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# Evaluating the nutritional and sensory qualities of substituted staple-based-Mung bean diets

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**Abstract**
The study evaluated four (4) recipes developed from staple foods (rice, yam, and plantain) substituted with Mung bean (*Vigna radiata*) in south east Nigeria. The principles of food-to-food enrichment was applied to generate culturally acceptable staple-based diets. The diets include Mung bean-rice jollof (MRJ), Mung bean-yam porridge (MYP), Mung bean-unripe plantain porridge (MUP) and Mung bean-ripe plantain porridge (MRP). Traditional methods of food preparation were adopted with slight modification (addition of tomato puree and cent leaf). Nutrient compositions and sensory properties of the diets were determined following the standard methods. The sensory qualities of the diets were determined using 30 untrained taste panels. It was found that all the porridge recipes with 70% Mung bean substitution, 75 g tomato puree and 20g cent leaf ranked highest in taste (7.0- 8.9) and general acceptability (7.1 -8.2), though not significant ($p<0.05$). Nutrient composition of the substituted Mung bean diets ranged from; 12.01%-18.34% (protein), 6.31mg-7.73mg (vitamin C), 1.75 mg- 2.17 mg (iron) and 0.45 mg-0.63mg (zinc). Substituted Mung bean diets were found to be containing 18 amino acids (per 100g protein). The energy content of Mung bean diets falls within the 376 -480 Kcal/100g recommended levels young children. Mung bean conveniently substituted yam and plantain (ripe and unripe) in traditional porridge meal and in jollof rice.

**Keywords:** culturally acceptable, staple-based, sensory evaluation, substituted Mung bean diet

## Introduction

Food security is not just producing enough food for everyone, it is also about the nutritional quality and diversity of the food for improving health. Malnutrition especially undernutrition is known to reduce a nations economic advancement by at least 8%, because of direct productivity losses, losses via cognition and losses via schooling (Horton and Seckel, 2013) [12]. It has been reported that large parts of the developing world are plagued by micronutrient malnutrition which are not easily noticed but have devastating health and nutritional consequences (http:/ /www. who.int/nutrition/topics/ida/en/). Iron deficiency is the most prevalent micronutrient disorder world wide with the highest prevalence found in infants, children, adolescents and women of childbearing age (Thompson, 2007) [21]. According to WHO (2013) report, large proportion of the population in developing countries consume less than the recommended dietary allowance for iron. This is because plant-based diets found in developing countries are considered to have low iron bioavailability containing almost exclusively non-haeme iron (Vijayalakshmi, *et al.*, 2003) [24]. The 1992 International Conference on Nutrition pinpointed food-based diet diversity strategies as the most sustainable means of alleviating micronutrient deficiencies (Eileen, Venkatesh and Venkatesh, 2003). It has been reported that varied diets are a key reason why most of the world's population is free from micronutrient malnutrition (www. fao. org/docrep /x0245e /x0245e. htm#P1_0). This could be accomplished by promoting consumption of foods that are naturally rich in micronutrients or are enriched through fortification. Research have proved that one way of enhancing the bioavailability of certain micronutrients is to combine foods that, when eaten together, increase the bioavailability of these micronutrients, a strategy known as food –to – food fortification (Vijayalakshmi, *et al.*, 2003) [24]. In another research, Vijayalakshmi *et al.* (2001) [23] reported that iron absorption and bioavailability from plant based-diets can be enhanced if consumed with plenty of vitamin C-rich foods such as tomato, cabbage, cauliflower, coriander, and lime juice. Ascorbic acid promotes non-haeme iron absorption by reducing ferric iron to the ferrous state, which is more soluble with pH present in the duodenum and small intestine (AVRDC, 1999). Increasing production and utilization of micronutrient rich foods, improving the bioavailability of such micronutreints through processing and cooking, and developing varieties with increased density of microntrients, decreased levels of inhibitors, or increased levels of promoter of food absorption are all food-based approaches with nutrition objectives (Ruel, 2001; Yang *et al.*, 2007). Mung bean is an ancient crop domesticated in the Indian, from where it spreads to other countries (Tomooka *et al.*, 1992) [22]. Mung bean has been transformed from marginal to relatively important crop in Asia, due to its numerous contributions in improving rural household income, expanding employment opportunities, diversifying diets, increasing nutritional security, and enhancing soil fertility (Shanmugasundaram *et al.*, 2009). Finding from recent research studies revealed that Mung bean has potentials of becoming an important crop in South eastern Nigeria, having an average potential grain yield of 3.5 t/ha (Agugo and Muoneke, 2009; Agugo and Chukw, 2009). In addition to its value as a protein-rich food, Mung bean also has relatively high iron content (Vijayalakshmi *et al.*, 2001) [23]. Several researches on food-to-food dietary enrichment have been reported in Nigeria. According to Agugo *et al.* (2013) [2] enhanced nutrient ranging from protein (14.76% - 15.33%), crude fiber (2.30% – 2.57%) and ash (2.17%-

3.23%) compositions of maize gruel (pap) complemented with mumg bean was found. In another research low protein content ranging from 0.24% - 0.64% was reported in stiff porridges prepared from *acha* and Bambara nut starch blends (Chima *et al.*, 2013) [5]. Appropriate nutrition is a basic human need that remains unmet for a vast number of children living in Sub-Saharan Africa with the very high rate in countries like Ethiopia and Nigeria (Adewara and Visser, 2011) [1]. Unfortunately, the diets commonly offered to young children are of low quality and often lack variety, which is the key to specific nutrient adequacy (Isa *et al.*, 2012) [17]. However, there is limited information on the utilization of substituted mung bean staple based diet as food options for growing (school age) children. This study is part of an intervention study that focused on evaluating the nutritional and sensory properties of culturally acceptable diets developed from rice, yam, and plantain in complement with mung bean. Most accepted staple based substituted mung bean diets were later fed to school children (5-12years).

## Materials and Methods

### Procurement of Research Materials

The raw materials, mung bean (*Vigna radiata*) seed was purchased from Lagos state in the western part of Nigeria. While the staple food materials; rice, yam, plantain, and other cooking components such as canned tomato puree, cent leaf, crayfish, vegetable oil, palm oil, salt and *maggi* star were procured from Owerri main market, in Imo State, Nigeria.

### Development of Substituted Mung Bean Recipes

Substituted mung bean recipes were developed in the food laboratory of the Department of Nutrition and Dietetics, Imo State Polytechnic, Umuagwo-Ohaji. Below are flow charts and procedures adopted in recipe development. Triplicate of each diet were produced with variation in the addition of mung bean and tomato puree depending on the food type. The staple based substituted Mung bean diets were subjected to sensory evaluation to select the most acceptable diets.

**Diet 1: Mung bean-rice jollof (MRJ);** Mung bean substituted rice in different proportions (70%, 40% and 50%) to obtain mung bean- rice jellof diets (Sample A). Triplicates samples of mung bean- rice jollof diets were prepared with recipes 1, 2 and 3 (Table 1) following the traditional method of meal preparation in south eastern region of Nigeria. Mung beans was washed and parboiled for 10 munities. After draining, parboiled mung bean sample was allowed to cook for 10 minutes before precooked rice (washed, boiled for 5 minutes and drained) was added. Other food components (groundnut oil, crayfish, canned tomato puree, fresh pepper, and onions) were added, stirred, and the mixture was allowed to cook till softness (for 10 minutes). Salt and magi star were added and allowed to boil for another 5 minutes. Finally washed cent leaf (10 g) was cut and added to the meal shortly (a minute) before turning off the gas. The meals were stored in covered clean dishes and labeled (sample A1-A3) for sensory evaluation. Flow chart for the production of Mung bean-rice jollof is presented below (Figure1).

**Diet 2: Mung bean-yam porridge, (MYP):** Seventy percent (70%) of Mung bean substituted 30% of yam in traditional meal preparation (Sample B). Recipes 1,2, and 3 of Mung bean-yam porridge were developed. The traditional method of cooking bean-yam porridge was adopted. The triplicate samples were prepared with variation in the addition of canned tomato puree (Table 2). Mung bean was washed and parboiled for 10minutes. Parboiled mung bean sample was allowed to boil to softness for 15 minutes before adding yam (peeled and cut into small pieces). The mixture (mung bean and yam) was allowed to boil for 5 minutes. Other food components (fresh palm oil, crayfish, onions, fresh pepper, salt, *maggi* star and canned tomato puree) were added and allowed to boil together for 15 minutes. Finally, sliced cent leaf was added a minute before turning off the gas. The procedure for meal preparation is shown in the flow chart below (figure 2).

**Table 1:** Recipe for mung bean –rice jollof (MRJ)

| Food materials | Recipes | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| Mung bean seed | 219 g | 292 g | 365 g |
| Rice (foreign) | 511g | 438g | 365 g |
| Vegetable oil | 15 ml | 15 ml | 15 ml |
| Fresh pepper | 30 g | 30 g | 30 g |
| Onions | 110 g | 110 g | 110 g |
| Canned tomato puree (tasty tom) | 75 g | 75 g | 75 g |
| Crayfish | 50 g | 50 g | 50 g |
| *Maggi* | 5 g | 5 g | 5 g |
| Cent leaf | 10 g | 10 g | 10 g |
| Salt | 5 g | 5 g | 5 g |

Recipe 1(30% M: 70% rice); Recipe 2 (40% M: 60% rice); Recipe 3 (50% M: 50% rice).

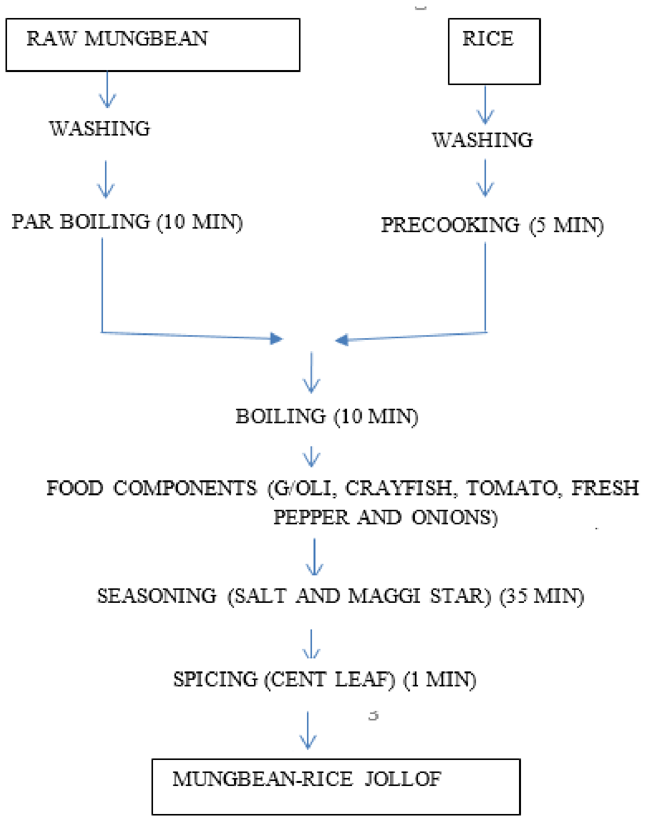


**Fig 1**: Flow chart for Mung bean-rice jollof (MRJ) diet

**Table 2:** Recipe for Mung bean-yam porridge (MYP)

| Food materials | Recipe | | |
|---|---|---|---|
| | **1** | **2** | **3** |
| Mung bean seed (M) | 511 g | 292 g | 365 g |
| Yam, ripe plantain and unripe plantain | 219g | 438 g | 365 g |
| Fresh palm oil | 15 ml | 15 ml | 15 ml |
| Fresh pepper | 30 g | 30 g | 30 g |
| Onions | 110 g | 110 g | 110 g |
| Canned tomato puree (tasty tom) | 75 g | 75 g | 75 g |
| Crayfish | 50 g | 50 g | 50 g |
| *Maggi* star | 10 g | 10 g | 10 g |
| Cent leaf | 20 g | 20 g | 20 g |
| Salt | 5 g | 5 g | 5 g |

**Recipe 1** (70% M: 30% yam/ripe plantain/ unripe plantain with 75 g tomato);
**Recipe 2** (40% M: 60% yam/ripe plantain/ unripe plantain with 75 g tomato);
**Recipe 3** (50% M: 50% yam/ripe plantain/ unripe plantain with 75 g tomato).

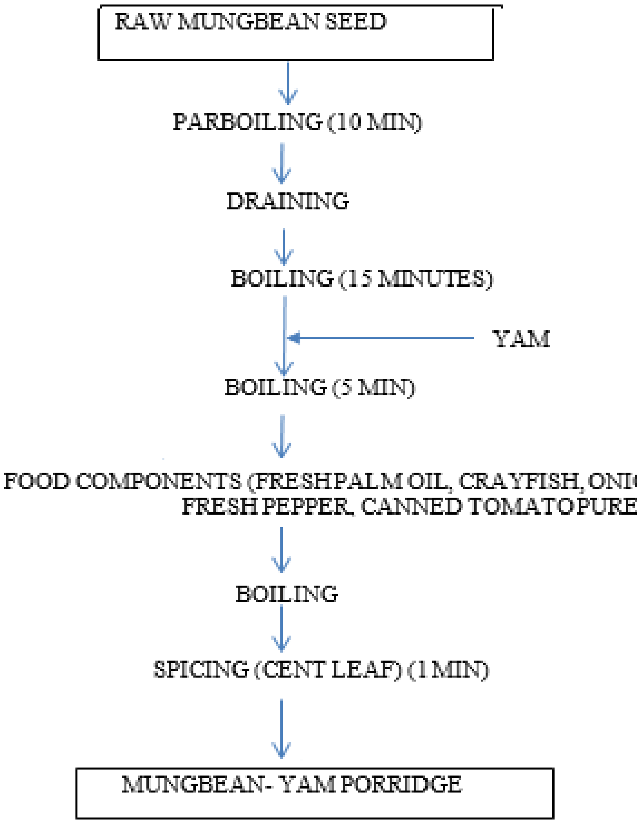


**Fig 2:** Flow chart for mung bean-yam porridge (MYP)

*The same unit of operations were employed in the preparation of sample C; mung bean- ripe plantain (MRP) porridge and sample D; mung bean-unripe plantain (MUP) porridge.

**Sensory evaluation**

The different mung bean recipes (A1, A2, A3; B1, B2, B3; C1, C2, C3 and D1, D2 D3) were organoleptically evaluated to select most acceptable diets (Table 3). The sensory evaluation was conducted with 30 (untrained) taste panels (school age children 5-12 years). Prior to the evaluation the children were properly instructed and also guided while filling the forms. A nine-point hedonic scale (Ihekoroonye and Nggody, 1985) [15] was used where 9 represents liked extremely and 1 represents disliked extremely. Clean drinking water was provided to the taste panels to rinse mouth after tasting each sample. The sensory evaluation was conducted in two days.

**Chemical analysis**

Hundred gram (100g) of most acceptable food samples (MRJ, MYP, MRP and MUP) were dried in an oven at 60°C for 2 hours, blended together to obtain a flour sample (2mm) used for chemical analysis. The proximate: macronutrients, micronutrient (zinc, vitamin C and iron) compositions and amino acid profile of selected Mung bean diets were determined following the different standard methods.

## Results

**Table 3:** Sensory evaluation result of supplementary Mung bean diets

| Samples | Parameters | | | | |
|---|---|---|---|---|---|
| | Taste | Aroma | Texture | Appearance | General Acceptability |
| A1 | 5.9$^{b}$ | 6.8$^{ab}$ | 4.4$^{d}$ | 6.6$^{ab}$ | 5.8$^{bc}$ |
| A2 | 7.3$^{ab}$ | 6.8$^{ab}$ | 6.7$^{abc}$ | 6.4$^{ab}$ | 6.8$^{ab}$ |
| A3 | 7.7$^{ab}$ | 6.5$^{ab}$ | 6.3$^{abcd}$ | 7.0$^{ab}$ | 7.9$^{a}$ |
| B1 | 8.9$^{a}$ | 8.0$^{a}$ | 8.0$^{a}$ | 7.3$^{ab}$ | 7.8$^{ab}$ |
| B2 | 8.5$^{a}$ | 7.3$^{ab}$ | 6.4$^{abc}$ | 6.9$^{ab}$ | 6.4$^{abc}$ |
| B3 | 8.2$^{a}$ | 6.5$^{ab}$ | 5.8$^{bcd}$ | 6.0$^{ab}$ | 6.5$^{ab}$ |
| C1 | 8.2$^{a}$ | 7.9$^{a}$ | 7.5$^{ab}$ | 8.0$^{ab}$ | 8.2$^{a}$ |
| C2 | 7.5$^{ab}$ | 6.8$^{ab}$ | 7.2$^{abc}$ | 7.0$^{ab}$ | 7.2$^{abc}$ |
| C3 | 6.9$^{ab}$ | 7.6$^{ab}$ | 7.9$^{a}$ | 7.1$^{ab}$ | 6.6$^{abc}$ |
| D1 | 7.0$^{ab}$ | 6.9$^{ab}$ | 6.5$^{abc}$ | 7.0$^{ab}$ | 7.1$^{abc}$ |
| D2 | 7.2$^{ab}$ | 7.4$^{ab}$ | 5.5$^{dc}$ | 5.9$^{b}$ | 5.7$^{c}$ |
| D3 | 7.1$^{ab}$ | 5.7$^{b}$ | 6.6$^{abc}$ | 5.5$^{b}$ | 5.8$^{bc}$ |
| **LSD** | **2.03** | **1.98** | **2.03** | **1.90** | **2.0** |

Means with the same letter are not significantly different ($P<0.05$):
**Sample A**= mung bean-rice jellof (MRJ): A1(30% M: 70% rice); A 2 (40% M: 60% rice); A3 (50% M: 50% rice):
**Sample B**= Mung bean-yam porridge (MYP): B1 (70% M: 30% yam); B 2 (40% M: 60% yam); B3 (50% M: 50% yam):
**Sample C**= Mung bean-ripe plantain porridge (MRP): C 1(70% M: 30% RP); C 2 (40% M: 60% RP); C3 (50% M: 50% RP).
**Sample D**= Mung bean unripe plantain porridge (MUP): D 1 (70% M: 30% UP); D 2 (40% M: 60% UP); D3 (50% M: 50% UP).

**Table 4:** Proximate composition of substituted mung bean diets

| Samples | Nutrients | | | | | | |
|---|---|---|---|---|---|---|---|
| | Moisture (%) | Crude protein (%) | Ash (%) | Ether extract (%) | Crude fiber (%) | CHO (%) | Energy Kcal (KJ) |
| A | 8.75±0.01 | 12.01±0.26 | 1.78±0.02 | 8.36±0.05 | 2.34±0.01 | 66.76±0.07 | 399(1670) |
| B | 9.45±0.00 | 18.31±0.42 | 1.92±0.00 | 11.78±0.02 | 2.79±0.02 | 55.75±0.05 | 413(1728) |
| C | 8.65±0.35 | 17.95±0.26 | 2.15±0.01 | 10.21±0.43 | 3.08±0.1 | 57.96±0.35 | 407(1704) |
| D | 9.79±0.04 | 18.34±0.08 | 2.62±0.00 | 11.02±0.6 | 2.81±0.04 | 55.42±0.39 | 405(1694) |

**Sample A**= Mung bean-rice jellof (50% M: 50% R) (MRJ):
**Sample B**= Mung bean-yam porridge (70% M: 30% Y) (MYP):
**Sample C**= Mung bean-ripe plantain porridge (70% M: 30% RP) (MRP):
**Sample D**=Mung bean unripe plantain porridge (70% M: 30% UP) (MUP)

**Table 5:** Vitamin and mineral composition of substituted mung bean diets

| Samples | Nutrients | | |
|---|---|---|---|
| | Vitamin C (mg/100g) | Iron (mg/100g) | Zinc (mg/100g) |
| A | 6.31±0.03 | 1.84±0.02 | 0.45±0.01 |
| B | 6.59±0.19 | 1.75±0.03 | 0.57±0.01 |
| C | 5.40± 0.00 | 1.92±0.02 | 0.51±0.02 |
| D | 7.73±0.11 | 2.17±0.01 | 0.63±0.03 |

**Sample A**= Mung bean-rice jellof (50% M: 50% R) (MRJ)
**Sample B**= Mung bean-yam porridge (70% M: 30% Y) (MYP)
**Sample C**= Mung bean-ripe plantain porridge (70% M: 30% RP) (MRP)
**Sample D**=Mung bean unripe plantain porridge (70% M: 30% UP) (MUP)

**Table 6:** Amino acid profile of substituted Mung bean diets

| Amino acid | SAMPLES | | | |
|---|---|---|---|---|
| | A mg/100g protein | B mg/100g protein | C mg/100g protein | D mg/100g protein |
| Leucine | 8.23 | 6.71 | 6.01 | 7.65 |
| Lysine | 4.64 | 3.42 | 3.34 | 4.03 |
| Isoleucine | 3.31 | 3.01 | 3.01 | 3.21 |
| Phenylalanine | 4.26 | 3.55 | 3.37 | 4.35 |
| Tryptophan | 1.02 | 0.81 | 0.84 | 0.89 |
| Valine | 3.51 | 3.39 | 3.04 | 3.27 |
| Methionine | 1.44 | 1.36 | 1.23 | 1.39 |
| Proline | 3.25 | 2.94 | 2.84 | 3.25 |
| Arginine | 6.88 | 5.51 | 5.16 | 6.37 |
| Tyrosine | 3.1 | 2.58 | 2.41 | 3.1 |
| Histidine | 2.3 | 1.17 | 2.2 | 2.27 |
| Cysteine | 0.97 | 0.79 | 0.79 | 1.03 |
| Alanine | 4.1 | 3.53 | 3.49 | 3.87 |

| | | | | |
|---|---|---|---|---|
| Glutamic acid | 11.96 | 10.98 | 10.6 | 11.89 |
| Glycine | 4.42 | 4.01 | 3.8 | 4.2 |
| Threonine | 3.27 | 2.89 | 2.83 | 3.22 |
| Serine | 3.59 | 3.03 | 3.0 | 3.73 |
| Aspartic acid | 8.99 | 8.25 | 7.88 | 8.84 |

**Sample A**= Mung bean-rice jellof (50% M: 50% R) (MRJ)
**Sample B**= Mung bean-yam porridge (70% M: 30% Y) (MYP)
**Sample C**= Mung bean-ripe plantain porridge (70% M: 30% RP) (MRP)
**Sample D**=Mung bean unripe plantain porridge (70% M: 30% UP) (MUP)

**Discussion**

Table 3. Shows result on the sensory attributes of the different triplicate samples of substituted mung bean diets. All the recipes developed from rice, yam, ripe plantain and unripe plantain in complement with mung bean were acceptable with scores above 4.5. It was found that all the porridge recipes with 70% mung bean substitution, (samples, B1, C1 and D1) ranked highest in taste (7.0- 8.9) and general acceptability (7.1 -8.2) in all the parameters though not significant (P<0.05). This confirms the report that the organoleptic tests in all foods are generally the final guide of the quality from the consumer's point of view (Akubor and Ojih, 2011) [3]. This finding does not correspond with the finding of Akubor and Ojih, (2011) [3], who reported lower ranks in taste (3.6-7.7) and general acceptability (3.7-4.5) for a traditional maize based porridge supplemented with soy bean. The sensory scores also differ from the report of Agugo *et al.* (2013) in taste (4.6-5.7) and general acceptability (4.3 -5.8), in mung bean-maize guel (pap). The high acceptability scores could be linked to the type of diet and the method of preparation applied, especially the addition of tomato puree and scent leaf to the porridge recipes. Though reports from some other researchers did not show improvement on the taste and general acceptability of foods with addition of tomato. According to Doménech-Asensi *et al*. (2013) [6] addition of tomato paste on sausage mortadella improved the color and have no effect on the overall consumer acceptability. Similarly, Kilcast (2004) [18], reported an improvement on the texture of meal prepared with tomato paste.

Most acceptable mung bean diets were subjected to proximate (macronutrient, micronutrient and amino acid profile) analysis. Percentage macronutrient compositions of the mung bean diets are presented in Tables 4. The moisture content of the diets ranged from 8.75% - 9.79%. The low moisture content obtained may be due to the samples were dried to obtained a homogenous blend of all the food components used in the meal preparation. The protein content of selected supplementary mung bean diets ranged from 12.01%-18.34%. The protein contents obtained with samples B (18.31%), C (17.95%) and, D (18.34%) were all above the 15% minimum level recommended for complementary food (FAO/WHO. 19940). The enhanced crude protein composition of the standard munbean diets (porridges and jollof) corresponds with the observation of Akubo and Ojih (2011), with soy-*apula* blends. Protein content of Mung bean flour has been reported to range from 9% - 25.1% (Deudie and Hardly, 1996; Agugo and Onimawo, 2009). Generally, protein content of legumes is between 20-30% of energy which corresponds to levels found in fish and meat (Hallstrom, 2011). The ash content ranged from 1.78%- 2.62%, highest ash content was observed with sample D (mung bean-unripe plantain blend). This finding is similar to the level of ash found in some other supplementary plant-based foods (Ocheme *et al.*, 2012; Akubor and Ojih, 2011) [20, 3]. The crude fiber composition of the diets ranged from 2.34% - 3.08% higher than the quantity reported by Akubo and Ojih (2011) [3] in complementary soy-apula maize based porridge).

Ether extract of the supplementary mung bean –diets ranged from 8.36% -11.78%. This range was higher than the fat content (1.4%-2.7%) of a weaning food mung bean–maize gruel reported (Agugo *et al.*, 2013) [3]. The high fat content obtained from the substituted Mung bean diets could be attributed to the traditional processing methods adopted. The carbohydrate content of the diets ranged from 55.42%-66.76%. This conforms with to the findings of Elemo *et al*. (2011) [8] and Hussain *et al*. (2012) [14] who reported higher carbohydrate content ranging from 63.7%–77.4% in complementary food processed from sorghum and cowpea, and 61.24–70.73% from wheat and lentil com- position flour, respectively. Only sample A, mung bean-rice jollof (66.76%) meet the carbohydrate content recommended by WHO/ FAO (2004) in the complementary food ≥65g/100g. This could be attributed to the low percentage (30%) composition of staples (yam and plantain) in the porridge recipes. However, the energy content of the mung bean diets fell within the 376 -480 Kcal/100g recommended levels of food for infants and young children (Cameron and Hofrande, 1983) [4].

Percentage micronutrient compositions of the mung bean diets are presented in Tables 5. The study revealed higher range of vitamin C composition of 6.31mg/100g – 7.73mg/100g in the substituted mung bean diets than iron (1.75 mg/100g – 2.17 mg/100g) and zinc (0.45 mg/100g – 0.63mg/100g). The micronutrient (vitamin, iron and zinc) compositions were higher in sample D (mung bean-unripe plantain porridge). Generally, the levels of iron and zinc obtained in the diets were lower than the compositions of iron (2.5mg) and zinc (8.0) reported by Akubo and Ojih (2011) and 2.8 mg (zinc) and 4.2mg (iron) reported by Agugo and Onimawo (2009). The finding is in contrast to the claim of Goplalan *et al*. (2000), that mung bean has been found to be rich in dietary iron in comparison to other pulses. Nevertheless, iron content of the different substituted mung bean diets were low compared to the levels reported by other researchers in plant-based foods. Southgate (2001), reported 6.76% iron per 100g of Mung bean seed, iron content of Mung bean was also observed to range from 4.33 mg, 3.99 mg and 3.34 mg for raw, boiled and tosted Mung bean flour, respectively (Agugo and Onimawo, 2009). Demirel *et al.* (2001) also reported iron level in some plant food materials to range from 3.10 -5.06 mg/kg. Another alternative to improving the nutritional quality of Mung bean is to develop receipes that ensure higher nutrient bioavailability than traditional Mung bean receipes (Ramakrishan *et al*.,2013). Vijayalakshmi *et al.,* (2001), reported higher content of iron (8.73%) in a traditional Mung bean diet cooked with raw tomato in India. The low iron composition observed with the substituted mung bean diets may be due to the processing methods applied. legumes are important sources of micronutrients such as iron, FAO and WHO recommende 45g daily consumption of legumes (pulses) to boost iron intake. However, 10-12 mg of iron per day has been recommended for children, preferably from their diets (Pineda and Ashmead, 2001).

About 90% of the total dietary supply of iron in most developing countries including Nigeria comes from plants, which contains non-hem iron that is poorly absorbed (Thompson, 2007) [21]. Iron among other nutrients such as zinc and vitamin A are most difficult to obtain in cereal and tuber-based diets, but the addition of legumes can slightly improve the iron content of those diets (FAO/WHO, 1998). However, the bio-avalability of non-haeme iron sources in Mung bean is low, but can be improved by adding a small portion (50g) of meat, poutry, or fish in foods during meal preparation (FAO/WHO,1998). And to increase absorption of iron, legumes should be consumed together with vitamin C (Hallstrom, 2011). World Health Organization (WHO) recommends the inclusion of vitamin C rich fruits and vegetables in the diet to boost absorption of iron by the body (INACG, 1993). It has been reported that the typical cereal based diet in Nigeria offers about 14-15 mg of iron per 2000 calories, but the actual absorption and utilization averages only 0.35 mg (Nnam, 2004). Vijayalashmi *et al.* (2003) [24], observed that *In vitro* iron bioavailability of Mung bean receipes was enhanced by 6% with the addition of tomato and other vegetables. Fifty gram (50 g) of crayfish was added to Mung bean- rice jollof (MRJ) and Mung bean porridges together with 75 g of tin tomato to improve the bioavailability of iron in the diets. Enhancing the quality of grain legumes is one of the best ways to tackle protein energy and micronutrient deficiencies especially, among school age children in developing countries (Ramaskrishnan *et al.*,2013). It is essential to work on statregies, which promote and facilitate dietray diversification to achieve complementarity of cereal or tuber-based diets with foods rich in miconutrients in populations with limited economics or limited access to food (FAO/WHO,1998).

The amino acid composition of the substituted mung bean diets is presented in Table 6, the analysis is based per 100 g protein. Mung bean diets were found to contain 18 amino acids that ranged from; leucine (6.01g - 8.23g), lysine (3.34g- 4.64 g), isoleucine (3.01g- 3.31g), tryptophan (0.81g-1.02 g), valine (3.04g-3.51g), methionine (1.23g-1.44g), proline (2.84g -3.25g), arginine (5.16-6.88 g), tyrosine (2.41 - 3.1 g), histidine (1.17-2.3 g), cysteine (0.79g-0.97g), alanine (3.49g-4.1g), glutamic acid (10.6g-11.96g), glycine (3.8g-4.42g), threonine (2.83g-3.27 g), serine (3.0g -3.73 g) and aspartic acid (7.88g-8.99g). However, the compositions of all the amino acids were higher in sample A (mung bean-rice jollof). This finding confirms the report of Young and Pellett (1994), that many plant proteins are lower in one or more essential amino acids than animal proteins (especially lysine and to a lesser extent methionine and threonine), while eating a variety of plants can serve as a well-balanced and complete source of amino acids. Both animal and plant proteins are made up of about 20 common amino acids. The proportion of these amino acids varies as a characteristic of a given protein (National Research Council, 1989) [19]. According to Imura and Okada (1998) [16], cysteine (sulphur-containing amino acids), tyrosine (aromatic amino acids), and arginine are always required by infants and growing children.

**Conclusion**

Staple foods such as rice, yam and plantain (ripe and unripe) can effectively complement mung bean especially in 50% (for jollof) and 70% (for porridge) proportion levels in traditional meal preparations. It is important to also note that inclusion of canned tomato puree and cent leaf in the different staple based substituted mung bean diets (jollof and porridge) not only enhanced the micronutrient composition of the diets but also improved their acceptability level.

**Recommendation**

Based on the findings of this research, the use of tomato puree and cent leaf is highly encouraged in the preparation of staple based substituted mung bean porridge and jollof rice.

**References**


1. Adewara, SO, Visser M. Use of anthropometric measures to analyze how sources of water and sanitation affect children's health in Nigeria. Environment for Development Discussion Paper Series. EfD DP, 2011, 11- 20.
2. Agugo, UA, Nwogwugu M, Sunday S, Uchegbulem A NP, Ariwado CA. Chemical and microbial qualities of weaning food produced fromage (Vigna radiata) and maize (Zea mays). Central European Journal of Experimental Biology. 2013; 2(3):34-39.
3. Akubor PI, Ojih SA. Effect of soybean addition on the chemical composition and sensory properties of Apula: A traditional maize based porridge. Nigerian Journal of Nutrition Sciences. 2011; 32(2):46-50.
4. Cameron M, Hofrande Y. Manual on feeding infants and young children. UN Acc. Sub-Commerce on Nutrition. Oxford Medical Publications. 1983; 3:38-72
5. Chima, CE, Abu JO, Matti AW, Salami SO. Quality characteristics of stiff porridges prepared from acha and Bambara nut starch bends. Nigerian Journal of Nutritional Sciences. 2013; 34(1):17-27.
6. Doménech Asensi G, García Alonso FJ, Martínez E, Santaella M, Martín Pozuelo G, Bravo S, *et al*. Effect of the addition of tomato paste on the nutritional and sensory properties of mortadella. Meat Sci. 2013; 93(2):213-219
7. Eileen Kennedy, Venkatesh Mannar, Venkatesh Iyengar. Alleviating Hidden Hunger Approaches that work, 2003.
8. Elemo GN, BO Elemo, JN C Okafor. Preparation and nutritional composite of a complimentary food formulated from germinated sorghum (Sorghum bicolor) and steamed cooked cowpea (*Vigna unguiculata* Walp). Am. J. Food Technol, 2011, 6:413-421.
9. FAO/ UN / International Life Sciences Institute (ILSI). *Preventing Micronutrient Malnutrition: A Guide to Food-based Approaches* http: //www. fao.org/ docrep/x0245e/x0245e.htm#P1_ Retrieved 10/11/2017
10. FAO/WHO. Energy and protein requirements. Geneva Technical Report Series. 1994; 552:218-550.
11. Food and Agriculture Organization. "The State of Food Insecurity in the World, 2012. Available: http://www.fao.org/docrep/016/i3027e/i3027e00.htm
12. Horton S, Skeckel R. Global economic lossess attributable to malnutrition 1990- 2000 and projections to 2050. In: Lomborg B. (ed). How much have global problems cost the world? Cambridge

university press, 2013. http://en.wikipedia.org/wiki/ Food supplement. Retrieved 22/04/2017
13. http://www.who.int/nutrition/topics/ida/en/ Retrieved: 10/11/2017
14. Hussain MS, M Anjam, B Uddin, M Hanif. Preparation and evaluation of complementary diets from germinated wheat and lentil for Bangladeshi children. Pak. J. Sci, 2012; 64:304-308.
15. Ihekoronye A, Ngoddy PO. Integrated Food Science and Technology for the tropics. Macmillan London, 1985, 60-134
16. Imura K, Okada A. "Amino acid metabolism in pediatric patients". Nutrition. 1998; 14(1):143-8.
17. Isa Y, Ahamed GM., Adegbusi KS. School feeding program in Nigeria: a vehicle for nourishment of pupils. The African Symposium: An online journal of the African Educational Research Network, December 2012 The African Symposium, 2012; 106(12):2.
18. Kilcast. Studies on the texture of tomato paste in food. Ed. David. Cambridge: Wood head pub, 2004. ISBN 185573248
19. National Research Council. (US) Subcommittee on the Tenth Edition of the Recommended Dietary Allowances. Washington (DC): National Academies Press (US), 1989.
20. Ocheme OB, Ariahu CC, Ingbian EK. Effect of maize-groundnut ratio on the quality and acceptability of Dakuwa-A Nigerian Cereal/groundnut snack. Nigerian Journal of Nutritional Siences. 2012; 33(1):18-22.
21. Thompson B. Food-based approaches for combating iron deficiency. In Kraener K and Zimmermam MB (eds). Nutritional Anemia. Sight and Life Press, Switzerland, 2007; 337-345.
22. Tomooka N, Lairungreang, C, Nakeerakas P, Egawa Y, Thavarasook KC. Center of genetic diversity and dissemination path ways in Mung bean deduced from seed protein electrophosis. Theor. App Genen. 1992; 83(3):289-293.
23. Vijayalakshmi P, Amirthaveni S, Devadas, RP. Possibilities of increasing bioavailability of iron from Mung bean and study on the effects of its supplementation on children and women. Project Report. Coimbatore, India: Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, India, 2001.
24. Vijayalakshmi P, Amirthaveni S, Devadas RP, Weinberger K, Tsou SCS, Shanmugasundaram S. Enhanced bioavailability of iron from Mung beans and its effects on health of schoolchildren. Shanhua, Taiwan: AVRDC—the World Vegetable Center, Technical Bulletin No. 30, AVRDC Publication, 2003, 03-559. 32 pp
25. WHO/ FAO. Human vitamin and mineral requirements. Report of a joint FAO/WHO consultation, Bangkok, Thailand. Rome: Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO), 2004.
26. World Hunger Education Service.htm. World Hunger and Poverty Facts and Statistics, 2013.
27. Young VR, Pellett PL. "Plant proteins in relation to human protein and amino acid nutrition" (PDF). American Journal of Clinical Nutrition. 1994; 59(5Suppl):1203S-1212S. PMID 8172124.).