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# MICRONUTRIENT, PHYSICOCHEMICAL AND ACCEPTABILITY RESPONSES OF "MOI-MOI" AS A FUNCTION OF COWPEA (*VIGNA UNGUICULATE L. WALP*) PARTIAL SUBSTITUTION WITH YELLOW MAIZE

**I. N. Okwunodulu[1]✉, C. C. Osuagwu[2], A. U. Onwuzuruike[3], S. C. Ubbor[4]**

[1,2,3,4]*Department of Food Science and Technology, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.*
✉*ncntokwu@yahoo.com*

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**ABSTRACT**

Neither legume nor cereal alone can meet all the nutrient needs of the body to prevent hidden hunger including bone health and development except when both complement and supplement each other. This study aimed at investigating the nutritional and acceptability changes of "moi-moi" from cowpea partially substituted with yellow maize in the ratios of 95: 5, 90: 10 and 80: 20%. The "moi-moi" produced with 100% cowpea served as control. Proximate, mineral, vitamin and physicochemical composition were investigated on both substituted and control with standard methods while sensory characteristics were evaluated subjectively with 20 untrained panellists. With increasing substitution levels of yellow maize, there were significant ($p<0.05$) decrease (lower than the control) in moisture (47.27-32.37%), crude protein (20.09-18.94%), and fat (10.02-8.66%). While ash content (1.45-1.73%), crude fibre (1.38-1.46%) and carbohydrate (18.86-36.85%) increased more than the control. Vitamin A (1.39-1.82 μg/100g) increased significantly ($p<0.05$) more than the control while vitamin C (0.06-0.04 mg/100g had no significant decrease. Mineral contents increased significantly ($p<0.05$) from 17.30-19.06 mg/100g, 12.44-13.43 mg/100g and 7.48-9.42 mg/100g for calcium, magnesium and phosphorous respectively more than their respective controls. The pH (6.12-6.00) and colour intensity (0.12-0.15) decreased significantly ($p<0.05$) lower than their respective controls. Acceptability decreased with yellow maize substitution level increase. The "moi-moi" produced with 100% cowpea had the best organoleptic properties (7.80) followed by 5% yellow maize substitution (6.85). Nutrient composition, calcium to phosphorous ratio, negative correlation of vitamin C with minerals and acceptability changed with increasing yellow maize substitution for all the substituted samples.

## 1. Introduction

"Moi-moi" is a popular protein-rich cowpea pudding usually served as a convenient snack or as a component of breakfast in Nigerian homes. It is consumed with pap (*ogi*), gari soaked in water, *akamu* (maize gruel) and cereal foods like rice or alone. "Moi-moi" preparation is the same all over West Africa. Cowpea is steeped in tap water for some hours to ease seed coat removal, hand dehulled and the hulls remove by water floatation. Dehulled cowpea cotyledons are then ground into smooth pastry slurry. Water and ingredients such as onion, pepper, oil, salt, water and other ingredients are added according to preference and mixed thoroughly with spoon. The pasty slurry is then scooped into aluminium plates with lids or wrapped with leaves or foil and steamed for 30-50 min to produce a steamed bean pudding called "moi-moi". Aside from wet cowpea cotyledons and maize seeds, 'moi-moi' could be prepared with their flours (Akusu and Kiin-Kabari, 2012) or with improved maize and other bean (Ejima and Ejima, 2015) using same processing technique of paste preparation and mixing.

Cowpea is an economic and readily available source of plant protein in West Africa (Henshaw, 2008; Mamiro *et al*., 2011). Unlike other legumes such as soybean and groundnuts, which are oil-protein seeds, cowpea is a starch-protein legume with a wider spectrum of utilisation than other legumes in West Africa (Henshaw, 2000). Cowpea seeds contain 36% to 68% carbohydrate, 2.7% to 5.8% crude fibre, 2.5% to 4.2% total ash and 0.9% to 2.4% fat. More so, protein, iron, calcium, phosphorus, potassium, magnesium, sodium and vitamin B complex are some of the important micronutrients found in cowpea (Okereke and Hans-Anukam, 2015). The calcium and iron content of cowpea are higher than that of meat, fish and egg while their thiamine, riboflavin and niacin content are comparable with that found in lean meat and fish (Achuba, 2006). Cowpea is especially rich in lysine, but is deficient in sulphur-containing amino acids (Ilesanmi and Gungula, 2016). Owing to the taste, ease of incorporation in other recipes and nutritional value, cowpea is widely used in Nigeria for everyday delicacies like “moi-moi”, “akara”, “danwake” amongst others (Adegbola *et al*., 2013; Akajiaku *et al*., 2014).The presence of anti-nutritional factors is one of the main drawbacks that limits the utilization of the nutritional and food quality of cowpea. The common anti-nutrients found in cowpea are trypsin inhibitors, tannin, phytate and lectins (Vadivel and Jonardhanen, 2003) but are removed during processing.

Maize (*Zea mays*) is a cereal crop widely cultivated in Nigeria and in the tropics. It is nutritionally superiority to other cereals in many ways except in protein value. The grains are rich in vitamins A, C and E, carbohydrate and essential minerals (Brownson, 2016). Maize is higher in fat and iron than wheat and rice (Mejia, 2003), but lower in protein as half of its protein is made up of zein which is low in two essential amino acids, lysine and tryptophan (Mejia, 2003; Akusu and Kiin-Kabari, 2012). About 50 species of maize exist and consist of different colours, size and shape. The white and yellow varieties are preferred by most people depending on the region. White maize seeds contain reasonable concentration of thiamine while yellow maize contains carotene, a precursor of vitamin A (Adu, 2010). Maize is also rich in dietary fibre (IITA, 2009). It is prepared and consumed in many ways which vary from region to region or from one ethnic group to the other. For instance, maize grains are used in the production of “Akamu”, “Agidi”, “Kokoro”, “Epitit”, “Ipekere” in Nigeria or as popcorn which is eaten all over West Africa.

Cowpea and maize, despite their great nutritional and economic importance, are highly susceptible to many diseases and pests during storage (IITA, 2009) and therefore need to be preserved through processing. One of the problems facing the poor socio-economic groups of developing countries such as Nigeria is protein-energy malnutrition due to consumption of starchy foods with little or no nutrient value. Substituting cowpea with that of maize is a legume-cereal technology that leads to complementation of their nutrient contents. For instance, vitamin A deficiency is a common disease among children of school age and pregnant/lactating mothers in developing countries like Nigeria (WHO/FAO, 2006). Yellow maize contains vitamin A precursor which along with good quality protein from cowpea will solve both protein malnutrition and vitamin A deficiency problem. This study therefore aimed at evaluating the nutritional changes of “moi-moi” from cowpea partially substituted with yellow maize.

## 2. Materials and methods

### 2.1. Materials

#### *2.1.1. Source of raw material*

Cowpea (Figure 1), yellow maize (Figure 2) and ingredients used for the “moi-moi” preparation were procured from Ubani main market in Umuahia North Local Government Area, Abia State, Nigeria.

**Figure 1.** Cowpea

**Figure 2.** Yellow maize

### *2.1.2. Preparation of "moi-moi"*

Cowpea and maize were first sorted to remove extraneous materials and steeped in stainless steel buckets separately with tap water covering the seeds. This is to hydrate their endosperms and make it easier for the separation of cowpea seed coat from the endosperm to obtain the cotyledons. Steeping will also hydrate and soften maize endosperm for easier milling. The cowpea cotyledons and maize were blended according to formulation ratio (Table 1), milled into fine and smooth slurry with variable speed kitchen blender (QLink, Japan). Similarly, 100% cowpea was milled same as control. The "moi-moi" samples were prepared separately (Figure 3) by mixing properly the slurry of the control and the substituted blends with same ingredients (Table 2) in a stainless steel bowl with stainless steel spoon. The mixed slurry obtained was dispensed (200 ml) into each 3 inch square formed aluminium foil, closed and steamed in aluminium pot for 30 min with a gas cooker. Then the 'moi-moi' wraps (Figures 4, 5, 6 and 7) were removed and allowed to cool to room temperature (25$^{o}$C) before all the analyses were carried out.

**Table 1.** Formulation ratios (%) for "moi-moi' preparation from cowpea partial substituted with yellow maize.

| Sample codes | Cowpea | Yellow maize |
|---|---|---|
| CP100 | 100 | 0 |
| CPYM1 | 95 | 5 |
| CPYM2 | 90 | 10 |
| CP YM3 | 80 | 20 |

CP100=100% cowpea, CPYM1=95:5% cowpea-yellow maize blend, CPYM2=90:10% cowpea-yellow maize blend and CPYM3=80:20 cowpea: yellow maize blend.

**Table 2.** Recipe per 400 g paste used for "moi-moi" preparation

| Ingredients | Quantity |
|---|---|
| Warm water | 1104 ml |
| Vegetable oil | 200 ml |
| Ground red pepper | 50 g<br>10 g |
| Onion | 40 g |
| Salt | 11 g |
| Crayfish | 10 g |
| Mixed spice | 1 g |
| Maggi cube | 1 g |

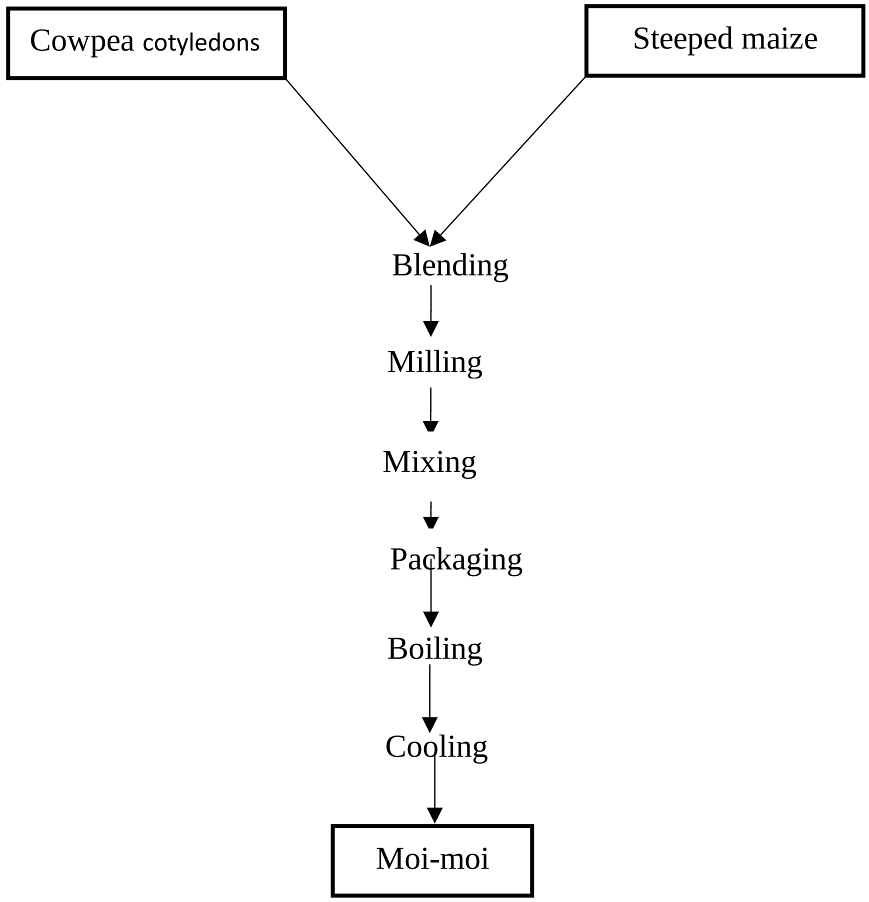


**Figure 3.** Preparation of "moi-moi" with cowpea cotyledons and maize seed blends.

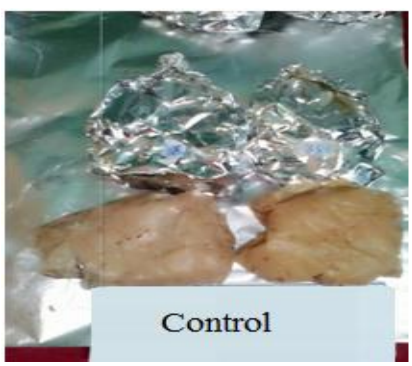


**Figure 4.** 100% cowpea.


**Figure 5**. 95% cowpea

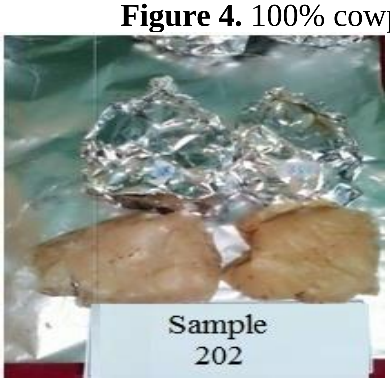


**Figure 6.** 90% cowpea: 10% yellow maize

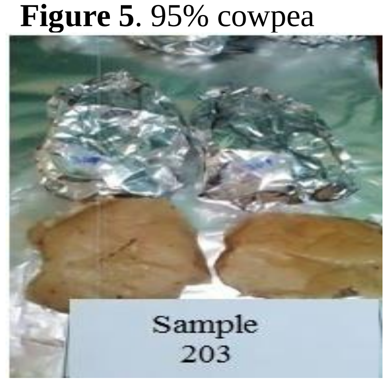


**Figure 7.** 80% cowpea: 20% yellow maize

## 2.2. Methods

### *2.2.1. Proximate analysis*

#### *2.2.1.1. Moisture content*

The moisture content was determined according to AOAC (2010) method and calculated thus:

% moisture=
$$\frac{weight\ of\ sample\ before\ drying - weight\ of\ sample\ after\ drying}{original\ weight\ of\ the\ sample}\ \frac{X\ 100}{1} \quad (1)$$

#### *2.2.1.2. Crude protein*

This was carried out using micro-kjeldahl digestion method described by AOAC (2010) and crude protein was calculated as:

$$\%\ Crude\ protein = \frac{(0.01x6.25x280xT)}{Weightofsample}\ x\frac{100}{1} \quad (2)$$

Where T= titre value.

#### *2.2.1.3. Ash content*

The method as described by AOAC (2010) was used to determine the ash content which percent content was calculated as.

$$\%\ Ash = \frac{Weight\ of\ crucible + Ash - Weigh\ of\ crucible}{Original\ weight\ of\ sample}\ x\frac{100}{1} \quad (3)$$

#### *2.2.1.4. Fat content*

Fat content was determined by the continuous solvent extraction in a soxhlet reflux apparatus (AOAC (2010) and the fat content was calculated as shown.

$$\%\ fat = \frac{W_2 - W_1}{Weight\ of\ sample}\ x\ \frac{100}{1} \quad (4)$$

Where

$W_1$= Weight of empty extraction flask

$W_2$ = Weight of flask + oil extracted.

#### *2.2.1.5. Crude fiber*

Crude fiber was determined by the method described by James [27] and calculated thus:

$$\%\ Crude\ fibre = \frac{Loss\ in\ Weight\ on\ incineration}{Weightof\ original\ sample}\ x\frac{100}{1} \quad (5)$$

#### *2.2.1.6. Carbohydrate*

Carbohydrate was calculated by difference (James, 1995) as indicated:-

% Carbohydrate =100% - (% moisture + % ash +%fat+% crude fibre + %crude protein). (6)

### *2.2.2. Vitamin determination*

#### *2.2.2.1. Vitamin A*

Vitamin A was determined with Spectrophotometric method of Onwuka (2018) and calculated thus:

$$Vitamin\ A\ (mg/\ 100g) = \frac{100}{W} x\ \frac{au}{as} x\ C \quad (7)$$

Where: au = absorbance of the test sample.

as = absorbance of the standard solution.

c = concentration of the test sample.

w = weight of sample (g).

### *2.2.3. Vitamin C*

Vitamin C was determined according to the method of Okwu and Josiah (2006) and calculated as shown:

$$Vitamin\ C\ (mg/100g) = 0.88\ x\frac{100}{10}\ x\ \frac{vf}{20}\ x\ \frac{T}{1} \quad (8)$$

Where:

$V_f$ = Volume of extract

T = Sample titre – blank titre

### *2.2.4. Mineral Determination*

#### *2.2.4.1. Calcium and magnesium*

Calcium and magnesium were determined with the Complexiometric titration method of Onwuka (2018). Total calcium and magnesium content were calculated separately using the formula:

Calcium (mg/mg) =
$$\frac{100}{W}\ x\ T - B\ (N\ X\ Ca/\ mg)\ x\ \frac{vf}{va} \quad (9)$$

Where W=Weight of sample

T = titre value of sample

B= Titre value of blank

Ca = Calcium equivalence

Mg =Magnesium equivalence

Va = Volume of extract titrated

Vf = Total volume of extract

N=Normality of titrant (0.02N EDTA).

### *2.2.3.2. Phosphorus*

The molybdate protocol of Onwuka (2018) was used and phosphorous content was calculated as shown:

$$\% \text{ Phosphorus} = \frac{\text{graph reading x solution volume}}{100} \quad (10)$$

Calcium: Phosphorous ratios were calculated using the method of Okwunodulu et al. (2022).

### *2.2.5. Physicochemical analysis*

The pH was determined by the method described by Akpakpunam and Sefa-Dedeh (1995) while the colour intensity of the samples was determined using ELICO spectrophotometer model SL. 171 (Nyderabad) India as described by Sharma (2003).

### *2.2.6. Sensory evaluation*

The method described by Iwe (2010) was used with 20 semi-trained panellists randomly selected from the staff and students of Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike. Nigeria. The panellists scored the samples according to 9-point Hedonic scale where 9 is like extremely, 5 is neither like nor dislike and 1 is dislike extremely.

### *2.2.7. Statistical analysis*

One-way analysis of variance of a completely randomized design using the Statistical Package for Social Science version 22 was carried out on the data obtained. Treatment means were separated using Duncan multiple range test at 95% confidence level (p<0.05). Also, vitamin C was used to correlate the minerals using Pearson Correlation method.

## 3. Results and discussion

### 3.1. Effects of partial substitution of cowpea with yellow maize on the proximate composition

### *3.1.1. Mosture content (MC)*

Proximate composition results as presented in Table 3 showed that MC (wet basis) of the cowpea-yellow maize “moi-moi” decreased significantly (p<0.05) with increasing yellow maize substitution of cowpea from 47.27% in sample CPYM1 (95% cowpea:5% yellow maize) to 32.27% in sample CPYM3 (80% cowpea:20% yellow maize).

**Table 3**. Proximate composition of “moi-moi” as affected by partial substitution of cowpea (%).

| Samples | Moisture | CP | Crude fibre | Fat | Ash | Carbohydrate |
|---|---|---|---|---|---|---|
| CP100 | $50.20^{a}\pm0.28$ | $20.70^{a}\pm0.01$ | $1.37^{c}\pm0.02$ | $10.67^{a}\pm0.02$ | $1.38^{d}\pm0.02$ | $15.70^{d}\pm0.32$ |
| CPYM1 | $47.27^{b}\pm0.01$ | $20.09^{ab}\pm0.01$ | $1.38^{c}\pm0.01$ | $10.02^{b}\pm0.02$ | $1.45^{c}\pm0.01$ | $18.86^{c}\pm0.04$ |
| CPYM2 | $41.64^{c}\pm0.01$ | $20.03^{ab}\pm0.04$ | $1.42^{ab}\pm0.02$ | $9.58^{c}\pm0.02$ | $1.49^{b}\pm0.01$ | $25.79^{b}\pm0.04$ |
| CPYM3 | $32.37^{d}\pm0.19$ | $18.94^{b}\pm0.03$ | $1.46^{a}\pm0.01$ | $8.66^{d}\pm0.01$ | $1.73^{a}\pm0.01$ | $36.85^{a}\pm0.21$ |

Values are means of triplicate determinations $\pm$ standard deviation. Values in the same column with different superscript are significantly different (p<0.05). CP100-100% cowpea, CPYM1-95: 5% cowpea-yellow maize, CPYM2-90:10 cowpea-yellow maize and CPYM3-80:20%-cowpea-yellow maize. CP- crude protein.

The decrease which was less than 50.20% from the control sample (CP100 =100% cowpea) could be attributed to increasing carbohydrate content with increase yellow maize substitution (Brownson, 2016). Carbohydrate increases total solids which in turn decrease MC (Okwunodulu and Nwabueze, 2019). The decrease in MC of the “moi-moi” samples may signify increase in stability, better texture chewability and acceptability due to higher dry matter (Adepoju and Etukumoh, 2014; Onoja *et al*., 2014). The MC of the control sample (50.20%) was lower than 55.40% reported for cowpea “moi-moi” (Ejima and Ejima, 2015) which may be attributed to the variety of maize, ingredients and the water ratio used. However, MC of cowpea-yellow maize “moi-moi” obtained in this study was within the range (36.10% - 44.10%) reported by Akusu and Kiin-Kabari (2012) for "moi-moi" prepared with cowpea and maize flour blends. This may be due to ingredient type, quantity as well as water: flour ratio used in the formulations.

***3.1.2. Crude protein (CP)***

Decreases in crude protein content due to increasing yellow maize substitution were lower than 20.70% from the control which points to protein reduction. The decrease (20.09-18.94%) could be aligned to the higher protein content of cowpea than yellow maize which was diluted with substitution. Higher crude protein (20.70%) obtained in the control sample confirmed the report that legumes such as cowpea contain substantial quantity of crude protein (Egouniety *et al*., 2002). Maize is a carbohydrate-rich crop without substantial amount of crude protein (Shah *et al*., 2015). The decreasing protein trend (20.09-18.94%) in this study analogized with but slightly higher than 20.25-15.40% obtained by Akusu and Kiin-Kabari (2012) for "moi-moi" produced with cowpea and maize flour. Perhaps, drying of cowpea and maize had no significant effect on their protein content. Protein in foods helps to build and maintain healthy muscle mass, supports tendon, ligaments and growth. Protein also helps to prevent spikes in blood glucose which are especially important for preventing type 2 diabetes, balancing energy level and keeping appetite and mood in check (Voet *et al*., 2008).

***3.1.3. Crude fibre (CF)***

The CF offers a variety of health benefits and is essential in reducing the risk of chronic disease such as diabetes, obesity, cardiovascular disease and diverticulosis. It lowers the concentration of low-density lipoprotein cholesterol in the blood, possibly by binding with bile's acids (Ishiwu and Tope, 2015). Crude fibre content of the cowpea-yellow maize "moi-moi" samples obtained in this study increased (1.38-1.46%) significantly ($p<0.05$) more than the control with increasing level of yellow maize substitution. The increase may have stemmed from high fibre content of yellow maize (IITA, 2009). These results implied that the fibre content of "moi-moi" and its associated health benefits could be increased by complementing it with yellow maize. The samples could be an ideal food for the obese and maintenance of weight. The results obtained in this study was higher than 0.75% to 0.83% reported by Nwosu (2011) for "moi-moi" produced from cowpea and asparagus bean seeds which could be attributed to variation in raw materials used and the processing methods used. Also, the increasing fibre trend in this study (1.38-1.46%) aligned with but slightly lower than 1.38% to 1.85% reported by Akusu and Kiin-Kabari (2012) for "moi-moi" produced with cowpea and maize flour blends. Variations in cowpea and maize varieties as well as ingredients used in the formulations may have contributed as well.

***3.1.4. Fat***

The fat content of the blended samples decreased (10.02%-8.66) with increasing levels of yellow maize substitution levels. These significant ($p<0.05$) decreases were lower than the control sample (10.67%) and may imply higher fat absorption by the carbohydrate and calcium content of the yellow maize (Igyor *et al*., 2011). The fat decrease could signified reduced fat-soluble vitamins and calorific value with yellow maize substitution (Coppin and Pike, 2001). Acceptability and swallowing may as well be reduced as they are dependent on fat content levels. Similar decreasing trend (14.75 to 9.98%) was reported by Akusu and Kiin-Kabari (2012) for "moi-moi" produced with cowpea and maize flour blends. Their fat values than those obtained in this study may be due to drying of cowpea and maize.

***3.1.5. Ash***

Ash content represents total minerals content in foods and therefore serves as an index for nutritional evaluation of mineral (Lienel, 2002). Significant ($p<0.05$) ash content increase (1.45-1.73%) due to increasing yellow maize substitution justified higher mineral of yellow maize than cowpea and mineral improvement in all the cowpea-yellow maize samples more than 1.38% from the control. Maize is a useful source of minerals (Gopalan *et al*., 2007; Shah *et al*., 2015). Similar increasing trend (1.70-1.96%) was reported by Akusu and Kiin-Kabari (2012) for "moi-moi" produced from cowpea and maize flour blend which is higher than those reported in this study probably due to variety and drying of cowpea and maize.

#### *3.1.6. Carbohydrate*

This is one of the energy substrate which content in the cowpea-yellow maize "moi-moi" samples increased (18.86%-36.85%) with increase in yellow maize inclusion levels higher than the control sample (15.70%). The increase could be due to high carbohydrate content of yellow maize (Brownson, 2016). This may likely increase the energy levels of the samples thereby making it a good weaning food. These results are in agreement with but higher than 21.39%-34.72% reported by Akusu and Kiin-Kabari (2012) from "moi-moi" made with cowpea-soybean blend, 30.79% -36.63% with cowpea-soybean reported by Ogundele *et al*. (2015) and 32.05%-35.53% reported by Nwosu (2011) from cowpea "moi-moi" complemented with asparagus bean. The variation could be due to bean variety, ingredients and the preparation technique used.

### 3.2. Effects of cowpea partial substitution with yellow maize on the vitamin composition of "moi-moi"

#### *3.2.1. Vitamin A*

Table 4 depicts the vitamin results that revealed significant ($p<0.05$) vitamin A increase (1.39-1.82 µg/100mg) of cowpea-yellow maize "moi-moi" samples more than the control (1.23 µg/100mg) with yellow maize substitution. The increase is vitamin A could be due to high content of beta carotene in yellow maize (Omafuvbe *et al*., 2003) which is a good source of pro-vitamin A (Tawanda *et al*., 2011). Vitamin A is a fat-soluble vitamin and a powerful antioxidant that plays a critical role in maintaining healthy vision, neurological function, healthy skin and support immune function. It is involved in reducing inflammation by fighting free radical damage. Vitamin A values obtained in this study were higher than 1.23 µg/100g obtained from the control sample, but below 2.67 µg/100g obtained from 100% cowpea "moi-moi" reported by Ejima and Ejima (2015). The ingredients used as well as varietal and processing technique employed could be sources of variation. This study showed that cowpea-yellow maize "moi-moi" samples could be beneficial for sight improvement especially for vulnerable low-income earners.

**Table 4.** Effects of the partial substitution on the vitamin composition of "moi-moi" produced with cowpea-yellow maize blend

| Sample | Vitamin A (µg/100g) | Vitamin C (mg/100g) |
|---|---|---|
| CP100 | $1.23^{d}\pm0.04$ | $0.07^{a}\pm0.04$ |
| CPYM1 | $1.39^{c}\pm0.01$ | $0.04^{b}\pm0.01$ |
| CPYM2 | $1.48^{b}\pm0.01$ | $0.05^{ab}\pm0.01$ |
| CPYM3 | $1.82^{a}\pm0.03$ | $0.06^{ab}\pm0.01$ |

Values are means of triplicate determinations ± standard deviation. Values in the same column with different superscript are significantly different ($p<0.05$). CP100-100% cowpea, CPYM1-95:5% cowpea-yellow maize, CPYM2- 90:10% cowpea-yellow maize and CPYM3 -80; 20% cowpea-yellow maize.

#### *3.2.2. Vitamin C*

Just like vitamin A, vitamin C increased (0.04-0.06 mg/100g) with increase in yellow maize substitution but lower than the control (0.07 mg/100g) with sample CYPM3 (80:20% cowpea-yellow maize) having the highest value (0.06 µg/100g). The increment is not significant ($p>0.05$) at levels of 10-20%. Vitamin C is associated with numerous health benefits like bone and joint development, maintenance of healthy immune system, purifies the blood and is an antioxidant (Cohen *et al.,* 2000). Vitamin C levels in this study were considerably low which could be attributed to the effect of heat during steaming as vitamin C is heat and light labile and possibly steeping since it is water soluble.

### 3.3. Mineral composition of "moi-moi" as affected by partial substitution of cowpea with yellow maize

#### *3.3.1. Calcium*

Mineral results as shown in Table 5 revealed that calcium content of cowpea-yellow maize "moi-moi" samples increased (17.20-19.06 mg/100g) significantly ($p<0.05$) with increase in yellow maize substitution. These increases were significantly ($p<0.05$) higher than the control (15.33 mg/100g) and could be attributed to higher calcium content of yellow maize than cowpea (Shah *et al.,* 2015). Therefore, yellow maize substitution is calcium enrichment compare to 100% cowpea 'moi-moi'. The values obtained in this study were within 12.10-19.10 mg/100g reported by Ejima and Ejima (2015) for improved maize and cowpea "moi moi" samples. Calcium is important in the body as it helps to build and maintain teeth and plays a key role in our cells. The samples are therefore good for infant, elderly and recovering patients as calcium-rich diet will helps to maintain bone strength and prevent rickets infants, prevent osteoporosis in adults and is needed for patient recovery.

**Table 5.** Partial substitution effects on the mineral composition of the "moi-moi" samples (mg/100g).

| Samples | Calcium | Magnesium | Phosphorous | Ca: P |
|---|---|---|---|---|
| CP100 | $15.33^{d}\pm0.04$ | $9.33^{b}\pm0.04$ | $6.92^{c}\pm1.35$ | $2.22^{a}\pm0.31$ |
| CPYM1 | $17.20^{c}\pm0.14$ | $12.44^{ab}\pm0.03$ | $7.48^{bc}\pm0.04$ | $2.30^{a}\pm0.30$ |
| CPYM2 | $17.88^{b}\pm0.01$ | $12.56^{ab}\pm0.02$ | $7.73^{b}\pm0.04$ | $2.31^{a}\pm0.02$ |
| CPYM3 | $19.06^{a}\pm0.03$ | $13.43^{ab}\pm0.01$ | $9.42^{a}\pm0.02$ | $2.02^{a}\pm0.04$ |

Values are means of triplicate determinations ± standard deviation. Values in the same column with different superscript are significantly different ($p<0.05$). CP-100% cowpea, CPYM1-95:5% cowpea-yellow maize, CPYM2-90:10% cowpea-yellow maize and CPYM3-80:20% cowpea yellow maize.

#### *3.3.2. Magnesium*

The magnesium content of yellow maize substituted "moi-moi" samples also increased (12.44-13.43 mg/100g) though without significant ($p<0.05$) variations with increasing yellow maize substitution more than 9.33 mg/100g from control. This may possibly mean that substitution levels had no significant ($p<0.05$) magnesium improvement. Magnesium values in this study were higher than 8.00 - 9.20 mg/100g reported by Ejima and Ejima (2015) from "moi-moi" produced with improved maize, and beans. These increases confirmed higher magnesium content of maize (Gopalan *et al*., 2007) which also reflected same on the moi-moi samples alongside the associated health benefits. Magnesium is a cofactor in more than 300 enzyme systems that regulate diverse biochemical reactions in the body, including protein synthesis, muscle and nerve function, blood glucose control, and blood pressure regulation (Soetan *et al*., 2010). It is required for energy production, oxidative, phosphorylation, glycolysis, contributes to the structural development of bones, synthesis of DNA, RNA and the antioxidant glutathione. Higher magnesium content of the substituted samples than the control predisposes it to a better diet to infants, elderly and recovery patients. It works in synergy with adequate ratios of calcium and phosphorous for bone health and development (Okwunodulu *et al*., 2022).

***3.3.3. Phosphorous***

Phosphorous values like other minerals increased (7.48 - 9.42) mg/100g) with significant ($p<0.05$) variation as the yellow maize substitution increased more than the control (6.92 mg/100g). Higher phosphorous content of yellow maize than cowpea may be responsible. Yellow maize substitution improved the phosphorous content of "moi-moi" which is a valuable nutrient for bone formation. Phosphorus synergizes with calcium to form calcium-phosphate that builds strong bones and teeth. Therefore the substituted samples will provide adequate phosphorous more than the control that will synergise with calcium to give a better calcium: phosphorous ratio.

***3.3.4. Ca: P ratios***

Calcium to phosphorous content in the body which is maintained by sufficient diet intake is important for infants' bone growth and development. Any imbalance results in rickets and high risk of bone fracture in children as well as osteomalacia and osteoporosis in adults. This is because the ratio determines calcium absorption, its retention and regulation in the body. Also, high phosphorous intake aids hypocalcaemia and bone fracture in infants. Maintaining appropriate ratio in the body through dieting is therefore mandatory for optimal body function and nutritional adequacy. Though there were no significant ($p>0.05$) variations among the entire Ca: P ratios in this study, but slight increase were recorded as yellow maize inclusion increased. The ratios increased (2.30-2.31) from 5-10% and decreased to 2.02 at 20% yellow maize inclusion levels. This simple suggest that yellow maize substitution beyond 10% in "moi-moi" preparation will start affecting bone health and development. Though the decrease was lower than the control, but they were within the recommended values (1.5: 1, 1:1, 1:2 and 2:1) by the nutritionists for bone health and development (Okwunodulu *et al*., 2022). Therefore, the samples will be good for infants, elderly and recovery patients to prevent rickets and osteoporosis.

***3.3.5.Correlation of vitamin C with calcium, magnesium and phosphorous***

Table 6 depicts the Pearson correlation of vitamin C with calcium, magnesium and phosphorous content of the ''moi-moi'' samples. All the results showed negative correlation irrespective of the blending ratios of cowpea and yellow maize. Calcium had slight stronger significant ($p>0.05$) correlation with vitamin C followed by magnesium and phosphorous. This could be associated to the decreasing vitamin C content of the 'moi-moi' samples due to increase in yellow maize inclusion thereby resulting to the decrease in vitamin C enhancement of mineral absorption. The maximum absorption order of the minerals is shown as phosphorous > magnesium > calcium. These concretised with the assertion that vitamin C enhances mineral absorption. Each mineral including vitamin C correlated maximally at 1.0 with each counterpart thereby showing that minerals are function of the overall mineral content of the samples. These notwithstanding, calcium correlated with magnesium at $p<0.01$ (99% confident level) and phosphorous at $p<0.05$ (95% confident level). These aligned with the literature report that magnesium enhances calcium-phosphorous synergy for strong bones and teeth formation (Okwunodulu *et al*., 2022). Therefore, yellow maize substitution should not be above 20% for maximum mineral absorption and their health benefits. The samples may likely contribute in preventing osteoporosis in adults and rickets in infants.

**3.4. Influence of cowpea substitution on the physicochemical properties of 'moi-moi'**

***3.4.1. pH***

Physicochemical results as presented in Table 7 showed that the pH of the yellow maize substituted "moi-moi" samples decreased (6.07-6.00) with increasing yellow maize inclusion. The decrease is significantly ($p<0.05$) lower than the control (6.12) and signified acidity content of yellow maize following steeping. With the pH decrease, the samples were moderately acidic and within the acceptable threshold with an advantage of lesser susceptibility to microbial proliferation that may cause gastrointestinal problems.

**Table 6.** Physicochemical properties of cowpea substituted "moi-moi" samples

| Samples | pH | Appearance |
|---|---|---|
| CP100 | $6.12^{a}$±0.00 | $0.18^{a}$±0.00 |
| CPYM1 | $6.07^{ab}$±0.01 | $0.12^{c}$±0.01 |
| CPYM2 | $6.03^{bc}$±0.01 | $0.13^{c}$±0.01 |
| CPYM3 | $6.00^{bc}$±0.03 | $0.15^{b}$±0.00 |

Values are means of triplicate determinations ± standard deviation. Values in the same column with different superscript are significantly different ($p<0.05$). CP100-100% cowpea, CPYM1-95:5%cowpea-yellow maize, CPYM2-90:10% cowpea-yellow maize and CPYM3-80:20% cowpea-yellow maize.

**Table 7.** Sensory scores of "moi-moi" produced with cowpea-yellow maize blends

| Samples | Taste | Texture | Appearance | Flavour | G A |
|---|---|---|---|---|---|
| CP100 | $7.75^{a}$±0.79 | $7.05^{a}$±0.51 | $6.85^{a}$±1.35 | $7.10^{a}$±1.52 | $7.80^{a}$±1.15 |
| CPYM1 | $7.10^{ab}$±0.79 | $6.25^{cd}$±1.12 | $5.80^{a}$±1.64 | $5.70^{b}$±1.87 | $6.85^{b}$±1.39 |
| CP90YM2 | $6.45^{b}$±1.88 | $6.30^{c}$±1.17 | $6.60^{a}$±1.14 | $5.65^{bc}$±1.39 | $6.65^{bc}$±1.39 |
| CPYM3 | $5.05^{c}$±2.11 | $6.60^{b}$±1.14 | $6.70^{a}$±1.49 | $5.25^{c}$±1.71 | $6.10^{c}$±1.74 |

Values are means of triplicate determinations ± standard deviation. Values in the same column with different superscript are significantly different ($p<0.05$). CP100-100% cowpea, CPYM1-95:5% cowpea-yellow maize, CPYM2-90:10% cowpea-yellow maize and CPYM3- 80:20% cowpea-yellow maize. GA- general acceptability.

#### *3.4.2. Appearance*

The appearance of the substituted samples increased (0.12-0.15) with yellow maize inclusion but lower than control (0.18). The improvement was only significantly ($p<0.05$) at 20% inclusion level. This could be due to steeping and yellow pigments in the yellow maize. Besides, caramelizaton during steaming of simple sugars released during yellow maize steeping may have contributed too (Nwosu, 2011). Steeping may have activated the dormant enzymes in yellow maize which in turn hydrolysed the starch to release the simple sugars. The sugars also may have reacted with the amine groups of the proteins and resulted in Maillard browning. Appearance attracts the consumers to initiate acceptability. Therefore, yellow maize substitution influenced the appearance of the substituted samples compared to the control by improving the aesthetic appeal and may likely improve the acceptability (Figures 5, 6 and 7).

### 3.5. Effect of substitution of cowpea on sensory characteristics

#### *3.5.1. Taste*

The sensory scores presented in Table 7 showed that taste scores of yellow maize substituted "moi-moi" samples decreased (7.10-5.05) significantly ($p<0.05$) with an increase in yellow maize substitution lower than the control (7.75). Decreasing taste scores may suggest acceptability reduction or rejection if yellow maize substitution increased beyond 20% used in this study depending on choice. These decreases may have contributed to the preference of the control to the substituted samples by the panellists alongside familiarity with the control sample.

#### *3.5.2. Texture*

The scores increased (6.25-6.60) with significant ($p<0.05$) variation as yellow maize substitution increased may be due to higher carbohydrate content of yellow maize (Table 3). Though the increased texture scores were significantly ($p<0.05$) lower than the control sample (7.05), but substitution levels beyond 20% may be higher provided acceptability is not compromised. Therefore, yellow maize inclusion improved cowpea-maize "moi-moi" texture which is one of the acceptability criteria.

***3.5.3. Appearance***

The same appearance improvement (5.80-6.70) trend was also obtained here as yellow maize inclusion increased, except there was no significant ($p>0.05$) variation in their improvement. May be the substitution levels had no significant ($p<0.05$) variation in appearance to the consumers. Though these increases were lower than the control (6.85), substitution beyond 20% may be more appealing to the consumers depending on choice. Therefore yellow maize inclusion improved the aesthetic appeal of the cowpea "moi-moi" depending on choice

***3.5.4. Flavour***

The scores decreased (5.70-5.25) significantly ($p<0.05$) with increasing yellow maize content which is in consonant with taste score as flavour is a combination of taste and smell. The decrease was lower than the control (7.10) and could be attributed to the inherent flavour lowering components of cereals compared to legumes (Ouoba *et al*., 2005). The substitution may have diluted the desirable beany flavour of the control sample which the panellist were used to. However, these decreases point to acceptability decrease and may lead to complete rejection at above 20% inclusion levels.

***3.5.5. General acceptability (GA)***

The GA decreased (6.85-6.10) significantly ($p<0.05$) with increase in yellow maize inclusion with control sample being the most preferred (7.80) followed by sample CPYM2 (95: 5% cowpea-yellow maize). This may follow that substitution level of lower than 5% may improve better or equal to the control. The 20% substitution level was the least preferred (6.10) may be due to higher substitution level. Similar decreasing acceptability trend (8.6-5.6) was reported by Akusu and Kiin-Kabari (2012) from "moi-moi" made from cowpea-maize flour blend. The acceptability scores of their control and substituted samples were higher than those obtained in this study probably due to maize and bean varieties, type and quantity of ingredients used, preparation method adopted and cowpea-maize proportion used.

## 4.Conclusion

The results of this study justified legume-cereal nutrient complementation and supplementation. With increase in yellow maize substitution levels of up to 20%, there were improvement in ash, crude fibre, and carbohydrate. Vitamins A and C, calcium, manganese, phosphorous and appearance also increased. Crude protein, moisture, fat and pH contents decreased. Some nutrients increased below the control. Higher nutrient may be obtained at higher inclusion levels, but that may compromise acceptability as maximum acceptability for the blends was obtained at 5% substitution level. The "moi-moi" produced from 100% cowpea was best preferred followed by that with 5% yellow maize substituted sample while most nutrients peaked at 5-10 yellow maize inclusion but may be increased up to 20% for maximum mineral absorption. Therefore, yellow maize substitution of cowpea for 'moi-moi' preparation becomes a matter of choice between increasing the substitution level to increase the nutrient and acceptability levels.

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