Science and Technology, University of Maiduguri, Nigeria

Abstract
Dabuwa, a stiff porridge of fonio grains and maize flour popular among various tribes of northeastern Nigeria especially the normadic Shuwa Arabs, was now produced from blends of fonio and pearl millet, or rice, or maize flour and each lot fortified with either cowpea or soybean flour. A 3×2×2×2 full factorial design was originally adopted for this study but later scaled down to a 3×2×2 fractional factorial which gave rise to 12 experimental runs. Legume supplementation was done at a constant level of 30%. Fonio (F) basic to dabuwa was incorporated at either 12.5% (F_1) or 22.5% (F_2). The proportions of the cereal flours in the modified dabuwa formulation were maize (Ma), millet (Mi) or rice(R) incorporated either at a level of 57.5% (Ma_1, Mi_1, R_1) or 47.5% (Ma_2, Mi_2, R_2). The control was the traditional *dabuwa* (25% fonio and 75% maize). All dabuwa were prepared using the traditional method. The blends and *dabuwas* were evaluated for mineral composition and amino acid profile. Greater enhancement of mineral elements were observed in the modified dabuwa blends than in the control, the concentrations (mg/100g) of the elements varied significantly ($p<0.05$) as follows: Mg 88.19-169.00, Ca 364.54-529.34, K 575.35-1189.22mg, P 254.25-429.27, Zn 1.61-4.71and Fe 3.32-6.03. A similar trend was replicated in the mineral contents of the dabuwas. K was the most dominant element (832.21 to 1396.00mg/100g), followed by calcium (585.00 to 789.89mg/100g), then phosphorus (439.67 to 708.22mg/100g). Most amino acid values of the modified dabuwa exceeded the RDA requirements by WHO/FAO/UNU. Observed values for limiting acids were: tryptophan (0.02-2.01g/100g protein), methionine + cysteine (0.72-4.62g/100g protein), lysine (4.10-5.78g/100g and threonine (2.79-4.13g/100g. Millet-containing *dabuwa* fortified with soybean had better amino acid profile; generally modified dabuwa had better mineral and amino acid profiles than the the traditional dabuwa. It was recommended that *dabuwa* should be produced from other cereals other than maize, and fortification with cowpea or soybean flour furrther enriches its nutritional value.

Keywords: maize, millet, rice, fonio, *Dabuwa*, mineral composition, amino acid profile

Introduction

Dabuwa is a dried stiff porridge traditionally produced from spiced dough of fonio grains and maize flour treated with beef fat (*man shanu*). This cereal-based multi-purpose food is native to the Shuwa Arab nomadic settlers. *Dabuwa* can be consumed in multiple ways: the fresh porridge (*tuwo*) eaten with stew or soup; as breakfast cereal soaked in boiled milk; or soaked in boiled water with added salt, pepper and beef fat; or reconstituted and prepared as popular jollof rice; or eaten as a snack without reconstitution. The consumption of cereal grains and grain legumes all over the world gives them an important position in international nutrition (Banu *et al*., 2012) [6], they fill many nutritional needs providing greater proportion of calorie and protein to humans worldwide (Nierenberg and Spoden, 2012) [19]. Cereals (rice, wheat, maize, millet, etc) generally are deficient in two essential amino acids: lysine and tryptophan which are abundant in grain legumes. Therefore, inexpensive grain legume proteins are natural complements to the proteins of cereal grains although they are deficient in sulphur amino acids. Such complementation provides an overall essential amino acid balance which can only be provided by multigrain flour blends (Singh, 1988; Liener, 1989) [16, 22]. The need for balanced nutrition in an era of increased consumer awareness, enhanced income and standard of living cannot be overstressed. Therefore, multigrain blends come to rescue providing healthy foods and functional ingredients from natural sources. Cow pea (Vigna unguicalata) is the most consumed pulse in Nigeria and it is heavily cultivated in semi-arid climates of northeastern Nigeria where *dabuwa* is commonly produced and consumed at the household level. Nigeria is the largest producer and consumer of cowpea, accounting for 61% of production in Africa and 58% worldwide (Hakeem *et al*., 2010) [12]. Soyabean (Glycine max), an oil seed, is the wonder crop of the world. It serves both as an industrial raw material and as a food crop, however, its utilization as food crop in Nigeria is only recently gaining ground mainly due to its well-known high nutritional density like all grain legumes. The need to attempt *dabuwa* preparation from multigrain flour blends arises from the fact that its current preparation is full of labour which on-the-move urban dwellers cannot indulge in; moreover, the use of other cereals such as rice and millet in its preparation has not been attempted especially in a region whose climate favours pearl millet cultivation, such as north eastern Nigeria, where *dabuwa* is popular. Rice on the other hand is ubiquitously cultivated in all regions of Nigeria. Fonio (Digitaria exilis) grains are a compulsory component of *dabuwa* and the environment favours its cultivation. Beef fat is profusely applied in traditional *dabuwa* preparation and being a saturated fat it is sparingly applied in the preparation of modified *dabuwa*. With these in view, the new improved *dabuwa* will appeal to a wide audience, providing greater nutritional value in an increasing food insecure environment due to lingering conflict. Therefore, in this present study, *dabuwa* was prepared from blends consisting of fonio with either maize, millet or rice fortified with either cowpea or soyabean flour, spiced and flavoured with beef fat, thereafter evaluated for mineral content and amino acid profile.

Materials and Methods

Raw materials collection

Raw materials for this study were purchased from Gamboru market, Jere Local Government Area of Borno State. These included maize, millet, rice, fonio, cowpea, soyabean, onions, caraway (black) seeds, ginger, cardamom and beef fat (*man shanu*). They were processed at the Nutrition unit of the Department of Food Science and Technology, Ramat Polytechnic, Maiduguri. Mineral content and amino acid profile determinations were conducted at the Nutrition Laboratory of the Department of Animal Science, Adamawa State University, Mubi, Adamawa state. All chemicals used in the analysis were assumed to be of analytical grade, sourced from the registered stores.

Preparation of cereal grain flours

Maize, millet and rice were separately sorted to remove foreign materials, decorticated, winnowed, soaked overnight, 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 tight fitting covers waiting further use. Fig.1 represents a flow chart for preparation of the cereal flours.

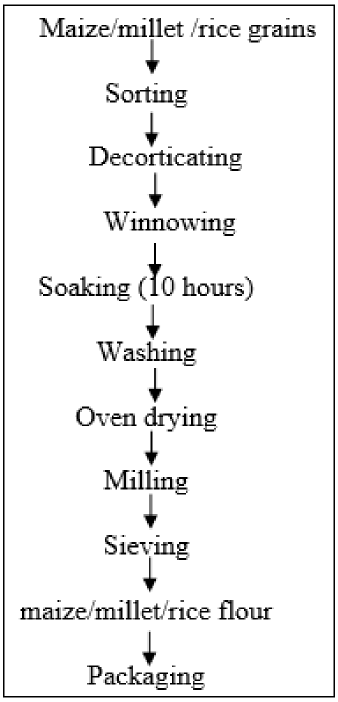

Fig 1: Flow chart for processing of maize, millet and rice flours

Preparation of Legume Flours

The method of Nkama (1993) [20] was used for both cowpea and soybean flour preparations. The cowpea and soybean after sorting and cleaning were soaked for 2 hours, dehulled manually (by lightly pounding in a mortar with a pestle), sundried slightly and the hulls 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 with tight-fitting lids. This process is shown in fig. 2.

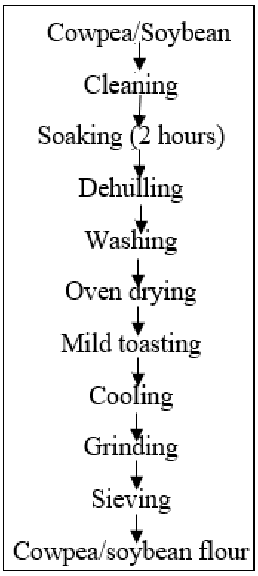

Fig 2: Cowpea/soybean flour production

Preparation of spice-mix and other ingredients

Fonio grains were sorted for extraneous materials, dehulled manually in a mortar with the use of a 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 is removed), and then finally dried. It was then packaged inside a plastic container with tight-fitting cover. Caraway seeds (for traditional *dabuwa*) were sorted to remove foreign materials, washed and dried. Beef fat (*manshanu)* was fried with chopped onions inside till the onions turned golden brown in colour. A spice-mix of onion, ginger and cardamom in the ratio of 3:1:1 respectively was prepared for the modified *dabuwa.* Onions were peeled, washed, chopped and oven dried. 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.

Formulation and coding of samples

Traditionally produced *dabuwa* was obtained from a blend of 25% fonio grains and 75% maize flour. Now two levels of fonio (12.5%-F_1 and 22.5%-F_2) were used and each level was blended separately with either 47.5% maize (Ma_1), millet (Mi_1) and rice (R_1), and the other with 57.5% maize (Ma_2), millet (Mi_2) or rice (R_2). Each of the legume flours (Cowpea-C, and Soybean-S) was added to each of the blends at a constant level of 30% leading to a full factorial experimental design (3×2×2×2=24 runs) but scaled down to a fractional factorial design (3×2×2 = 12 runs) (Box *et al*; 2005). The coded runs were as follows: F_1Ma_1C, F_2Ma_2C, F_1Mi_1C, F_2Mi_2C, F_1R1C, F_2R_2C, F_1Ma_1S, F_2Ma_2S, F_1Mi_1S, F_2Mi_2S, F_1R_1S, F_2R_2S and traditional *dabuwa* as the Control (FMa).

Table 1: Ingredient formulation for the control and enriched *dabuwa*.

Runs	Fonio (g)	Maize (g)	Millet (g)	Rice (g)	Cowpea (g)	Soybean (g)	Spice-mix (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 denotes 12.5% and 22.5% respectively while those of Ma, Mi and R denotes 57.5% and 47.5% respectively.

Production of *Dabuwa*

Traditional *Dabuwa* was processed as shown in Figure 3. Water, onions and blackseeds were brought to boil in a pot. Fonio grains were sprinkled and while stirring, some part of the *Manshanu* was added and the pot covered and allowed to cook for 10 minutes. Maize flour was mixed with water to obtain thick slurry. This slurry 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 stiff porridge obtained was scooped out onto beef fat-greased trays, allowed to cool, and then cut manually into thin small pieces and finally dried.

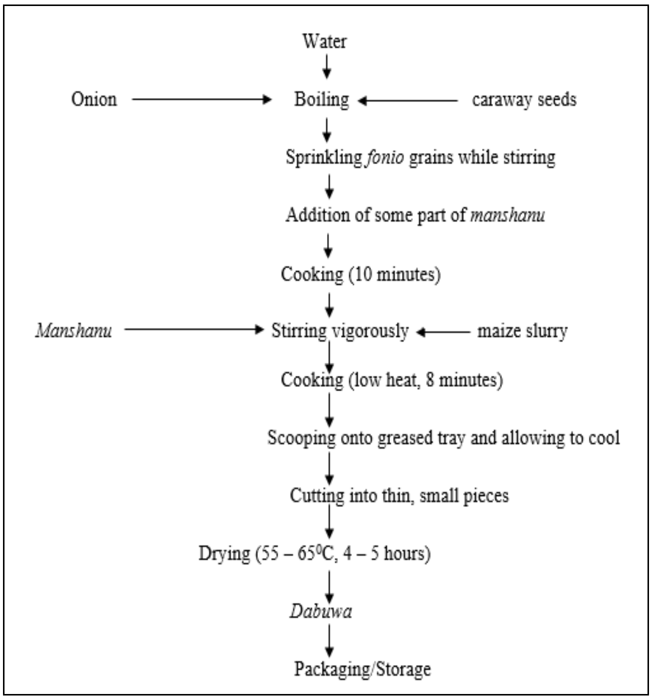

Fig 3: Flow chart for processing of traditional *dabuwa*.

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

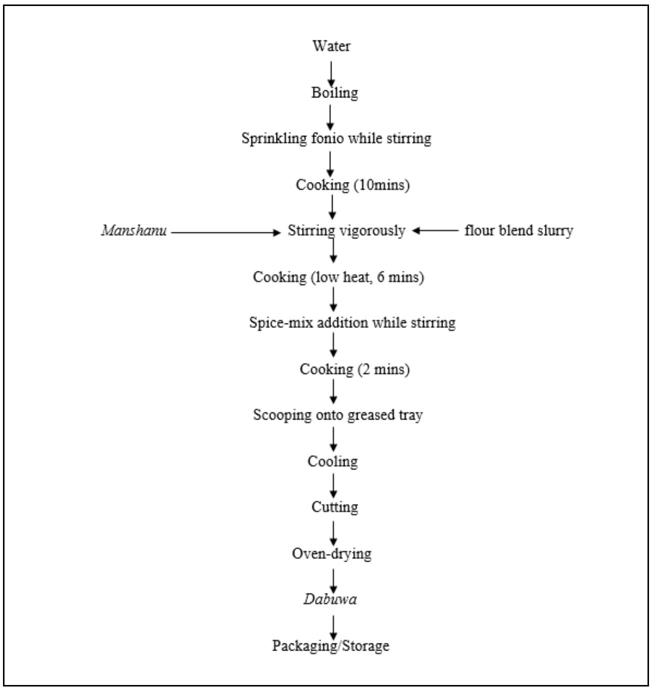

Fig 4: Flow diagram for processing of enriched *Dabuwa.*

Chemical Analysis

Determination of Amino Acid Profile

The amino acid profile of the dabuwa was determined using methods described by AOAC (2000) [2]. Dabuwa were first dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Technicon sequential Multi-Sample Amino Acid Analyzer (TSM). The samples were defatted using chloroform/methanol mixture of ratio 2:1. About 4g of the sample was put into extraction thimble and extracted for 15 hours in Soxhlet extraction apparatus. The defatted samples were utilized to estimate amino acids. 30mg of the sample was hydrolysed with 6N HCL at 110ºC for 24h. Amino acid analysis was performed on reverse phase- high pressure liquid chromatography (HPLC) (Buck Scientific BLC 10/11 USA) equipped with UV 338nm detector. A C18, 2.5×200mm, 5um column and a mobile phase of 1:1:2 (100Mm Sodium Phosphate, pH 7.2: acetonitrile: methanol) was used at a flow rate of 0.45ml/minute and an operating temperature of 40^{O}C. Mixed standards were analysed in a similar manner for identification. Peak identification was conducted by comparing the retention times of authentic standards and those obtained from the samples. These data were integrated using peak simple chromatography data system processor (Buck Scientific Chromatopac Data Processor).

Mineral Analysis

The dry ash procedure for elemental analysis using AAS/Flame photometry (JENWAY ME 882) as described by AOAC (2010) was used for mineral analysis. Five gram (5g) samples each were ashed in a furnace (VECSTAR VTF 2245, UK.) at 550±10ºC until grey ash was obtained. The ash was cooled to room temperature and dissolved by adding 2ml of Conc. nitric acid (HNO_3) and transferred to a 100ml volumetric flask and made up with distilled water to mark. This was then shaken and filtered. Absorbance of at least five different concentrations of each mineral element were recorded and standard curves were prepared, then samples were run using Buck 230 atomic absorption spectrophotometer Las Vegas USA (for other elements except potassium) and Jenway ME 882 Flame photometer, UK for Potassium using air acetylene flame integrated mode. Concentrations of the unknown elements in the digests were quantified from the calibration curve of standard solutions of each element determined.

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 ($p<0.05$).

Results and Discussion

Mineral composition of flour blends

The mineral contents of the blends were generally enhanced surpassing FAO/WHO (2011) threshold limits. Mineral content varied significantly ($P\leq0.05$) in the following order(mg/100g): K:575.35 (F_1Mi_1S) to 1189.22 (F_2R_2S); Ca:364.54 (F_1Ma_1C) to 529.34 (F_2R_2S); P: 234.42 (F_1Mi_1C) to 429.27 (F_1R_1C); Mg: 88.19 (FMa) to 169.00 (F_2R_2C); Fe:3.32 (FMa) to 6.03 (F_2R_2S) and Zn:1.61 (FMa) to 4.71 (F_2R_2S). The general observation was that legume flour supplementation enhanced mineral contents of the blends more in soybean supplemented blends than in blends with cowpea. Mineral content of soyabean meal reported by Banaszkiewicz (2011) [5] are less than the concentration found in the blends (Table 2). The values of different mineral elements reported by Inobeme *et al* (2014) [15] for white cowpea varieties were less than as found in the soyabean meal as reported by Benasckiewcza (2011). Similarly, Bagirathy (2014) [4] reported mineral contents of rice that are still less than as found in soyabean meal indicating the mineral content of the blends (Table 2) were enhanced through multiple blending of flours from fonio, the basic flour used in *dabuwa* formulation in addition to contributions from soyabean or cowpea, and the cereals (maize, millet, or rice). It was also observed that blends with greater proportion of fonio (22.5%) and 30% soybean supplementation had greater amounts of the minerals determined especially Mg, Zn, and Fe. This was observed in F_2Ma_2S, F_2Mi_2S and F_2R_2S. The Control in most cases contained lesser amounts of the minerals than the treated blends. Among the cereal grains, the blends containing maize appeared to have lower levels of the minerals determined and were closer to the mineral contents of the Control (FMa). Cereals contain minerals such as P, Ca, K and Mg in varying quantities often dictated by agronomic, climatic and varietal factors. Also the degree of refining to obtain the flours contributed to the variation in mineral elements of the flours. Kumar *et al (*2016) [14] and Eggum (1979) reported Fe and Zn levels in brown rice, maize and millet to have lower values than those obtained in this study indicating beneficial effect of legume flour fortification on proximate and mineral contents of the blends and *dabuwa* accentuating the reports from several authors that grain legumes are rich sources of macro- and micro- nutrients. Mg, Ca and K levels were higher than the recommended amounts (FAO/WHO, 2011) [23]. The Control and maize-containing blends however, fell short of the recommended values for Zn (3.20mg/100g sample) and all samples did not meet the recommended value for Fe (16.00mg/100g sample) by FAO/WHO (2011). Zn, Fe together with iodine, folate and vitamin A are essential micronutrients of worldwide deficiency and their deficiencies are the most widely spread of the micronutrients (Regan *et al*; 2015). But on a 2000 calorie diet, modified dabuwa satisfied the RDA for the assayed minerals.

Table 2: Effect of cowpea and soybean supplementation on the mineral content (mg/100g) of composite blends

Formulation *Cowpea supplementation*	Mg	Ca	Zn	K	P	Fe
F_1Ma_1C (12.5:57.5:30)	$94.70^{h}\pm0.30$	$364.54^{h}\pm0.48$	$1.77^{g}\pm0.04$	$672.02^{g}\pm1.02$	$272.38^{g}\pm1.63$	$4.71^{e}\pm0.09$
F_2Ma_2C (22.5:47.5:30)	$102.27^{f}\pm0·51$	$379.06^{g}\pm0.39$	$2.32^{f}\pm0.25$	$686.89^{f}\pm0.64$	$284.91^{f}\pm0.27$	$5.46^{c}\pm0.31$
F_1Mi_1C (12.5:57.5:30)	$105.42^{f}\pm0.63$	$392.42^{f}\pm0.26$	$2.73^{e}\pm0.19$	$706.60^{e}\pm2.27$	$234.42^{j}\pm54.8$	$5.82^{ab}\pm0.11$
F_2Mi_2C (22.5:47.5:30)	$126.19^{e}\pm0.23$	$457.66^{d}\pm0.63$	$3.38^{d}\pm0.17$	$827.98^{de}\pm1.03$	$364.21^{d}\pm1.14$	$5.16^{d}\pm0.09$
F_1R_1C (12.5:57.5:30)	$135.27^{d}\pm4.48$	$474.66^{cd}\pm4.69$	$3.67^{c}\pm0.25$	$842.63^{d}\pm0.54$	$377.31^{c}\pm0.31$	$5.53^{bc}\pm0.38$
F_2R_2C (22.5:47.5):30)	$169.00^{a}\pm0.87$	$522.66^{ab}\pm0.77$	$4.40^{ab}\pm0.03$	$1048.71^{c}\pm15.07$	$396.24^{b}\pm0.79$	$5.77^{ab}\pm0.17$
Soybean supplementation						
F_1Ma_1S (12.5:57.5:30)	$144.00^{c}\pm0.40$	$371.83^{gh}\pm0.91$	$2.02^{f}\pm0.04$	$682.14^{fg}\pm2.89$	$278.53^{g}\pm0.41$	$5.08^{de}\pm0.06$
F_2Ma_2S (22.5:47.5:30)	$105.08^{f}\pm0.87$	$386.66^{fg}\pm2.56$	$2.50^{ef}\pm0.19$	$696.61^{ef}\pm1.90$	$291.56^{e}\pm0.32$	$5.56^{bc}\pm0.08$
F_1Mi_1S (12.5:57.5:30)	$100.61^{g}\pm1.16$	$411.46^{e}\pm0.19$	$2.32^{f}\pm0.15$	$575.35^{i}\pm1.05$	$261.68^{h}\pm5.57$	$5.25^{cd}\pm0.12$
F_2Mi_2S (22.5:47.5:30)	$125.98^{e}\pm0.93$	$440.33^{de}\pm9.49$	$3.29^{d}\pm0.16$	$698.21^{ef}\pm3.70$	$269.04^{h}\pm0.87$	$5.52^{bc}\pm0.08$
F_1R_1S (12.5:57.5:30)	$154.27^{b}\pm0.73$	$480.42^{c}\pm2.08$	$4.06^{b}\pm0.06$	$1124.93^{b}\pm2.58$	$429.27^{a}\pm1.63$	$5.66^{b}\pm0.15$
F_2R_2S (22.5:47.5):30)	$153.62^{b}\pm0.43$	$529.34^{a}\pm1.47$	$4.71^{a}\pm0.28$	$1189.22^{a}\pm0.98$	$388.99^{b}\pm0.88$	$6.03^{a}\pm0.08$
Control FMa (25:75)	$88.19^{i}\pm0.47$	$519.34^{b}\pm0.39$	$1.61^{gh}\pm0.02$	$642.45^{h}\pm9.31$	$254.25^{i}\pm4.11$	$3.32^{f}\pm0.21$
Mean	122.23±1.15	425.72±2.56	2.98±0.13	853.36±4.27	339.45±12.54	5.30±0.14
CV (%)	1.15	0.50	5.53	0.45	2.85	3.16

Values are mean ± standard deviation of duplicate determinations.
Means in the same column with different letters are significantly different ($p\leq0.05$).
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.

Mineral composition of modified *Dabuwa* and the control

Mineral contents of the various *Dabuwa* as shown in Table 3 reflected closely the trend observed in the blends (Table 2). Mg, Ca, Zn, K, P and Fe contents of the *Dabuwa* (mg/100g) varied from 94.46 (FMa) to 207.85 (F_2R_2S), 585.00 (FMa) to 789.89 (F_2R_2S), 2.46 (FMa) to 6.20 (F_2R_2S), 832.21 (FMa) to 1396.00 (F_2R_2S), 439.67 (FMa) to 702.22 (F_2R_2S) and 8.69 (FMa) to 37.65 (F_2R_2S) respectively. The overall mean concentration (mg/100g) for Mg, Ca, Zn, K, P and Fe were 144.80, 685.73, 4.31, 1272.17, 572.79 and 25.96mg/100g respectively. The Control, FMa had the least value for all mineral elements, although there was general enhancement of all the mineral elements investigated. This enhancement could be linked to higher dry matter contents of *dabuwa* than observed in the blends. Observed values exceeded the recommended values (FAO/WHO, 2011) [23] for Mg, Ca and K. However, not all samples met RDA requirement of 3.20mg/100g and 16mg/100g for Zn and Fe respectively (FAO/WHO, 2011) [23]. A study on maize, cassava starch, defatted soybean, moringa leaves and moringa seeds for plant-based food material blends (Ijarotimi *et al;* 2017) yielded Fe and Zn values less than observed in this study. But similar increase in mineral elements was reported by Iombor *et al* (2016) for bread produced from wheat-sesame blend which were found to be greater than the Control bread (100% wheat bread). Khan et al (2009) observed a general increase in the mineral elements in wheat – soyabean flat bread, greater than in the Control (100% wheat flour). A similar scenario was observed in both the *dabuwa* blends and the *dabuwa*; although the increase in the mineral elements was greater than observed by Khan *et al* (2009). Fe, Zn, I, folate and vitamin A deficiencies are the most widespread micronutrient deficiencies (MNDs) and are common contributors towards poor growth, intellectual impairment, perinatal complications and increased risk of morbidity and mortality (Regan *et al;* 2015). The fact still remains that MNDs, rightly referred to as "hidden hunger" (Muthayya *et al*; 2013) have direct effects on individuals and indirect effects on societies despite being preventable through fortification of cereal- or root-based traditional diets with grain legumes. Minerals are inorganic components of biological materials required in small amounts for bone and teeth formation; and as constituents of enzymes and body fluids. They play vital roles for the proper functioning of the living organisms as in nerve transmission, electrolyte balance, muscle contraction and optimal enzyme performance as cofactors.

Table 3: Effect of cowpea and soybean supplementation on the mineral content (mg/100g) of *dabuwa*.

Formulation	Mg	Ca	Zn	K	P	Fe
Cowpea supplementation						
F_1Ma_1C (12.5:57.5:30)	103.56^{i}±0.49	624.73^{i}±0.42	2.55^{i}±0.13	946.73^{h}±11.40	466.00^{j}±3.61	11.31^{e}±0.03
F_2Ma_2C (22.5:47.5:30)	117.52^{h}±0.47	634.29^{h}±0.38	3.82^{g}±0.10	1065.67^{gh}±6.81	482.00^{gh}±2.00	11.97^{e}±0.16
F_1Mi_1C (12.5:57.5:30)	130.71^{f}±1.49	682.21^{f}±0.68	5.04^{cd}±0.07	1130.00^{fg}±10.15	497.00^{g}±5.00	22.82^{c}±0.20
F_2Mi_2C (22.5:47.5:30)	151.16^{e}±0.35	701.61^{e}±0.62	4.04^{f}±0.07	1192.00^{e}±35.68	644.33^{d}±6.03	24.12^{c}±0.14
F_1R_1C (12.5:57.5:30)	176.27^{d}±0.84	751.78^{c}±0.56	5.32^{c}±0.10	1217.67^{d}±9.07	672.33^{cd}±12.01	30.60^{bc}±0.22
F_2R_2C (22.5:47.5):30)	190.33^{b}±1.22	772.85^{b}±0.78	5.73^{b}±0.21	1285.21c±47.82	692.67^{b}±3.06	35.57^{b}±0.27
Soybean supplementation						
F_1Ma_1S (12.5:57.5:30)	110.38^{hi}±1.04	616.83^{j}±5.33	4.08^{f}±0.16	958.00^{h}±6.00	474.33^{i}±3.51	14.65d^{e}±0.13
F_2Ma_2S (22.5:47.5:30)	123.68^{g}±0.37	656.73^{g}±0.88	4.45^{e}±0.13	1080.00^{g}±12.12	490.33^{g}±2.31	17.19^{d}±0.33
F_1Mi_1S (12.5:57.5:30)	115.12^{h}±0.69	615.82^{j}±0.16	3.10^{h}±0.07	1148.67^{f}±20.03	504.00^{ef}±2.00	23.16^{c}±0.22
F_2Mi_2S (22.5:47.5:30)	122.64^{f}±0.36	725.07^{d}±0.84	4.72^{d}±0.29	1191.00^{e}±47.29	516.67^{e}±1.53	24.62^{c}±0.22
F_1R_1S (12.5:57.5:30)	184.74^{c}±3.22	757.67^{c}±0.22	5.51^{bc}±0.05	1388.33^{b}±14.57	687.00^{c}±8.54	31.62^{bc}±0.13
F_2R_2S (22.5:47.5):30)	207.85^{a}±1.53	789.89^{a}±0.45	6.20^{a}±0.16	1396.00^{a}±39.95	708.22^{a}±6.00	37.65^{a}±0.39
Control FMa (25:75)	94.46^{j}±0.47	785.00^{k}±5.57	2.46^{ij}±0.05	832.21^{i}±55	439.67^{jk}±1.53	8.69^{f}±0.13
Mean	144.80±1.01	885.73±1.80	4.31±0.113	1272.17±21.98	572.79±4.34	25.96±0.18
CV (%)	0.851	0.249	3.220	1.71	0.688	0.838

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

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.

Amino acid profile of modified *dabuwa* and the control

Soybean supplemented *dabuwa* had higher amino acid content than the cowpea supplemented *dabuwa* and there existed a significant difference ($p \leq 0.05$) between the control and the enriched *dabuwa* as shown in Tables 4a and 4b. Amino acid values observed are lower than those reported by Makanjuola and Olakunle (2017) [17] for maize ogi with locust beans, but relatively close to results by Ijarotimi *et al.* (2017) [17] for flour blends from maize, soybeans and moringa. Fonio and millet are known to cotain more sulphur amino acids than other cereals (Edet et al., 2017; Amodou et al., 2013) [8, 1]. Generally, variability in nutrient composition of different grains, their flours and products exist due to variations in geographic location as well as differences in soil composition, climate and farming practices. It is generally observed that grain yield and protein content are inversely related.

Essential amino acid profile of *dabuwa* and Control

As shown in Table 4a, essential amino acids (mg/100g protein) of *dabuwa* and the Control varied significantly in the following order: leucine 7.82 (FMa) to 9.47 (F_2Mi_2C), phenylalanine + tyrosine 4.22 (F_2R_2S) to 6.13 (F_2Mi_2C), lysine 4.10 (F_1Ma_1C) to 5.78 (F_2Mi_2S), isoleucine 3.72 (FMa) to 5.47 (F_2Mi_2C), valine 3.80 (F_2Mi_2S) to 4.60 (F_2Ma_2C), threonine 2.79 (F_2R_2C) to 4.13 (F_2Ma_2S), histidine 1.49 (F_2Ma_2C) to 2.89 (F_1R_1S), methionine + cysteine 0.72 (FMa) to 4.62 (F_2Mi_2C) and tryptophan (FMa) to 2.01 (F_1Mi_1S) respectively. There was no specific pattern in the variation of these amino acids. Leucine was the most dominant, followed by phenylalanine + Tyrosine. Observed amino acid values for all millet containing *dabuwa* met RDA requirement (WHO/FAO/UNU, 2007). Essential amino acid (EAA) profile of the fortified dabuwa did not indicate any systematic variation, however, the treated dabuwa had better enhancement of EAA than the Control and methionine + cysteine and tryptophan contents were low in some cases. Contents of lysine and tryptophan, two limiting essential amino acids were enhanced in the fortified dabuwa especially in the millet-containing dabuwa. Amadou (2013) observed that millet protein has greater content of sulphur amino acids than most cereals. Kang et al (2017) reported methionine, lysine and threonine in soyabean flour, values far below what Benasckiewicz (2011) found in soyabean meal for the limiting amino acids indicating that reported amino acid values are influenced by analytic procedures and processing methods for the raw materials. Kang et al (2017) reported methionine (0.38mg/100g), lysine (2.55mg/100g) and threonine (1.25mg/100g). Khan et al (2009) observed remarkable enhancement of the EAA in unleavened flat bread produced from wheat – soyabeans blends, the reported values for all the EAAs were in some cases comparable with the values obtained in this study. Comparatively, egg protein (WHO/FAO/UNU, 2007) has superior amino acid profile than legume flour fortified dabuwa as revealed here, however, the adult requirement for the essential amino acids would be satisfied by the treated dabuwa (WHO/FAO/UNU, 2007).

Nonessential amino acid profile of *dabuwa* and control

Observed values for the nonessential amino acids serine, alanine, proline, arginine, aspartate, glutamate and glycine ranged from 3.76 (F_1R_1S) to 5.48 (F_2Mi_2C), 3.79 (FMa and F_2Mi_2S) to 4.25 (F_2Mi_2S), 2.55 (F_2R_2C) to 3.76 (F_1R_1S), 5.18 (FMa) to 5.63 (F_2Mi_2C), 7.73 (F_2R_2C) to 8.93 (F_2Ma_2C), 13.24 (F_2R_2C) to 14.53

(F_2Mi_2C and F_1Mi_1S), and 3.20 (FMa) to 3.74 (F_2Mi_2C)g/100g protein respectively (Table 4b).

Glutamate was the most dominant in all samples, followed by aspartate and then arginine. Proline and alanine had the least concentration. There was no clear-cut picture in the amino acid concentration of cowpea or soyabean fortified dabuwa.

Classification of amino acid composition.

A classification of the amino acids in terms of total amino acid (TAA), total essential amino acid (TEAA), and total nonessential amino acid (TNAA) compositions of *dabuwa* in g/100g protein are shown in Table 4c. Observed values after classification were 71.27 – 88.61, 30.08 – 43.47, and 40.02 – 45.14 for TAA, TEAA and TNAA respectively. Result revealed the higher level of fonio and cowpea enriched F_2Mi_2C (22.5:47.5:30) had the highest TAA, TEAA and TNAA of 88.61, 43.47 and 45.14 respectively. Ijarotimi *et al*. (2017) [17] reported relatively similar values for plant-based food material blends from maize, cassava starch, defated soybeans, moringa leaves and seeds.

Table 4: Effect of cowpea and soybean supplementation on the essential amino acid profile of *dabuwa* produced from three

RUNS	TRY	LYS	LEU	ISO	PH+TY	ME+CY	VAL	THR	HIS
Cowpea supplementation									
F_1Ma_1C	0.24^{f}	4.10^{i}	7.85^{f}	3.77^{f}	4.39^{fg}	0.80^{e}	4.12^{e}	3.13^{c}	1.68^{e}
F_2Ma_2C	0.55^{d}	4.81^{d}	9.45^{a}	4.35^{e}	4.87^{e}	1.32^{d}	4.60^{a}	3.22^{c}	1.49^{f}
F_1Mi_1C	1.95^{b}	5.40^{c}	9.11^{b}	5.18^{b}	5.69^{a}	4.24^{ab}	4.32^{c}	4.07^{a}	2.14^{c}
F_2Mi_2C	1.76^{bc}	5.15^{cd}	9.47^{a}	5.47^{a}	6.13^{a}	4.62^{a}	4.50^{b}	4.07^{a}	2.30^{b}
F_1R_1C	1.30^{c}	5.61^{b}	8.77^{d}	4.76^{d}	5.09^{d}	2.46^{bc}	3.89^{g}	3.90^{b}	2.06^{d}
F_2R_2C	0.56^{d}	4.49^{g}	8.57^{e}	4.94^{cd}	4.53^{f}	2.43^{bc}	4.20^{cd}	2.79^{e}	2.06^{d}
Soybean supplementation									
F_1Ma_1S	0.44^{e}	4.76^{e}	8.75^{d}	4.27^{ef}	4.46^{fg}	1.15^{de}	4.58^{a}	3.15^{c}	1.72^{e}
F_2Ma_2S	1.86^{bc}	5.19^{cd}	8.92^{c}	5.01^{c}	5.48^{c}	4.20^{ab}	4.17^{d}	4.13^{a}	1.92^{de}
F_1Mi_1S	2.01^{a}	5.47^{c}	9.05^{b}	5.01^{c}	5.41^{c}	4.28^{ab}	4.20^{cd}	3.96^{ab}	2.15^{c}
F_2Mi_2S	1.26^{c}	5.78^{a}	8.49^{ef}	4.68^{de}	5.10^{d}	2.43^{bc}	3.80^{gh}	3.83^{bc}	1.98^{de}
F_1R_1S	0.58^{d}	4.79^{e}	8.43^{ef}	5.21^{b}	5.06^{d}	2.65^{b}	4.01^{f}	2.90^{d}	2.89^{a}
F_2R_2S	0.50^{d}	4.62^{f}	8.59^{e}	4.97^{c}	4.22^{g}	2.16^{c}	4.12^{e}	2.81^{e}	2.85^{a}
FM_a	0.02^{g}	4.30^{h}	7.82^{f}	3.72^{f}	4.28^{g}	0.72^{e}	4.10^{e}	3.12^{cd}	1.55^{ef}
Egg protein*	1.7	7.0	8.6	5.4	9.3	5.7	6.6	4.7	2.2
Adult requirement*	0.5	1.6	1.9	1.3	1.9	1.7	1.3	0.9	

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

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. TRY=Tryptophan, LYS=Lysine, LEU= Leucine, ISO= Isoleucine, PH+TY= Phenylalanine + Tyrosine, ME+CY= Methionine + Cysteine, VAL=Valine, THR=Threonine, HIS=Histidine.

*WHO/FAO/UNU, 2007.

Table 5: Effect of cowpea and soybean supplementation on the nonessential amino acid (g/100g protein) profile of *dabuwa.*

RUNS	SER	ALA	PRO	ARG	ASP	GLU	GLY
Cowpea supplementation							
F_1Ma_1C	4.23^{e}	3.83^{b}	2.67^{e}	5.19^{cd}	8.48^{b}	13.54^{d}	3.25^{d}
F_2Ma_2C	4.50^{d}	3.90^{ab}	2.93^{d}	5.29^{c}	8.93^{a}	14.39^{b}	3.45^{b}
F_1Mi_1C	4.98^{bc}	3.89^{ab}	3.27^{bc}	5.55^{ab}	8.31^{c}	14.36^{b}	3.48^{b}
F_2Mi_2C	5.48^{a}	4.25^{a}	3.57^{ab}	5.63^{a}	8.54^{b}	14.53^{a}	3.74^{a}
F_1R_1C	4.85^{c}	3.81^{b}	3.37^{b}	5.43^{b}	8.35^{c}	14.31^{bc}	3.63^{ab}
F_2R_2C	3.85^{g}	3.97^{ab}	2.55^{ef}	5.42^{b}	7.73^{f}	13.24^{e}	3.26^{d}
Soybean supplementation							
F_1Ma_1S	4.28^{e}	3.84^{b}	2.70^{e}	5.20^{cd}	8.89^{a}	14.29^{bc}	3.28^{d}
F_2Ma_2S	5.07^{b}	4.04^{ab}	3.35^{b}	5.60^{a}	8.20^{d}	14.18^{c}	3.34^{c}
F_1Mi_1S	4.18^{ef}	3.82^{b}	3.17^{c}	5.52^{ab}	8.54^{b}	14.53^{a}	3.67^{ab}
F_2Mi_2S	4.70^{cd}	3.79^{b}	3.28^{bc}	5.40^{b}	8.33^{c}	13.98^{cd}	3.48^{b}
F_1R_1S	3.76^{gh}	4.22^{a}	3.76^{a}	5.50^{ab}	7.89^{e}	13.83^{cd}	3.46^{b}
F_2R_2S	3.98^{fg}	4.01^{ab}	3.65^{ab}	5.45^{b}	7.78^{f}	13.43^{de}	3.35^{cd}
FMa	4.09^{f}	3.79^{b}	2.64^{e}	5.18^{cd}	8.38^{c}	13.45^{de}	3.20^{e}

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

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. SER=Serine, ALA=Alanine, PRO=Proline, ARG=Arginine, ASP=Aspartate, GLU=Glutamate and GLY=Glycine.

Table 6: Essential, non-essential and total amino acid contents of dabuwa.

RUNS	Parameters and their compositions (g/100g crude protein)		
	TAA	TEAA	TNAA
Cowpea Supplementation			
F_1 Ma_1C	71.27	30.08	41.19
F_2Ma_2C	78.05	34.66	43.39
F_1MI_1C	85.91	42.07	43.84
F_2MI_2C	88.61	43.47	45.14
F_1R_1C	81.59	37.84	43.75
F_2R_2C	74.59	34.57	40.02
Soyabean Supplementation			
F_1Ma_1S	75.76	33.28	42.48
F_2MA_2S	84.66	40.88	43.78
F_1mI_1S	84.97	41.54	43.43
F_2MI_2S	80.31	37.35	42.96
F_1R_1S	77.24	36.52	40.72
F_2R_2S	76.34	34.84	41.50
Control			
FMa	71.34	30.61	40.73
Total adult requirement per day*		11.1	
Egg protein*		49.0	

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.

TAA = Total amino acids, TEAA = Total essential amino acids, TNAA = Total non-essential amino acids

*WHO/FAO/UNU, 2007

Conclusion

Use of cereal-legume flours to produce the dried stiff porridge *dabuwa*, had enhanced the mineral content as well as amino acid profile of the product. *Dabuwa* should therefore, be re-popularized, fortified and patronized by the general populace so as to meet the protein as well as the macro and micro nutrient requirement of populations of the under-developed (in particular) and developing nations in general.

Reference

1. Amodou I. Millets: Nutrition, Composition, some Health Benefits and Processing – A Review. Emirates J of Fd and Agric. DOI: 10.9755/ejfa.V2517.12045. 25(7): 501-508.
2. AOAC. Association of Official Analytical Chemists. 18th ed. Official methods of analysis. Washington DC, 2020.
3. AOAC. Association of Official Analytical Chemists. 19th ed. Official methods of analysis. Washington D.C, 2010, 652-671.
4. Bagirathy AP, Govarethinam. A comprehensive Study of Mineral Contents in selected Malaysian Brown and white Rice. M.Sc. Chem Thesis. University of Malaysia, Kuala Lampur, 2014.
5. Banaszkiewicz T. Nutritional value of Soybean Meal, Soybean and Nutrition, Prof. Hany El-Shemy (Ed.), ISBN: 978-953-307-536-6, InTech, Available from: http://www.intechopen.com/books/soybean-and-nutrition/nutritional-value-of-soybean-meal
6. Banu H, Itagi N, Singh V. Preparation, Composition, Functional Properties and Antioxidative Activities of Multigrain Composite Mixes. *J Food Sci Technol*,2012:49(1):74-81. Doi: 10.1007/s13197-011-0267-6.
7. Box GE, Hunter JS, Hunter WG. Statistics for experimenters: Design, Innovation, and Discovery, 2nd Edition. Wiley. ISBN. 978-0-471-71813-0.
8. Edet EE, Onwuka GI, Orieke COM. Nutritional Properties of Composite flour blends of Rice (Oryza sativa), Acha (Digitaria exilis) and Soyabean (Glycine max) and Sensory Properties of Noodles Produced from the flour. Asian J of Advances in Agric Res, 2017, 1(2).
9. Eggum BO. The nutritional of value of rice in comparison with other cereals in proceedings of Workshop chemical aspects of rice grain quality. *Phillipines: International Rice Research Institute, 1979,* 91-111.
10. FAO/WHO. Human vitamin and mineral requirement. Report of a Joint FAO/WHO Expert Consultation. Food and Nutrition Division, Bangkok, Thailand, 2001.
11. FAO/WHO. Joint FAO/WHO Food Standards Programme: CODEX Committee on FTP Director listing. FAO of the United Nations. Italy, Rome, 2011.
12. Hakeem AA, Mohammed SG, Adeosun JO, Ihedioha D. Farmers' guide to increased productivity of improved legume-cereal cropping systems in the Savannas of Nigeria. IITA, Ibadan, Nigeria, 2010, 104.
13. Ijarotimi OS, Ebisemiju MO, Oluwalana IB. Proteins, Amino Acid Profile, Phytochemicals and Antioxidative Activities of Plant-based Food Material Blends. American Journal of Food Technology,2017:12:285-294. DOI: 10.3923/ajft.2017.285. 294
14. Kumar A, Metwal M, Kaur S, Gupta AK, Puranik S, Singh S, *et al.* Nutraceutical value of finger millet [Eleusine coracana L. Gaertn.] and their improvement using Omics approaches. Frontiers in plant Science,2016:7:934.
15. Inobeme A, Nlemadim AB, Obigwa PA, Ikechukwu G, Ajai AI. Determination of Proximate and Mineral Compositions of White Cowpea Beans (Vigna unguiculata) Collected from Markets in Minna, Nigeria. International Journal of Scientific and Engineering Research,2014, 5(8). ISBN 2229-5518
16. Liener IE Implications of antinutritional componenets in soybean foods. *Crit. Rev. Food Sci.* 34, 31.
17. Makanjuola and Olakunle M. (2017). Amino Acids Profile of Powdered Fermented Maize Meal (Ogi) Fortified with Powdered Unfermented Locust Bean Seeds (Pakia Biglobosa). IOSR *Journal of Environmental Science, Toxicology and Food Technology* (IOSR-JESTFT),2017:11(11):28-32.
18. Muthayya S, Rah JH, Sugimoto JD. The global hidden hunger indices and maps: An advocacy tool for action. *PLoS One*,2013:8:e67860.
19. Nierenberg D, Spoden K. "Global Grain Production at Record High Despite Extreme Climatic Events". In: Global Trends that Shape our Future. Source: Worldwatch Institute. Vital Sign, 2012.
20. Nkama I. Traditional methods of production of high protein-energy foods from grain legumes in the north-eastern states of Nigeria. *Annals of Borno*,1993:10:138-148.
21. Regan L. Bailey Keith P, West Jr, Robert E Black. The Epidemiology of Global Micronutrient Deficiencies. National Institutes of Health (NIH). *Annals of Nutrition and Metabolism*,2015:66(2):22-23.
22. Singh RB. "Trends and Prospects for Mungbean Production in South and South eastern Asia". In: S. Shanmugasundaram and B.T. Mclean (eds) Mungbean: Proceedings of the second International Symposium, pp 552-559, AVRDC, Shanhua, Taiwan, Rep. of China, 1988.
23. WHO/FAO/UNU. Protein and Amino Acid Requirement in Human Nutrition. Report of a joint World Health Organisation (WHO)/Food and Agriculture Organisation (FAO)/United Nations University (UNU) Expert Consultative Technical Report. Geneva, Switzerland. WHO Technical Report Series, 2007, 935.