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Research Article

# Impart of Different Packaging Materials on Some Physicochemical and Acceptability of *Moi moi* Prepared from Cowpea (*Vina unguiculata*)

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## Abstract

*Moi-moi*, a popular ready to eat cowpea paste steamed gel is normally packaged with aluminium plate, aluminium foil, banana leaves and etere leaves that imparts different flavours of varying acceptability, and nutrients. We explored the physicochemical and sensory attributes of *moi-moi* prepared from dehulled cowpea and wrapped in aluminum plate, foils, banana and etere leaves, coded and steamed separately for 45min. Results showed that all the *moi-moi* samples wrapped in aluminium plates and foils were higher in moisture content (50.10 to 51.50%), ash (1.75 to 1.80%), fat (4.24 to 4.64), iron (0.24 to 0.29 mg/100g) and calcium (187.50 to 215.50 mg/100g) with aluminium plate having an edge over the foil all except in fat. *Moi-moi* samples wrapped in leaves were higher in protein (4.81 to 4.90mg/100g) fiber (0.58 to 0.75%), carbohydrate (33.06 to 38.20%), vitamin C (0.96 to 2.92 mg/100g) and colour (0.12 to 0.46) with that from *etere* leading in all. The leaves had more impart on acceptability than aluminium materials due to phytochemical and biochemical leaching into the *moi-moi* with those wrapped in *etere* being the most preferred followed by those in aluminium plate.

**Keywords:** Packaging Material; Physicochemical; Acceptability; *moi-moi*; Cowpea

## Introduction

*Moi-moi* or *moin-moin* is a popular ready to eat steamed gel produced from cowpea paste [2] in Nigeria [2] and West Africa [3]. It is produced by mixing wet milled dehulled beans or cowpea flour with water, vegetable oil and seasonings into a homogenous slurry or paste, wrapped or packaged in leaf pouches or other packaging materials like aluminum containers and steamed. During steaming, the paste solidifies into irreversible gel between 73 to 87°C due to hydration of complex carbohydrate, protein gelation [4,5] and curdling of complex carbohydrate [6]. Bean variety affects the yield and phase separation of moi-moi of which *isiocha* variety had been advanced as the best [1] It is consumes as a breakfast snack with pap (ogi) alone, and with other cereal foods like rice in most Nigerian homes [7]. *Moi-moi* is commonly consumed at any time of the day as excellent source of added nutrient [8] and protein in restaurants and ceremonial occasions by both adults and children [9].

Natural packaging materials like banana and etere or *uma* (*Thaumatococcus danielli*) leaves are used in packaging quick consumed food products [10,11]. They boost the colour, flavour and enhance the nutritional potentials by leaching some important biochemical compounds associated with green leaves into moi-moi during cooking. Due to scarcity in urban areas where they are highly demanded, *moi-moi* is presently packed in tin containers, and flexible plastics like polyethylene film bags, aluminium foils and plates [11] to meet higher demands and decency involved due to change in life style. These packaging leaves imparts either desirable or undesirable flavour component into food products. Desirable flavour enhances product acceptably unlike undesirable one [12]. Acceptability of *moi-moi* also depends on appearance colour, taste, aroma and texture which are major parameters that determine product quality [13].

Cowpea is a popular, most economical and nutritious leguminous crop in Africa commonly called 'beans' in Nigeria, *oloyin* in Yoruba, *agwa* in Igbo and *niebe* in Francophone countries. Cowpea contains about 24.3% protein, 1.9% fat, 6.3% fiber, 63.6% carbohydrates, 0.00074% thiamine, 0.00042% riboflavin and 0.00281% niacin [14]. Cowpea is an affordable alternative protein source to the people of the rural communities in Nigeria and other developing countries [15]. Cowpea protein is deficient in essential sulphur-containing amino acid like methionine and cysteine but are comparatively rich in lysine therefore combining it with cereal protein will provide a good quality dietary proteins for human beings [16]. Cowpea proximate composition ranges for moisture (11.10% to 19.35%), fat (0.62% to 2.13%), crude fiber (1.88% to 4.51%), protein (17.04 to 23.73%), ash (2.60% to 3.36%) and carbohydrate (55.90% to 61.58%) had been recognized [15]. Though cowpea contains some anti-nutritional factors like oxalate, phytate, tannin, lectin and stachyose [17], they are reduced significantly by soaking cooking, boiling and pre-processing methods [18].

Food packaging is the act of wrapping or enclosing food in material main for packing foods such as polyethylene, glasses, papers, leaves, aluminum foil and others so as to contain and protect the food from outside influences and damage while providing consumers with the nutrients therein. Food packaging has been advanced as a key factor that determines consumer preference, purchase desires and food consumption [19], hence plethora of dynamic and attractive packaging designs specifically to promote consumer acceptability and product purchases. Other importance of packaging materials had been acknowledged [11].

Banana or plantain leaves are the most common and widespread traditional packaging leaves for foods like *moi-moi, akara*, and *agid*. They are excellent, cheap and readily available packaging materials for quickly consumed foods [20] but are permeable to moisture, oxygen, odour or micro-organisms [11] when foods are packed in them. Banana leaves are large, flexible and naturally water proof liable to impart desirable flavour and aroma to foods cooked in or served on them [10]. They are commonly wilted over mild flame to make it more pliable before using.

*Etere* or *Uma* in Igbo and *ewe omo* in Yoruba are medium to large leaves used for wrapping various quickly consumed local food products [21]. It is cheap, not as readily available as banana leaves and imparts unique flavor, colour and nutrients into foods by leaching a lot of biochemical pigment and phytochemicals [22] into the foods like *moi-moi*.

Recently, there has been much increase in the use of aluminum foil for packaging of *moi-moi* [11]. Aluminium foil with common thickness of 0.012 to 0.015μ are often lacquered or laminated with a thin film of plastic to increase its corrosion resistance for packaging dairy products. It has barrier properties, grease proof, non-absorption; shrink proof, odourless, tasteless, opaque to light, bright in appearance and non-toxic. They also have low tear strength, susceptible to strong acid and alkali. Aluminium cans and plates, naturally coated with aluminium oxide are another most widely used material for cooking *moi-moi* with higher effective barrier to temperature, moisture, high resistant to most forms of corrosion and chemical attack [23]. They have excellent barrier to moisture, air, odours, light and micro-organisms with good flexibility, surface resilience, hygienic condition and therefore better than leaves and nylons in cooking *moi-moi* [24]. This study therefore aimed at evaluating the impart of some packaging materials on the physicochemical and acceptability of *moi-moi* from cowpea.

## Materials and Methods

Cowpea, aluminum foil and plates, and seasonings were purchased from Ndoro Oboro weekly market in Umudike, Abia State. Banana and *etere* leaves were gotten from Lokpanta village in Umunneochi Local Government Area, Abia State.

### *Moi-moi* preparation

The *moi-moi* samples were prepared according to Enwere [25] with little modifications (Figure 1). Sorted 2.5kg of cowpea seeds were steeped with enough clean water for 5min, hand dehulled and the hull removed by water floatation to obtain cleaned cotyledons. The cotyledons were wet milled for 15min into smooth paste with a variable speed kitchen blender model No N5-360D, New Brook Corporation Texas, USA. The paste was mixed (Table 1), whipped for 2min in mortar with pestle and divided into four batches each of which was wrapped separately in aluminium plate, aluminium foil, banana (wilted over flame) and *etere* leaves. Each batch was steamed separately for 45min in pots using 0.05mpa steam pressure at 1100C to obtain *moi-moi* (Figure 2). Each *mio-moi* sample was allowed to cool at room temperature before sensory and laboratory analyses.

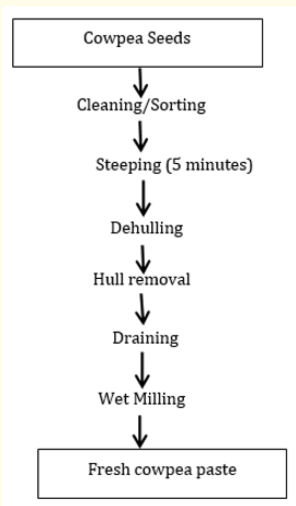


**Figure 1:** Flow diagram for the processing of cowpea paste.

**Figure 2:** Flow diagram for of *moi-moi* production.

| Ingredients | Quantity |
|---|---|
| Cowpea paste | 600g |
| Onion | 25g |
| Pepper | 20g |
| Salt | 1.5g |
| Seasoning (magi) | 2g |
| Vegetable oil | 25ml |
| Crayfish | 40g |
| Hot water | 100ml |

**Table 1:** Recipes for the moi-moi production.

## Analyses

### Proximate composition

### Moisture content

The moisture content was determined by AOAC (2000) method and calculated thus:

% moisture =

$$\frac{weight\ of\ sample\ before\ drying - weight\ of\ sample\ after\ drying}{original\ weight\ of\ the\ sample}\ \frac{X\ 100}{1}$$

### Crude protein

This was carried out using micro-kjeldahl digestion method described by AOAC [26] and crude protein calculated as:

$$\%\ crude\ protein = \frac{(0.01 \times 6.25 \times 250 \times T}{Weight\ of\ sample} \times \frac{100}{1}$$

Where T= titre value.

### Fat content

Fat content was determined by the continuous solvent extraction in a soxhlet reflux apparatus (AOAC) [26] and the fat content calculated thus.

$$\%\ fat = \frac{W_2 - W_1}{Weight\ of\ sample} \times \frac{100}{1}$$

Where $W_1$ = Weight of empty extraction flask and $W_2$ = Weight of flask + oil extracted.

### Ash content

The method of AOAC [26] was used to determine the ash content which percent content was determined thus.

$$\% \text{ Ash} = \frac{\text{Weight of crucible + Ash-Weigh of crucible}}{\text{Original weight of sample}} \times \frac{100}{1}$$

### Crude fiber

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

$$\% \text{ crude fibre} = \frac{\text{Loss in Weight on incineration}}{\text{Weight of original sample}} \times \frac{100}{1}$$

### Carbohydrate

Carbohydrate was calculated by difference [26] thus

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

### Mineral content

### Calcium and magnesium

Versanate EDTA titrimetric method of Udoh and Oguwale [28] was employed. Twenty milliliter (20ml) 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 and 20ml of ammonia buffer was added to raise the pH to 10.00 (a point at which both calcium and magnesium form complexes with EDTA). Both the mixture and blank were titrated against 0.02N EDTA solution using Eriochrome Black T as indicator until their colour changed from deep red to a permanent blue end point. Same titration procedure was carried out for magnesium but 10% NAOH was used in place of Eriochrome Black T. Titer values which represent $Mg^{2+}$ and $Ca^{2+}$ were calculated thus:

$$\text{Ca/Mg (mg/mg)} = \frac{100}{\text{w}} \times \text{T-B (Nx Ca/Mg)} \times \frac{\text{Vt}}{\text{Va}}$$

Where: W= Weight of ample, T = Titire value of product, B= Titire value of Blank, Ca= Calcium equivalence, Mg= Magnesium equivalence, N= Normality of titrant (0.02N EDTA), Vt = Total extract volume, Va= Volume of extract analyze.

### Iron

Method of Onwuka [29] was adopted. One gram (1g) of the sample was digested in a digestion flask with 20ml of acid mixture of 650ml concentrated $HNO_3$ and 20ml $H_2S0_4$, and 90ml PAC. The mixture was heated until a clear digest was obtained thereafter was diluted with distilled water to 500ml. An aliquot of 20ml was subjected to AAS analysis at 248.3nm [30].

A stock solution containing 1000mg/ml of $fe^{3+}$ ion was prepared by dissolving 1.0g of pure iron wire in 100ml concentrated HNO3, boiled in water bath and diluted to 1000ml with distilled water. From this stock solution, standard solutions with concentrations 0.0, 0.5, 1.0, 2.0 and 4.0 ppm were prepared and used to plot a calibration graph with which to extrapolate for iron content of the samples.

### Vitamin C

Five grams (5g) of the product were dispersed into 50ml of EDTA/TCA solution and homogenized. The homogenate was filtered through Whatman No 42 filter paper and more EDTA/TCA was used to wash the residue in the filter paper until 50ml filtrate was obtained. A 20ml portion of the filtrate was mixed with 10ml of 30% KI solution in a conical flask followed by 1% starch solution. The mixture was titrated against 0.01m $CuSO_4$ solutions. A reagent blank was also titrated. Vitamin C content was calculated based on 1ml 0.0.Im $CuSo_4$ = 0.88mg vitamin C thus.

$$\text{Vitamin C mg/100g} = \frac{100}{\text{w}} \times 0.88 \times \text{(T-B)} \times \frac{\text{Vt}}{\text{Va}}$$

Where: W= Weight of product, T= titer value of product, B= titer value of blank, Vt= total extract volume, Va= volume of extract titrated [31].

### Colour

Colour intensity [32] of the samples was evaluated using Genesys 10vis Thermo Corporation spectrophotometer at 600nm after 1:50 dilution with distilled water thus:

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

Where: F: Dilution factor to adjust absorbance and A= Absorbance.

### Sensory evaluation

Iwe [33] method was used. Twenty (20) untrained panelists comprising both male and female students within the age bracket of 18 to 30yrs selected from the Department of Food Science and technology, Michael Okpara University of Agriculture, Umudike were used. The panelists were selection based on interest, familiarity with *moi-moi* and availability. Unwrapped samples were presented to each panelists in same types of plates along with bottled water, instructed to rinse their mouths before and after tasting each sample and score them according to 9-point Hedonic scale where 9=like extremely and 1=dislike extremely. Quality attributes evaluated were colour, taste, aroma, texture and general acceptability.

### Statistical analysis

Completely randomized design (CRD) [34] was used. Mean values of all the triplicate analytical determinations were subjected to analysis of variance (ANOVA). Significant difference were determined using SPSS statistical tools version 21 at 5% ($P<0.05$) acceptable level.

## Results and Discussion

### Proximate analysis

Physicochemical results of all the *moi-moi* samples were presented in Table 1.

### Moisture content (MC)

Moisture content of *moi-moi* samples increased significantly ($p<0.05$) from 50.10% in sample 504 (*moi-moi* packed in *etere*) to 55.10% in sample 502 (*moi-moi* packed in aliminium foil). This could be likened to more moisture loss in *moi-moi* packed in *etere* than in aliminium foil due to lower water barrier property of *etere* leaves during steaming [23]. Similar result had been acknowledged [12]. The MC of *moi-moi* packed in *etere* leaves was lower than 55.03% reported [7] while *moi-moi* packed in aliminium foil was slightly higher. Both MC results were higher than 40.23% to 44.12% [8]. The difference could be due to bean: water ratio, bean variety, type of packaging materials, soaking time and levels of ingredients used [7]. Aluminium foil is preferred to packaging in *etere* leaves when moisture barrier and aseptic packaging conditions against micro-organisms is a major issue [10]. The MC of *moi-moi* packed in both aliminium foil and plate were significantly ($p<0.05$) different, and higher than those from both leaves which MC were not significantly ($p<0.05$) different. This testified significant ($p<0.05$) variations in their flexibility and barrier properties probably due to wider differences in the type and nature of their closures while those of the leaves were similar. Aluminium foils are more flexible with better closure than the plate which is rigid with loose lids. Permeable nature of the leaves [11] and their similar closure may have been responsible for their similar MC. Again during cooling after steaming, more moisture must have evaporated from *moi-moi* packed in leaves than in aluminium foil and plate [16]. Insignificant ($p>0.05$) lower (50.10%) moisture content of *moi-moi* wrapped in *etere* than banana leaf (52.16%) may stem from flaming which may have made banana leaf more flexible with better seal than *etere*. Water, an essential for life maintenance, aids in chewing, swallowing and acceptability of foods (Table 2).

### Ash

Packaging material effects reflected on the significant ($p<0.05$) ash content increase of *moi-moi* samples from 1.75% in sample 504 (*moi-moi* packed in *etere*) to 1.83% in sample 501 (*moi-moi* packed in aliminium plate). Higher ash content (1.83%) of sample 501(*moi-moi* packed in aliminium plate) than 1.80% in 502 (*moi-moi* packed in aluminium foil) attested lamination of the foil with thin plastic film [23] which may have resulted in lower aliminium migration into *moi-moi* than in aluminium plate. Ash content obtained from all the *moi-moi* samples were higher than1.49% [13] and 0.93% [7], but within the range of 1.39 to1.95% [8] probably due to packaging material types and bean variety used. Significant ($p<0.05$) ash content difference between all the *moi-moi* samples may have revealed significant ($p<0.05$) difference in ash content contributions by the packaging materials. Lower ash content of the leaves implies lower ash content. Besides, some of their potential phytochemical leached into the moi-moi during boiling may have interacted with some *moi-moi* minerals [35] and resulted in lower ash content than aluminium materials. Therefore to boost mineral composition of *moi-moi*, aluminium plate may be the best option due to its high ash retention which is an index of food minerals [11]. Calcium aids good teeth and bones formation, and reduces or prevents osteoporosis in adults if taken regularly. Iron is necessary for formation of hemoglobin that carries oxygen in the blood to muscle tissues. Iron also helps in energy production and a healthy immune system which deficiency results in anemia [36].

| | MC | Ash | Fat | Protein | Fiber | CHO | Iron | Ca | Vit C | Colour intensity |
|---|---|---|---|---|---|---|---|---|---|---|
| | | % | % | % | % | % | Mg/100b | Mg/100g | Mg/100g | |
| 501 | $52.16^b \pm 0.28$ | $1.83^a \pm 001$ | $4.42^b \pm 0.01$ | $4.90^b \pm 0.01$ | $0.66^b \pm 0.01$ | $36.03^c \pm 0.33$ | $0.29^a \pm 0.01$ | $215..50^a \pm 071$ | $0.96^d \pm 0.01$ | $0.12^d \pm |0.00$ |
| 502 | $55.10^a \pm 0.14$ | $1.81^{ab} \pm 0.01$ | $4.64^a \pm 0.01$ | $4.81^c \pm 0.01$ | $0.58^c \pm 0.01$ | $33.06^d \pm 0.17$ | $0.27^b \pm 0.01$ | $210.50^b \pm 0.71$ | $2.92^a \pm 0.01$ | $0.14^c \pm 0.00$ |
| 503 | $51.50^c \pm 0.14$ | $1.80^b \pm 0.01$ | $4.31^c \pm 0.01$ | $4.91^b \pm 0.02$ | $0.69^b \pm 0.01$ | $36.79^b \pm 0.33$ | $0.24^b \pm 0.01$ | $209.50^b \pm 0.71$ | $1.13^c \pm 0.01$ | $0.20^b \pm 0.00$ |
| 504 | $50.10^c \pm 0.14$ | $1.75^c \pm 0.01$ | $4.24^c \pm 0.01$ | $4.98^a \pm 0.01$ | $0.73^a \pm 0.01$ | $38.20^a \pm 0.14$ | $0.26^b \pm 0.01$ | $187..50^c \pm 0.71$ | $1.17^b \pm 0.01$ | $0.46^a \pm 0.00$ |
| LSD | 0.06 | 0.35 | 1.00 | 0.506 | 0.056 | 1.00 | 0.230 | 0.230 | 1.00 | 1.00 |

**Table 2:** Physico-chemical composition of *moi-moi* prepared from cowpea and packaged in aluminium plate, aluminium foil, banana leaves and etere leaves.

Values are mean triplicate determinations with ± standard deviations. Similar superscript on the same column are not significantly different (P < 0.05), MC= Moisture content, Ca= Calcium content, Vit C= Vitamin C content, CHO- Carbohydrate content, Fe= Iron content, 501-Alluminium Plate, 502- Alluminium foil, 503 - Banana leave,504 - *Etere* leave.

### Fat

Fat content of the *moi-moi* samples ranged from 4.24% in sample 504 (*moi-moi* packed in etere) to 4.64% in 502 (*moi-moi* packed in aluminium foil). The significant (p<0.05) difference could be due to leaching of fat into boiling water from *moi-moi* packed in *etere* due to loss of barrier property to heat. Again, the rate and amount of heat transfer through the leaves may have contributed in rendering of fat out of *moi-moi* unlike in laquered aluminium plate and laminated foil. Protective properties of lacquering against temperature, high resistant to most forms of corrosion and chemical attack had been reported [23]. Significant (p<0/05) fat difference between *moi-moi* samples packed in aluminium materials could be explained by the degree of lacquering and lamination. The higher retention of fat by aluminum foil will predispose the *moi-moi* for better acceptability. Fat is an energy substrate, good source of fat soluble vitamins and enhancement of general nutrient intake [37]. Fat also encourages paracellular intestinal absorption of aluminium which may have leached into *moi-moi* when consumed [38].

### Protein

Protein content of the *moi-moi* samples as affected by packaging materials was lowest (4.81%) in sample 502 (*moi-moi* packed in aluminium foil) and highest (4.98%) in 504 (*moi-moi* packed in etere). Significant (p<0.05) different between them could be due to possible hydrolyses of absorbed thaumatin [39] content from etere which leached into the *moi-moi* during boiling to amino acid [22]. This could also be the reason why protein content of *moi-moi* samples packed in leaves were higher than those packed in aluminium packaging materials. Protein content of *moi-moi* from the leaves were also higher than 4.90% [7], but lower than 21.89% [8] while those packed in alluminium plate and foil were lower. Types of packaging materials, ingredients and bean variety used may be responsible. Significant (p<0.05) lower protein content difference of *moi-moi* packed in banana than etere leaves could be due to wilting over flame which may have burnt off some of the thaumatin. Aside from energy, protein is crucial for regulation and maintenance of growth and repair of body tissues in infants' and young children's body. Protein deficiency results in marasmus and kwashiorkor [37].

### Fiber

Crude fiber content of the *moi-moi* samples increased significantly (p<0.05) from 0.58% in sample 502 (*moi-moi* packed in aluminium foil) to 0.73% in sample 504 (*moi-moi* packed in etere). The difference could be due to variation in type of packaging material used [7]. Leaching of fiber from the leaves and potential absorption of same by the *moi-moi* may have contributed as the fiber content of all the *moi-moi* samples packed in leaves were higher than those packed in aluminium packaging materials. Similarity of the fiber content of *moi-moi* sample packed in aluminium plate and banana leaves could be due to flaming of banana leaves before packing which may have reduced some of the fiber content. General lower fiber content of moi-moi obtained in this study could be due to dehulling of cowpea [7,40] but could be increased by addition of vegetables. Addition of vegetables such as fluted pumpkin in *Okpa* had been reported to increase fiber content [41]. Addition of scent leaves is practice. Fiber content of the *moi-moi* samples were slightly lower than 0.81% reported [7] which may be attributed to cowpea variety, packaging material, processing methods and recipes used in preparing the *moi-moi*. Dietary fiber is the indigestible component of plant material that lowers serum cholesterol, obesity and enhances intestinal health, normalizes bowl movements, prevents constipation and helps control blood sugar [37].

### Carbohydrate

Packaging material imparts on carbohydrate content of all *moi-moi* samples increased from 33.06% in sample 502 (*moi-moi* packed in aluminium foil) to 38.20% in 504 (*moi-moi* packed in *etere*). Significant ($p<0.05$) different between the samples could perhaps be due to significant ($p<0.05$) carbohydrate contributions by the *etere* [39]. All the carbohydrate values obtained were higher than reported values of 32.85% [7] and 32.55% [8]. The variation could be due to cowpea variety, ingredients and the nature of packaging materials used. Interestingly, carbohydrate content of *moi-moi* depends on the nature of packaging material as validated by higher carbohydrate content of the leaves than the aluminium packaging materials with *etere* having the highest seconded by banana leaves. Carbohydrate content of leaves had been reported [39] which may leach into *moi-moi*. Carbohydrates is one of energy substrates which fuels children's metabolism, supports growth, keeps their brain and nervous system working and maintains overall health [42].

### Mineral composition

### Iron (Fe)

Dietary iron content of the moi-moi samples ranged from 0.24 mg/100 in sample 503 (*moi-moi* packed in banana leaves) to 0.29mg/100g in sample 501 (*moi-moi* packed in aluminium plate). Significant dietary iron difference ($P<0.05$) only existed between sample 501 (*moi-moi* packed in aluminum plate) and the rest samples which were similar. General low iron content of all the *moi-moi* samples obtained was a reflection of low ash content earlier reported which is an index of mineral [29]. Dehulling, variety and ingredients used may be responsible [40] including calcium-iron interactions [43] and leaves phytochemical interactions with some *moi-moi* mineral [17]. Chemical reactions between the leaves and food components during steaming resulting in desired *moi-moi* flavour had been advanced [22]. For adequate iron retention, aluminium plate may be more preferable. Iron metabolizes protein for energy with the help of calcium, regulates growth, aids cell differentiation, forms muscle myoglobin and interaction [44,45].

### Calcium

Calcium content of all the *moi-moi* samples increased from 187.50mg/100 in sample 504 (*moi-moi* packed in *etere*) to 215.50mg/100g in sample 501 (*moi-moi* packed in aluminium plate). There is significant ($p<0.05$) calcium difference between *moi-moi* samples packaged in aluminium materials like wise those packed in leaves which projected imparts of packaging materials on calcium content of moi-moi. Obviously, all the *moi-moi* samples packed in aluminium materials were higher than those packed in leaves which are traceable to the leaching of phytochemicals (oxalate and phytate into the *moi-moi* [21] that may have interacted with the minerals including calcium [29]. Nutrient interactions have been reported as nutrient loss [46]. Significant ($p<0.05$) higher calcium content (215.50mg/100g) of sample 501(*moi-moi* packed in aluminium plate) than 210.50mg/100g from 502 (*moi-moi* packed in aluminium foil) may mean that the level of lacquering in aluminium plate may have higher protective effect on *moi-moi* against higher temperature [23] than the plastic laminate of the foil. Relatively higher temperature in *moi-moi* packed in aluminium foil may have enhanced protein–calcium interaction. In addition, leaching of aluminium from the foil into the *moi-moi* may have affected calcium [47].Similarly, significant ($p<0.05$) higher calcium content (209.50mg/100g) of sample 503 (*moi-moi* packed in banana leave) than 187.30mg/100g in 504 (*moi-moi* packed in etere) may prefigure more phytochemicals in *etere* than banana leaves. Again, wilting of banana leaves over mild flame may possibly reduce calcium leaching rate unlike in *etere* leaves. Aluminium plate may be the best in terms of calcium retention and should be promoted if calcium is being targeted. Also, possible use of fish and crayfish should be encouraged to promote calcium intake to enhance bone development. Calcium is the most abundant mineral in the body that supports bone development and good teeth liable to reduce or prevent osteoporosis in adults [36].

### Vitamin C

Influence of packaging materials on vitamin C content of *moi-moi* samples revealed increased from 0.96mg/100g in sample 501 (*moi-moi* packed in aluminium plate) to 2.92mg/100g in sample 502 (*moi-moi* packed in aluminium foil). This may be as a result of lower moisture barrier properties of the plate thereby allowed more vitamin C (water soluble) into the steaming water. There is significant ($p<0.05$) difference between all the vitamin C content of *moi-moi* samples which substantiated differential impart of packaging materials on vitamin C. However, all the vitamin C content of *moi-moi* samples packed in leaves were significantly ($p<0.05$) lower than 2.92mg/100g from aluminium foil but higher than

0.96mg/100g from aliminium plate. Most of vitamin C must have leached into the steaming water from aluminium plate than leaves probably due to poor lid sealing. Besides, aluminium foil may have offered the best barrier against vitamin C leaching due to plastic film laminate and flexibility which enhances sealing [20]. Significant ($p<0.05$) higher vitamin C content of *moi-moi* wrapped in etere (1.17mg/100g) than in banana leaves (1.13mg/100g) could be due to better heat protection. Flaming of banana leaves during wilting must have destroyed some vitamin C that could have leached into *moi-moi*. Aluminium foil frequently used in packaging *moi-moi* therefore retains more vitamin C than other materials. Vitamin C not ony improves the nutritional quality but reduces nutritional disorders, stabilizes food products, enhances nutrient absorption, improves the aesthetic appeal and other health related properties [48,49].

### Colour intensity

Packaging material effects on colour intensity of *moi-moi* samples increased from 0.12 in sample 501 (*moi-moi* packed in aluminium plate) to 0.46 in 504 (*moi-moi* packed in *etere*). There was significant ($p<0.05$) difference between all the samples. It is interesting to note that the leaves had more colour influence on the mio-moi than aluminium materials. This could be due to leaching of biochemical green pigments (chlorophyll) and phytochemicals present in them into *moi-moi* during steaming [39] unlike in the aluminium materials. Higher colour intensity (0.46) of sample 504 (*moi-moi* packed in *etere* leave) than (0.20) from 503 (*moi-moi* packed in banana leaves) may mean that the wilting of banana over flame must have destroyed some of the green pigments that could have leached into the *moi-moi*. Besides, lower leaching of green pigments by banana leaves than *etere* had been reported [11]. Despite the destruction, colour intensity of *moi-moi* from banana leaves was still higher than those of the aluminium materials. Alumunium migration into *moi-moi* must have been more in the foil than plate during steaming to explain differential colour intensity between them. Therefore it could be concluded that *moi-moi* packed in aluminum materials most especially plate retained their natural colour than those packed in leaves despite aluminium migration into *moi-moi* [47]. However addition of red oil plus other fatty food like meat egg and milk into *moi-moi* will help to reduce the danger of excess aluminum accumulation from *moi-moi* over time in the body [38]. Therefore, leaves may be preferred due to its biochemical potentials, thaumatin, essential oils and desirable flavour contribution into *moi-moi*. Colour is an index of acceptability as consumers eat with their eyes and use what they observed to confirm quality [50].

### Sensory analysis

### Colour

Table 3 presents the sensory scores of all the *moi-moi* samples. Mean sensory colour scores revealed that sample 501 (*moi-moi* packed in aluminium plate) had the highest score (7.6) while 502 (*moi-moi* packed in aluminium foil) had the least (6.9). The discrepancy may be due to more migration of aluminium from the foil than plate [47] resulting in undesirable colour from foil than plate. It could be recalled that the foil had more colour intensity than the plate (Table 2). Conversely, *moi-moi* wrapped in *etere* with higher colour intensity (0.46) had higher colour score (7.35) than 7.15 from *moi-moi* wrapped in banana leaves with colour intensity of 0.20. This implied that the more the organic and biochemical leaching into *moi-moi*, the more desirable the colour which validated the report that banana and *etere* leaves have positive effects on *moi-moi* colour [39]. Therefore, colour of *moi-moi* samples packed in leaves was more attractive to the panelists with that from *etere* having an edge. Aluminium migration therefore affected colour negatively and the leaves positively. This implied that the consumers preferred *moi-moi* colour (bright orange colour) packed in leaves [24]. Significant ($p<0.05$) difference between sample 501(*moi-moi* packed in aluminum plate) and the rest samples which are similar also attested the effects of leaching on *moi-moi* colour. This study therefore revealed that aside from the original *moi-moi* colour, enhanced colours from green pigments offer attractive colour. Colour, flavour and texture are considered major quality factor of food.

| Product | Colour | Taste | Aroma | Texture | General Acceptability |
|---|---|---|---|---|---|
| 501 | $7.6^a \pm 0.68$ | $6.65^d \pm 1.69$ | $7.4^a \pm 1.39$ | $7.55^a \pm 1.15$ | $7.25^b \pm 1.89$ |
| 502 | $6.9^b \pm 1.29$ | $6.75^c \pm 2.10$ | $7.20^a \pm 1.15$ | $7.30^b \pm 1.42$ | $7.20^b \pm 1.36$ |
| 503 | $7.15^b \pm 1.60$ | $7.10^a \pm 1.68$ | $7.05^a \pm 1.32$ | $7.20^b \pm 1.82$ | $7.20^b \pm 1.64$ |
| 504 | $7.35^b \pm 1.53$ | $6.85^b \pm 1.95$ | $7.25^a \pm 1.97$ | $7.65^a \pm 1.14$ | $7.75^a \pm 1.21$ |
| LSD | 0.132 | 0.495 | 0.506 | 0.365 | 0.313 |

**Table 3:** Sensory scores of *moi-moi* prepared from cowpea packaged in different packaging material.
Values are mean of triplicate determinations ± standard deviations. Values with different superscripts on same column are significantly difference ($P<0.05$)., 501 is *moi-moi* packed in aluminum Plate, 502 is *moi-moi* packed in aluminum foil, 503 is *moi-moi* packed in banana leave and 504 is *moi-moi* packed in etere leave.

### Taste

Taste scores of all the *moi-moi* samples varied from 6.65 in sample 501 (*moi-moi* packed in aluminum plate) to 7.1 in sample 503 (*moi-moi* packed in banana leaves). Significant ($p < 0.05$) difference between all the samples implies significant ($p<0.05$) difference in taste contributions of the packaging materials. Higher taste scores of *moi-moi* sample packed in leaves than those of aluminum materials attested earlier report that leaves impart better desired flavour on *moi-moi* than the aluminum materials. Thaumatin (protein metabolite), essential oil and bean protein may have hydrolyzed into amino acids to generate the perceived flavour in *moi-moi* [22]. Higher taste scores of moi-moi from banana leaves than *etere* may mean more leaching of phytochemicals and essential oil from etere into *moi-moi* which was not desired by the panelists. Similarly, the lower the barrier properties of packing materials, the lower the taste score as reflected in higher taste scores of samples 502 (*moi-moi* packed in aluminum foil) than 501 (*moi-moi* packed in aluminum plate) and 503 (*moi-moi* wrapped in banana leaves) than 504 (*moi-moi* packed in *etere*).

### Aroma

Aroma sensory scores of all *moi-moi* samples as affected by different packaging materials had no significance ($P < 0.05$) difference between them. Panelist ranked sample 503 (*moi-moi* packed in banana leaves) the least (7.05). Banana leaves wilting that destroys heat labile phytochemicals like oxalate and phytate [11,18] that could have enhanced the aroma [39] may be responsible. Higher aroma scores (7.4) of sample 501 (*moi-moi* packed in aluminum plate) than others could be as a result of poor aluminum migration into *moi-moi* due to lose lid. The barrier properties of packing materials had an inverse relation with the aroma which explain why *moi-moi* aroma packed in *etere* was higher than those packed in banana leaves and that packed in aluminium plate higher than the foil. This study revealed that *moi-moi* aroma depends on the type of wrapping materials, closure and barrier properties.

### Texture

Wrapping material influence on *moi-moi* texture scores increased from 7.20 in sample 503 (*moi-moi* packed in banana leaf) to 7.65 in 504 (*moi-moi* packed in *etere*). Leaves contain carbohydrate [39] which hydrolysis, leach into *moi-moi*, gelatinizes [11] and enhances texture. Wilting must have affected some of carbohydrate content of banana leaves. Therefore, packaging of *moi-moi* in leaves is preferred to aluminum foil and plate. *Moi-moi* samples packed in aluminum plate and *etere* had no significant ($P > 0.05$) difference but differ significantly ($P< 0.05$) with *moi-moi* wrapped in aluminum foil and banana leaves. This implies that barrier properties of packaging materials, types [16] and pretreatments decide texture. Aluminum plate and etere leaf were more porous than aluminum foil and banana leaf and allowed more moisture out of *moi-moi* samples [20]. This may explain the reason why the MC of sample 502 (*mio-moi* packed in aluminum foil) was higher than that from sample 501 (*moi-moi* wrapped in aluminum plate). Also, MC of sample 503 (*moi-moi* packed in banana leaves) was higher than sample 504 (*moi-moi* packed in *etere*) in Table 2. Moisture and consistency during mixing affect texture [24]. Texture is those properties like soft, hard, toughness or tenderness of food that are sensed by touching with hands or mouth which decides consumer enjoyment, acceptability and market value [51].

### General acceptability

This study showed that *moi-moi* sample wrapped in *etere* leaf was the most accepted (7.75%) with significantly ($P < 0.05$) difference between the rest similar samples. Those packaged in aluminum foil and banana leaf had the least score (7.20 each). Higher acceptability of *moi-moi* from etere is justified as it was rated second in colour, taste, aroma and best in texture. Acceptability of *moi-moi* depends on appearance colour, taste, aroma and texture which are major parameters that determine the quality attributes of the product [13,20]. *Etere* leaves have been recognized to promote higher acceptability level and overall food quality when used in packaging foods generally [12,23]. Besides, contributions to health promoting activities [52], essential oil, phytochemical and biochemical pigments by *etere* leaves have been acknowledged [22,39]. *Moi-moi* packed in aluminum plate with best score in texture, second best in colour and aroma, and least in taste was rated second by the panelists. *Moi-moi* wrapped in aluminum foil and banana leaf came third due to their poor ratings in all the attributes except in taste where *moi-moi* from banana leaf was rated highest. Despite these, all the *moi-moi* samples were moderately liked (> 7) on the nine point Hedonic scale which is in line with literature report [13] that *moi-moi* produced from cowpea are generally excepted especially when cowpea is mixed with other legumes.

## Conclusion

This research work revealed that all the packaging material had different impart on the *moi-moi*. While the leaves added more protein, fiber, carbohydrate and colour to *moi-moi* with *etere* having an edge. Aluminum packaging materials only contributed vitamin C and minerals with aluminum plate having an edge. In terms of acceptability *moi-moi* packed with *etere* leave was more acceptable due to its significant influence on colour, taste, texture and aroma more than other materials. Types of packaging materials and pretreatment influenced packaging materials' barrier properties which in turn affected their impart on *moi-moi*. Barrier properties affected positively most of the sensory attributes.

## Authors Contribution

This is our original collaborative work. Author INO designed the study, discussed, coordinated the entire study and wrote the manuscript. Author CN conducted the literature searches and managed all the analyses of the study, Author FUO read, supervised the analyses and approved the final manuscript for publication Author CCO assisted in discussion and literature search.

## Conflict of Interest

The authors declare that they have no conflict of interests.

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