Physicochemical, Atwater Factor and Acceptability Changes of *Moi-Moi* from Cowpea (*Vigna unguiculata* (L) Walp) as a Function of White Maize Substitution

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Abstract. Cereal grains complement legumes when consumed together in a beneficial ratio to gives good quality protein. Maize protein is deficient in lysine but rich in sulphur containing amino acids lacking in cowpea thereby complementing that to enhance the nutritive value of the *moi-moi*. Cowpea white maize *moi-moi* samples were produced from cowpea and white maize blending ratio (%) of 95: 5, 90: 10 and 80: 20 while *moi-moi* produced from 100% cowpea (CP100:WM0) served as control sample. Proximate, mineral, vitamin and physicochemical composition were evaluated with standard analytical methods. Energy values were by calculation using Atwater general factor system (AGFS) and sensory scores were by subjective means with 25 semi-trained panelists. With increasing white maize substitution of cowpea, crude fibre (1.40 to 1.47%), ash (1.41 to 1.70%), carbohydrate (17.31 to 31.51%), energy (241.50 to 279.08 Kcal), vitamin A (1.33 to 1.63 µg/100g), calcium (17.07 to 18.94 mg/100g), magnesium (12.38 to 13.17 mg/100g), phosphorous (7.20 to 7.53 mg/100g) and colour (0.13 to 0.29) were increased. But moisture (48.53 to 37.82%), protein (20.52 to 18.82%), fat (10.02 to 8.64%), vitamin C (0.04 to 0.03 mg/100g), pH (6.05 to 5.83), and general acceptability (7.10 to 5.70) were decreased. The control sample, 100% cowpea *moi-moi* had the best organoleptic properties. Increasing substitution of cowpea with white maize resulted in acceptable *moi-moi* samples at lower levels with significant ($p < 0.05$) nutritional changes.

Introduction

Moi-moi is a steamed seasoned (vegetable oil, Cray-fish, salt among others) soft gel prepared from wet-dehulled and wet-milled cowpea (*Vigna unguiculata* Walp) paste packaged in leaves or aluminum foil. Upon cooling, it solidifies to assume the shapes (pyramid or cylindrical) of packaging materials used. It is an economic protein-rich snack consumed with pap (*ogi*) and rice as breakfast meals in most Nigeria homes [1, 2].

Cowpea is the major legume [5] for preparing *moi-moi*, *akara*, *danwake* among others which traditional preparation method is laborious and time consuming, hence the use of cowpea flours [6, 7] to avoid soaking, dehulling, and wet milling. Besides, cowpea can be cooked with cereal grain like rice or with tubers like yam, cocoyam, and potatoes and consumed as major protein sources [3, 4]. Cowpea anti-nutrients [9, 10] are removed or reduced by dehulling, soaking, cooking, germination, fermentation among others. Though some of these processes may individually or collectively reduce some nutrients [8, 11], but steeping and germination increase same and their bioavailability, and decrease anti-nutrients [6]. However, dehulling of cowpea seeds removes the much needed dietary fibre which health benefits include among others healthy digestive system, reduced risk of chronic diseases such as diabetes, obesity, lowering bad cholesterol and postprandial glucose up surge [11].

Maize is considered as a staple food [12] that is ranked second most important cereal crop behind sorghum in Nigeria based on the number of people it feeds [13]. Due to its higher yielding potential compared to other cereals, it is globally termed as queen of cereals [14]. Maize contains various nutrients and health benefits; hence its wide use for human foods. Maize is deficient in

proteins and essential amino acids such as lysine and tryptophane and therefore not a good protein source, but rich in calories.

Cereal grains and legumes mutually complement each other when consumed together in a beneficial ratio (7 legume: 18 cereal) to provide a better amino-acid profile [15]. Lysine deficient maize protein, rich in sulphur containing amino acids, supplements sulphur deficient cowpea, rich in lysine. Cooking of legume-cereal based foods (breadfruit and maize meal) and consumption of *ogi* with *akara* or *moi-moi*, bread with *akara* or boiled cowpea among others in Nigeria is an age long menu which origin is uncertain. The aim of this study was to improve the nutrient and acceptability status of *moi-moi* for both young and adults by supplementing it with maize.

Materials and Methods

Cowpea, white maize, aluminum foil and the ingredients used were procured from Urbani main market in Umuahia North Local Government Area of Abia State, Nigeria.

Preparation of cowpea-white maize *moi-moi*

Cowpea-white maize *moi-moi* samples was prepared (Figure 1) by separately sorting, cleaning and respectively steeping in tap water for 20 min and 2 h. Each was drained thereafter and cowpea was hand dehulled and the hulls were removed by water floatation while white maize was washed with clean water to obtain steeped cowpea cotyledons and white maize respectively which was blended (Table 1). Each blend which represents a sample was mixed separately in a bowl with warm water and recipes (Table 2). The mixture was then milled, properly mixed, wrapped in aluminum foil, cooked for 30 min and cooled to obtain *moi-moi* samples.

Table 1: Cowpea and white maize blend ratios for *moi-moi* production.

Sample codes	Cowpea (%)	White maize (%)
CP100:WM0 (control)	100	0
CP95: WM5	95	5
CP90: WM10	90	10
CP80:WM20	80	20

Table 2: Recipe for *moi-moi* production

Ingredients	Quantity
Cowpea	365 g
White Maize	35 g
Warm water	1104 ml
Vegetable oil	200 ml
Ground red pepper	50 g
Onion	40 g
Salt	11 g
Crayfish	10 g
Mixed spice	1 g
Maggi cube	1 g

Figure 1: Flow chart for preparation of cowpea-white maize *moi-moi* sample

Analyses

All the *moi-moi* samples were subjected to proximate, nutrient, physicochemical and acceptability analyses separately in triplicates as stated below. The mean of the triplicate values were used for statistical analyses.

Moisture content determination

Moisture content was determined according to AOAC [16]. Ten grams (10 g) of the sample were measured into previously weighed moisture cans (W_1). The sample in the can (W_2) was dried in the oven at 105°C for 3 h, cooled in desiccators and reweighed. This process was repeated several times but at 30 min interval until a constant weight was obtained, thereafter was cooled in desiccators, reweighed. The final dry weight was recorded (w_3) and used to calculate the percentage moisture content of the sample as shown below:

$$\% \text{ Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

Where W_1 = initial weight of empty can

W_2 = weight of can + sample before drying

W_3 = weight of can + sample after drying

Crude protein determination

The method described by AOAC [16] was used. Total nitrogen (N_2) was determined and multiplied with factor 6.25 to obtain the protein content. One gram (1.0 g) of the sample was mixed with 10ml of concentrated H_2SO_4 in a digestion flask. A tablet of selenium catalyst was added and heated in a fume cupboard until a clear solution (the digest) was obtained which was diluted to 100 ml in a volumetric flask. 10 ml of the digest was mixed with equal volume of 45% NaOH solution in a kjeldahl distillation apparatus. The mixture was diluted into 10 ml of 4% boric acid containing 3 drops of mixed indicator (bromocresol green/methyl red). A total of 50 ml of distillates was collected and titrated against 0.02N EDTA from green to deep red end point. The N_2 obtained was used to calculate protein as below: $\% \text{ Protein} = \% N_2 \times 6.25$

$$\% N_2 = \frac{(100 \times N \times 14 \times V_t)}{W \times 1000 \times V_a} \text{ TBK}$$

Where: W = weight of sample

N = normality of titan (0.02 H_2SO_4)

V_t = total digest volume (100ml)

V_a = volume of digest analyzed (10ml)

T = titre value of sample

B = titre value of blank

Determination of ash

The method described by AOAC [16] was used. Three grams (3 g) of the sample were added to a weighed dried porcelain crucible and ignited in the muffle furnace at 550°C . The sample was allowed for 3 h to ash to a grayish white ash, brought out from the furnace using a forceps and left in a desiccators to cool. The ash was weighed and percent ash was calculated as shown below:

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

Where: W_1 = weight of empty crucible

W_2 = weight of crucible + food before drying or ashing

W_3 = weight of crucible + ash

Fat content determination

The fat content was determined by continuous solvent extraction in a soxhlet reflux apparatus described by James [17]. Exactly 2g of the sample was wrapped in a porous paper and carefully placed inside a soxhlet reflux flask. The reflux was mounted on a weighed extraction flask containing 200ml of petroleum ether on the electro thermal heating mantle. The set was connected to a condenser that cools the evaporated petroleum ether while boiling which in turn fill up the reflux flask. The solvent will extract the oil during the reflux into the boiling flask. This process of boiling, vaporization, condensation and subsequent oil extraction was allowed to continue for 4 hours thereafter the solvent was recovered and the extracted oil was obtained by drying the flask in the oven at 60°C for 30 minutes. After cooling in the desiccators, the flask was reweighed. The fat content was calculated thus:

$$\% \text{ Fat content} = \frac{W_2 - W_1}{W_3} \times \frac{100}{1}$$

Where

W_1 = Weight of the empty flask

W_2 = Weight of flask oil T extract

W_3 = Weight of sample used.

Crude fibre determination

This was determined according to AOAC [16] protocol. Two grams (2 g) of each sample were digested by boiling with 200 ml of 1.25% H_2SO_4 solution under reflux for 30 min. The digest was allowed to cool and then filtered with Buckner funnel equipped with muslin cloth. The residue was washed thrice with hot water, scooped into a conical flask and digested with 200 ml of 1.25% NaOH solution under reflux for 30 min boiling. The digest was cooled, filtered and washed thrice with distilled water. The residue was drained and scooped into a previously dried and weighed crucible and then put into the oven to dry at $105^\circ C$ to a constant weight. The dish with its content was reweighed after drying and then placed in the muffle furnace to ash at temperature of $550^\circ C$ for 3 h. The weight of ash obtained was used to calculate the percent fibre thus:

$$\% \text{ Crude fibre} = \frac{W_2 - W_3}{\text{Weight of sample}} \times \frac{100}{1}$$

Where:

W_2 = weight of crucible + sample after boiling, washing and drying

W_3 = weight of crucible + sample as ash

Determination of caloric value

Caloric value was estimated using Atwater general factor system as described by AOAC [16] by multiplying the proportion of protein, fat and carbohydrate by their respective physiological fuel value of 4, 9, and 4kcal/g respectively and taking the sum of their products thus:

$$F_e = (\% \text{ CP} \times 4) + (\% \text{ CF} \times 9) + (\% \text{ CHO} \times 4)$$

Where: F_e = Food energy (in grain calories)

CP = Crude protein

CF = Crude fat

CHO = Carbohydrate

Determination of vitamin A

The spectrophotometric method by Onwuka [18] was employed in determination of vitamin A. 5 g of sample was dissolved in 30 ml of absolute alcohol (ethanol) and 3 ml of 5% potassium hydroxide was added to it. The mixture was boiled under reflux for 30 minutes, cooled rapidly with running water and filtered. 30 ml of distilled water was added, transferred into a separating funnel and 3 portions of 50 ml of ether were used to wash the mixture. The lower layer was discarded and the upper layer was washed with 50 ml of distilled water. The extract was evaporated to dryness, dissolved in 10 ml of isopropyl alcohol and its absorbance was measured at 325nm. The vitamin A content of the samples was calculated as shown below.

$$\text{Vitamin A (mg/100g)} = \frac{100 \text{ au}}{W_{as}} \times C$$

Where: au = absorbance of test sample
 as = absorbance of standard solution
 c = concentration of the test sample
 w = weight of sample.

Vitamin C determination

The method of Okwu and Josiah [19] was used. Ten grams (10 g) of sample was extracted with 50 ml EDTA/TCA extracting solution for 1 hour and filtered through a Whatman filter paper into a 50ml volumetric flask and made up to the mark with the extracting solution. 20ml of the extract was pipette into a 250 ml conical flask into which 10 ml of 30% KI and 50 ml of distilled water were added. This was followed by 2 ml of 1% starch indicator and titrated against 0.01 ml CuSO_4 solution to a dark end point. The vitamin C content of the samples was calculated as shown below:

$$\text{Vitamin C (mg/100g)} = 0.88 \times \frac{100}{10} \times \frac{V_f}{20} \times \frac{T}{1}$$

Where: V_f = Volume of extract
 T = Sample titre – blank titre

Determination of calcium and magnesium

Calcium and magnesium content of the *moi moi* were determined by the complexiometric titration method of Onwuka [18]. About 20 ml portion of the extract was dispersed into conical flask and treated with pinches of the masking agents (hydroxylamine hydrochloride, sodium cyanide and sodium potassium ferrocyanide). The flask was shaken to dissolve the mixture; 20 ml of ammonia buffer added to it to raise the pH to 10.00 and titrated against 0.02N EDTA solution using Erichrome Black T as indicator to permanent blue end point. A reagent blank was also titrated same. The titre values represent both Ca^{2+} and Mg^{2+} in the test sample. The analysis was repeated to determine Ca^{2+} alone in the test samples. Titration of calcium alone was done as above, but with 10% NaOH in place of ammonia buffer and solechrome dark blue indicator in place of Erichrome black T. Total calcium and magnesium content were calculated separately using the formula below:

$$\text{Ca/ mg (mg/mg)} = \frac{100 \times T - B (N \times \text{Ca/mg}) \times V_f}{W V_a} \times \frac{1}{1}$$

Where W=Weight of sample
 T = titre value of sample
 B= Titre value of blank
 Ca = Calcium equivalence
 Mg =Magnesium equivalence
 V_a = Volume of extract titrated
 V_f = Total volume of extract
 N=Normality of titrant (0.02N EDTA).

Phosphorus determination

Molybdate method using hydroquinone as a reducing agent described by Onwuka [18] was used. Five grams (5 g) of the sample in a 50ml graduated flask was mixed with 10ml of molybdate mixture and diluted to mark with water. The mixture was then allowed to stand for 30 minutes for colour development thereafter absorbance at 600nm against a blank was taken. A curve relating absorbance to phosphorus present and standard curve using phosphorus standard solution were constructed following the same procedure to determine the concentration of phosphorus in the sample thus:

$$\% \text{ Phosphorus} = \frac{\text{graph reading} \times \text{solution volume}}{100}$$

pH determination

The pH was determined by the method described by Akpakpunam and Sefa-Dedeh [20]. Ten gram (10 g) of the sample was dissolved in 100ml of distilled water. The mixture was allowed to equilibrate for 3 min at room temperature. The pH was then determined by inserting the electrode of the pH meter into the sample and the reading taking from the result displayed on the pH meter.

Colour intensity determination

Colour intensity was determined using UV-VIS spectrophotometer as described by Sharma [21]. Five grams (5 g) of the sample was diluted with 50ml of distilled water, brought to 25-30°C, placed in a corvette and absorbance readings were taken at 600nm. The colour intensity was calculated as follows:

$$\text{Colour intensity} = \frac{A \times F}{\text{Weight of sample (g)}}$$

Where F: Dilution factor to adjust absorbance

A: Absorbance

Sensory evaluation

Organoleptic properties of the *moi moi* were evaluated using 25 semi-trained panelists randomly selected from the staff and students of Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike aged between 18 to 35y. The *moi moi* samples were presented in identical plates with appropriate codes. Portable water was also served to the panelists to rinsing their mouth after each tasting so as not to interfere with the taste of the proceeding samples. Sensory attributes evaluated were appearance, taste, flavour, texture and general acceptability. The panelists were instructed to score according to 9-point Hedonic scale where 9 is like extremely, 5 is neither like nor dislike and 1 is dislike extremely [22].

Statistical analysis

The design was completely randomized design (CRD) and data obtained were subjected to One way analysis of variance of a using the Statistical Package of Social Science version 22. Means were separated using Duncan multiple range test at 95% confidence level ($p < 0.05$).

Results and Discussion

Results of proximate composition of the samples were presented in Table 3. With increasing white maize substitution levels for cowpea, the MC of the *moi-moi* blends decreased with significant ($p < 0.05$) variation. The decrease could possibly be due to the ability of maize starch to bind and hold water in their mesh network thereby reducing the available free water. The MC decrease (49.53-37.86%) was lower than the control sample (50.20%). Substitution beyond 20% may likely affect the acceptability as desired texture and flavour will be compromised. Decreasing MC implied increasing dry matter content [23, 24] and crude fibre with their associated health benefits. Therefore, increasing substitution will increase such health benefit of *moi-moi* provided the acceptability is not affected and may likely decrease salivation, mastication and swallowing [25]. Results obtained in this study (37.86 to 50.20%) were higher than 40.14% to 49.89% reported for plant ash fortified *moi-moi* prepared from cowpea [26] probably due to fortification. Lower MC (50.20%) of the control sample than 55.40% reported for cowpea [27] could be traced to variety and bean: water ratio used.

Protein is endowed with a lot of health benefits like maintaining healthy muscle mass, supporting tendon, ligaments and other body-tissue. Protein also helps to prevent kwashiorkor and spikes in blood glucose, which is especially important for preventing type 2 diabetes, balancing energy levels and keeping your appetite and mood in check. Increasing cowpea complementation (5-20%) with white maize decreased the protein content of the *moi-moi* with significant ($p<0.05$) variation which likely will affect the associated health benefits. The decrease could be due to dilution effect of the cowpea protein by maize. Cowpea has higher protein content than cereal grains, as evident in 20.70% from the control sample [15]. Maize is known as carbohydrate-rich crop without substantial amount of crude protein [14]. However, the protein content of the samples is noteworthy since it is higher than 10.42 to 18.69% reported for plant ash fortified *moi-moi* produced from cowpea. The lower values could be attributed to protein-calcium interaction [26]. Protein contributes to food flavour.

Results obtained in this study showed significant ($p<0.05$) increase (1.40 to 1.47%) in crude fibre content of *moi-moi* more than the control (1.37%) with increasing level of white maize substitution. Therefore, increasing substitution above 20% may likely increase the associated health benefits provided the acceptability is not affected. Crude fibre reduces the risk of chronic diseases such as diabetes, obesity, cardiovascular disease, and diverticulitis, and lowers cholesterol concentration in the blood and obesity [29]. Fibre is good roughage for intestinal health and weight management [30]. The results obtained in this study was within 1.35% to 2.00% reported for *moi-moi* produced from blends of cowpea and bambara nut [1] which could be attributed to variation in raw materials used as well as processing techniques used. But the results are higher than 1.27% to 1.37% reported from plant ash fortified *moi-moi* produced from cowpea [26].

Significant ($p<0.05$) decreasing fat content of the cowpea-white maize *moi-moi* samples with increasing white maize substitution levels portends lowering of energy, fat soluble vitamins, mouth feel, flavour and palatability. The decrease, (10.02% (CP95:WM5 to 8.64% (CP80:WM20)) was below 10.67% from the control sample. But increasing substitution beyond 20% could likely increase stickiness to the wrapping materials and decrease acceptability as fat acts as releasing agent and flavour enhancer. Energy level will also be decreased.

Table 3: Effect of white maize substitution of cowpea on proximate composition of *moi-moi* produced from the blends (%)

Samples	Moisture content	Crude protein	Crude fibre	Fat content	Ash content	Carbohydrate content	Energy value (Kcal)
CP100:WM0	50.20 ^a ±0.28	20.70 ^a ±0.01	1.37 ^d ±0.02	10.67 ^a ±0.02	1.38 ^c ±0.02	15.70 ^d ±0.32	241.57 ^c ±1.03
CP95:WM5	49.33 ^b ±0.03	20.52 ^a ±0.01	1.40 ^{cd} ±0.00	10.02 ^b ±0.03	1.41 ^{bc} ±0.00	17.31 ^c ±0.01	241.50 ^c ±0.37
CP90:WM10	40.09 ^c ±0.01	19.90 ^b ±0.01	1.43 ^{bc} ±0.01	9.63 ^c ±0.03	1.44 ^b ±0.01	27.52 ^b ±0.02	276.31 ^b ±0.20
CP80:WM20	37.86 ^d ±0.03	18.82 ^c ±0.01	1.47 ^a ±0.01	8.64 ^d ±0.01	1.70 ^a ±0.00	31.51 ^a ±0.04	279.08 ^a ±0.01

a-d: Values are means ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different ($p<0.05$). CP- cowpea and WM- white maize.

Ash content results obtained in this study (1.41 to 1.70%) were lower than 2.50 to 3.50% reported for *moi-moi* produced from maize, improved maize and beans [27]. Bean and maize varieties used could be responsible for the ash variations. Increasing white maize substitution levels (5 to 20%) resulted to a corresponding ash increase (1.41(CP95:WM5) to 1.70% CP80:WM20) with significant variation. The increase which could be attributed to higher mineral content of white maize than cowpea [31, 32] was mineral enrichment as it is also higher than the control sample (1.38%). Ash is an index of total minerals content in foods and a viable tool for nutritional evaluation of mineral [33]. Therefore, white maize substitution is mineral improvement which levels of addition will depend on acceptability of the *moi-moi*.

Carbohydrate content of cowpea-white maize *moi-moi* samples increased from 17.31 to 31.51% with increasing level of white maize addition possibly due to higher carbohydrate content of white maize than cowpea [32]. These increases were higher than the control sample (15.70%) and will be an improvement in energy and texture. Increasing beyond 20% may likely increase the carbohydrate content more; but that becomes a matter of choice. These results are lower than 18.28 to 36.0% reported for plant ash fortified *moi-moi* produced from cowpea [26], and higher than 16.35 to 34.65% reported for bambara-cowpea *moi-moi* [1].

Energy values of the cowpea-white maize *moi-moi* samples were significantly ($p < 0.05$) improved (241.50 to 279.08 Kcal) more than the control sample (241.37 Kcal) with increasing white maize substitution. The increment may be due to higher carbohydrate and content of white maize than cowpea which are good energy substrates. Dietary energy is needed for basal metabolic rate, physical activities and aeration of new tissue during growth and pregnancy [34].

Vitamin composition of the *moi-moi* samples are presented in Table 4. Vitamin A content increase with increasing levels of white maize substitution of cowpea signified improvement in the *moi-moi* samples. The significant ($p < 0.05$) improvement is justified by higher vitamin A increase (1.55 to 1.63 $\mu\text{g}/100\text{g}$) than the control sample (1.23 $\mu\text{g}/100\text{g}$) which may have stemmed from higher value in white maize than cowpea. Vitamin A is a fat-soluble antioxidant that plays a critical role in maintaining healthy vision, neurological function, healthy skin and support immune function. It is involved in reducing inflammation through fighting free radical damage. The values obtained in this study exceeded 1.15 and 1.25 $\mu\text{g}/100\text{g}$ obtained respectively from maize and bean *moi-moi*, but lower than 2.67 $\mu\text{g}/100\text{g}$ from improved maize *moi-moi* [27]. Therefore, cowpea-white maize *moi-moi* could be beneficial for sight improvement especially for vulnerable low income earners.

Vitamin C is water soluble vitamin responsible for bone and joint development, maintaining healthy immune system, purifies the blood, acts as an antioxidant and nutrient absorption [35]. Vitamin C did not improve with increasing white maize substitution rather it decreased lower than control sample (0.07 mg/100g) without significant ($p < 0.05$) variation, Therefore, the health benefits will be compromised with increasing white maize substitution. Low vitamin C content of the samples could be attributed to poor source and cooking effect as vitamin C is water soluble and, heat and light labile.

Table 4: Effect of white maize substitution of cowpea on vitamin composition of *moi-moi* produced

Samples	Vitamin A ($\mu\text{g}/100\text{g}$)	VitaminC($\text{mg}/100\text{g}$)
CP100: WM0	1.23 ^d $\pm$ 0.04	0.07 ^a $\pm$ 0.04
CP95: WM5	1.33 ^c $\pm$ 0.04	0.04 ^b $\pm$ 0.00
CP90: WM10	1.45 ^b $\pm$ 0.07	0.03 ^b $\pm$ 0.00
CP80: WM20	1.63 ^a $\pm$ 0.04	0.03 ^b $\pm$ 0.01

a-d: Values are means $\pm$ standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p < 0.05$). CP- cowpea and WM- white maize.

The results are presented in Table 5. Calcium content increased from 17.07 to 18.94 mg/100g with increasing level of white maize substitution from 5% (CP95:WM5) to 20% (CP80: WM20), due to the significant amount of calcium present in maize [14]. The significant ($p < 0.05$) increases signified calcium improvement along with the health benefits as they were higher than the control (15.33 mg/100g). The values obtained in this study were within 12.10 -19.10 mg/100g reported for maize, improved maize and beans *moi-moi* [27]. Calcium is important in the body for building and maintenance of teeth and it plays a key role in our cells. It is advisable for adults to consume a calcium rich diet to maintain bone strength [36].

Magnesium content of the samples increased (12.38 to 13.17 mg/100g) more than the control (9.33 mg/100g) with significant ($p < 0.05$) variation as the level of white maize substitution increased because maize contains reasonable amount of magnesium [27]. The increase was magnesium improvement which was higher than 8.00 to 9.20 mg/100g) reported for *moi-moi* produced from maize and beans [27]. The increases confirm the report that maize has reasonable amount of magnesium [31]. This is beneficial since 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 [37]. It is required for energy production, oxidative, phosphorylation and glycolysis. It contributes to the structural development of bone and is required for the synthesis of DNA, RNA and the antioxidant glutathione. Phosphorus synergizes with calcium to form calcium phosphate, a predominant bone mineral for strong bones and teeth.

Table 5: Mineral composition of *moi-moi* produced from cowpea-white maize blend (mg/100g)

Samples	Calcium	Magnesium	Phosphorous
CP100: WM0	15.33 ^d $\pm$ 0.04	9.33 ^c $\pm$ 0.04	6.92 ^d $\pm$ 1.35
CP95: WM5	17.07 ^c $\pm$ 0.02	12.38 ^b $\pm$ 0.05	7.20 ^c $\pm$ 0.07
CP90: WM10	17.84 ^b $\pm$ 0.02	12.83 ^b $\pm$ 0.01	7.53 ^b $\pm$ 0.04
CP80: WM20	18.94 ^a $\pm$ 0.01	13.17 ^a $\pm$ 0.02	9.13 ^a $\pm$ 0.04

a-d: Values are means $\pm$ standard deviation of triplicate determination. Mean values in the same column with different superscript are significantly different ($p < 0.05$).

There is significant ($p < 0.05$) phosphorous improvement (7.20 to 7.53 mg/100g) on the *moi-moi* samples more than the control sample (6.92 mg/100g) with increasing white maize substitution. The improvement could stem from higher mineral content of maize than cowpea [32]. Phosphorous content could be improved more than this at substitution levels higher than 20% provided the acceptability is not compromised. Phosphorous is essentially needed for growth and repair of body cells and tissues.

The physicochemical results were presented in Table 6. With increasing white maize substitution level, the pH (5.83 to 6.05) of the samples decreased below the control sample (6.12) with significant ($p < 0.05$) variation. This decrease signified increasing acidity and if lower than 5 may result to rejection especially if the substitution level is beyond 20%. Also, the decrease may have stemmed from steeping which decreased the maize pH. However, the pH of the samples is moderately acidic, which may be an advantage because it may not encourage the growth of pathogens that may cause gastrointestinal problems.

Table 6: Physicochemical composition of *moi-moi* samples from cowpea and white maize blends

Samples	pH	Colour Intensity
CP100: WM0	6.12 ^a ±0.00	0.18 ^c ±0.00
CP95: WM5	6.05 ^{ab} ±0.07	0.13 ^d ±0.01
CP90: WM10	5.97 ^{bc} ±0.01	0.20 ^b ±0.00
CP80: WM20	5.83 ^c ±0.04	0.29 ^a ±0.01

a-d: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p < 0.05$).

Increasing white maize substitution levels (5 to 20%) resulted to significant ($p < 0.05$) colour increase (0.13 to 0.29). The increase which was more than the control sample (0.18) implied enhancement of aesthetic appeal and acceptability of cowpea-white maize *moi-moi* as colour provokes acceptability. Colour intensity refers to the brightness or dullness of a product. The aesthetic appeal of the *moi-moi* could be increased beyond this by complimenting with more than 20% of white maize provided acceptability is not compromised. This colour increase may stem from direct effect of heat (Maillard browning) which may have caramelized the hydrolyzed maize sugar [1] during steeping and boiling.

Results of sensory scores were presented in Table 7. The taste scores of cowpea-white maize *moi-moi* samples decreased from 6.75 (CP95:WM5) to 5.54 (CP80:WM20) with significant ($p < 0.05$) variation as white maize substitution levels increased (5 to 20%). The decrease which was lower than control sample (7.75) was taste reduction and could possibly be due to panelist's familiarity with 100% cowpea *moi-moi* which was diluted by maize. The control sample (CP100:WM0) was best preferred, followed by sample containing 5% white maize addition (CP95:WM5) which portends that substitution beyond 5% will compromise the taste.

Texture scores also decreased significantly ($p < 0.05$) from 6.50 (CP95:WM5) to 6.15 (CP80:20WM) lower than control sample (7.05) with increasing white maize substitution levels. Significantly, increasing complementation of cowpea with white maize may have resulted to harder textured *moi-moi* samples due to higher carbohydrate content of white maize which the panelists were not use to. Increasing substitution beyond 20% may likely compromise texture as the samples were liked slightly below 20% substitution levels unlike control which was liked moderately.

From the scores (6.45 to 5.80), appearance of the substituted *moi-moi* samples increased with significant ($p<0.05$) variation as white maize substitution levels increased, but lower than control (6.85). The increase could stem from steeping and higher carbohydrate content of white maize than cowpea. Substitution level beyond 20% will increase the texture more than the control but may affect the consumer preference.

The flavour scores decreased without significant ($p<0.05$) variations lower than control sample (7.10) with increase in white maize substitution levels. The decrease may be as a result of increasing dilution of the desirable beany flavour conversant to the panelists by white maize. Therefore, increasing substitution is flavour loss which will significantly affect acceptability especially at higher substitution levels ($>20\%$).

General acceptability decreased with increasing white maize substitution levels with control sample (CP100: WM0) being the most preferred (7.80) followed by 5% substituted sample (7.10). Generally, it could be inferred that, consumers would prefer the organoleptic properties of *moi-moi* produced from 100% cowpea in all the attributes evaluated followed by 5% substituted sample except in appearance where it scored the least.

Table 7: Effect of white maize substitution of cowpea on sensory scores of *moi-moi*

Samples	Taste	Texture	Appearance	Flavour	General Acceptability
CP100: WM0	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
CP95: WM5	6.75 ^b ±1.71	6.50 ^b ±0.95	5.80 ^c ±1.77	6.40 ^{ab} ±1.82	7.10 ^b ±1.17
CP90: WM10	5.90 ^c ±1.37	6.20 ^c ±1.36	6.40 ^{bc} ±1.19	6.35 ^{ab} ±1.31	6.08 ^c ±1.47
CP80: WM20	5.45 ^d ±1.43	6.15 ^{cd} ±1.6	6.45 ^b ±1.88	6.25 ^{abc} ±0.85	5.70 ^d ±1.30

a-d: Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$). 25 panelists were used.

Conclusions

With increasing levels of white maize substitution, crude fibre, ash, carbohydrate, energy, vitamin A, calcium, magnesium, phosphorous, colour and appearance were improved. The improvement was up to 20% white maize substitution at the expense of acceptability as 5% substituted *moi-moi* was the second best behind 100% cowpea *moi-moi*, the most preferred. But moisture, protein, fat, vitamin C, pH, taste, texture, flavour and general acceptability were decreased. With these nutritional and energy improvement, *moi-moi* samples along other nutritious foods will prevent hidden hunger, weaning deficiencies in infants, protein energy malnutrition and kwashiokor.

Conflict of Interest

The authors declare that there is no conflict of interest. We are approved of the publication in your journal.

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