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Effect of Wet and Dry Processing on the Proximate and Mineral Composition of Traditional Nigerian Steamed Legume Pudding (*Moi-Moi*) Prepared from Cowpea (*Vigna unguiculata*) and Bambara Groundnut (*Vigna subterranea*)

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ABSTRACT

Moi moi is a widely consumed steamed legume pudding in Nigeria, traditionally prepared from cowpea (*Vigna unguiculata*) but increasingly formulated with other legumes such as Bambara groundnut (*Vigna subterranea*). This study evaluated the effects of wet and dry processing on the proximate and mineral compositions of *Moi-Moi*, a traditional Nigerian steamed legume pudding prepared from cowpea (*Vigna unguiculata*) and Bambara groundnut (*Vigna subterranea*). Four samples of *Moi-Moi* formulation were prepared from wet-processed beans, dry-processed beans, wet-processed Bambara groundnuts, and dry-processed Bambara groundnuts. Proximate analysis of composition (protein, fat, fibre, ash, moisture, and carbohydrates) and mineral analysis (magnesium, potassium, calcium, iron, zinc, and phosphorus) were conducted using the standardized procedures of AOAC with data analysis through ANOVA with Bonferroni multiple paired comparisons at $p < 0.05$. Dry processing significantly increased the concentrations of protein, fibre, and ash compared to wet processing in the two legumes. The highest protein concentration was observed in the dry bean *Moi-Moi* sample (24.23%), while the lowest was recorded in the wet Bambara groundnut *Moi-Moi* sample (16.67%). Magnesium and calcium concentrations were highest in the dry Bambara groundnut *Moi-Moi* sample (68.56 mg/100g and 88.97 mg/100g, respectively). Potassium, iron, zinc, and phosphorus concentrations were highest in the dry bean *Moi-Moi* sample (231.09 mg/100g, 12.43 mg/100g, 8.24 mg/100g, and 119.22 mg/100g, respectively). Dry processing retained higher mineral content than wet processing, while Bambara groundnut enhanced nutritional value. Dry-processed Bambara groundnut *Moi-Moi* offers a nutrient-dense alternative for improving dietary quality.

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INTRODUCTION

Legumes play a critical role in food production in sub-Saharan Africa owing to the cheap availability of protein, carbohydrates, dietary fiber, and minerals (Affrifah *et al.*, 2021; Abebe & Alemayehu, 2022; Tan *et al.*, 2020). The cowpea (*Vigna unguiculata*) plant is a particularly significant legume in this part of the world due to its widespread consumption, nutritional value, and relatively low price (Affrifah *et al.*, 2021; Abebe & Alemayehu, 2022). Furthermore, legumes play an essential role in enhancing agricultural sustainability through the biological nitrogen fixation of certain legumes, such as cowpea and Bambara groundnut (Tan *et al.*, 2020; Abebe & Alemayehu, 2022). Hence, there is a growing interest in the use of indigenous legumes as a result of increasing concerns about food affordability, dietary requirements, and food resilience against climate change (Tan *et al.*, 2020; Khan *et al.*, 2021). In West Africa, the *Moi-Moi* is a very popular steamed cowpea dish.

The moiomioi food product is made by blending cowpea paste or flour with water, oil, and spices to form a gel-like structure through steaming (Okwunodulu *et al.*, 2021; Okwunodulu *et al.*, 2019). The product is often eaten alone or with meals made up of cereals like pap and rice and is known as a protein-enriched, ready-to-eat food for consumption by both adults and children (Okwunodulu *et al.*, 2021; Okwunodulu *et al.*, 2019; Arukwe *et al.*, 2023). Due to its high demand, there has been an interest in processing and using different leguminous plant sources (Arukwe *et al.*, 2023; Okwunodulu *et al.*, 2021).

Despite being the traditional ingredient for *Moi-Moi* preparation, Bambara groundnut (*Vigna subterranea*) has great potential to replace cowpea as the raw material due to its nutritional benefits (Halimi *et al.*, 2019; Tan *et al.*, 2020; Khan *et al.*, 2021). Bambara groundnut is one of the underutilized pulses in Africa, with high nutritional value, including proteins, complex carbohydrates, dietary fiber, and important minerals such as iron, zinc, magnesium, and potassium (Tan *et al.*, 2020; Ramatsetse *et al.*, 2022; Khan *et al.*, 2021). The crude protein content recorded in Bambara groundnut is highly variable among genotypes, ranging from 21.18–26.00% in Kenyan landraces to 30.7% across different germplasm datasets (Chelangat *et al.*, 2023; Halimi *et al.*, 2019). It is drought-resistant, adapted to poor soil, and significant for food and nutrition security in areas with stressed climates (Tan *et al.*, 2020; Chelangat *et al.*, 2023;

Khan *et al.,* 2021). However, Bambara groundnut is underutilized in food product development due to its difficult-to-cook nature, limited knowledge of its use, and processing difficulties (Yahaya *et al.,* 2022; Tan *et al.,* 2020).

The processing method is an integral part that determines the nutritional quality of products based on legumes (Affrifah *et al.,* 2021; Rousseau *et al.,* 2020). Processing operations such as soaking, dehulling, milling, germination, fermentation, and thermal treatment in cowpea and other legumes are aimed at improving organoleptic properties and reducing antinutritional compounds, but can also result in changes in proximate and mineral composition (Okwunodulu *et al.,* 2021; Rousseau *et al.,* 2020). Wet processing increases hydration and tissue softening, whereas dehulling and washing remove fractions with higher levels of fiber, phytate, and minerals (Yahaya *et al.,* 2022; Rousseau *et al.,* 2020). The processing method in Bambara groundnuts has an essential impact on proximate and mineral composition, as in one study, steaming resulted in the highest amount of proteins. At the same time, dehulling reduced the concentrations of calcium, potassium, and iron (Yahaya *et al.,* 2022). In processing methods of cowpea, the impact on nutritional characteristics is also rather significant, but it depends on the processing method. For example, soaking and washing may lead to the reduction in some micronutrients and folic acid, whereas milling may increase iron content (Akissoé *et al.,* 2021).

The available evidence suggests that traditional cowpea processing can significantly affect moisture, lipids, ash, nitrogen-free extracts, and minerals, despite minimal changes in protein content on a dry matter basis (Akinyele, 1989). Traditional processing can also enhance nutrient value by reducing antinutritional factors such as phytate, tannins, and oligosaccharides, thereby improving mineral utilization (Yahaya *et al.,* 2022; Ghaffar *et al.,* 2025; Silotolo *et al.,* 2026). For instance, soaking and boiling have been found to reduce the levels of phytate in many pulses, and the soaking of Bambara groundnut in sodium bicarbonate and salt reduces anti-nutritional factors and increases minerals (Ghaffar *et al.,* 2025; Yahaya *et al.,* 2022). However, while some positive effects can be gained through traditional processing, there are negative effects in the form of losses of nutrients through leaching (Rousseau *et al.,* 2020; Akissoé *et al.,* 2021).

Studies conducted on *Moi moi* itself demonstrate that the proximate composition and mineral content can be affected by formulation and process parameters. The partial replacement of cowpeas with sprouted pigeon peas increased protein, fiber, ash, and several minerals in the *Moi moi* (Arukwe *et al.,* 2023). On the other hand, the partial replacement with white and yellow maize increased the carbohydrate content, fiber content, ash content, calcium content, magnesium content, and phosphorus content, but reduced the protein content and moisture content compared with 100 percent cowpea *Moi-Moi* (Okwunodulu *et al.,* 2021; Carpathian Journal of Food Science and Technology, 2024). The type of packaging used may affect nutrient composition, with leaf-wrapped *Moi-Moi* having higher protein, fiber, and carbohydrate content. In contrast, aluminum-packaged *Moi-Moi* had higher moisture, ash, iron, and calcium (Okwunodulu *et al.,* 2019). However, there is little literature comparing the two processing techniques with respect to the proximate and mineral composition of *Moi-Moi* made from cowpeas and Bambara groundnuts (Akissoé *et al.,* 2021; Khan *et al.,* 2021; Mamoudou & Mune, 2024). The existing literature mostly addresses either the processing of cowpea products, the nutritional composition of Bambara groundnuts, or product substitution (Affrifah *et al.,* 2021; Halimi *et al.,* 2019; Arukwe *et al.,* 2023). This limits the ability to determine the most effective processing method for retaining protein, fiber, ash, and important minerals such as calcium, magnesium, iron, zinc, potassium, and phosphorus (Rousseau *et al.,* 2020).

An understanding of these properties is key to nutrition as well as food product development. Proteins aid in the growth and maintenance of body tissues, fiber contributes to digestion, while minerals like iron, zinc, calcium, magnesium, potassium, and phosphorus help in oxygen transport, immunity, bone development, and metabolism, respectively (Tan *et al.,* 2020; Ramatsetse *et al.,* 2022; Abebe & Alemayehu, 2022). Such processes that preserve the nutrients but minimize anti-nutritional limitations can contribute significantly to the nutritional content of *Moi-Moi* in people dependent on plant foods (Rousseau *et al.,* 2020).

The study is, therefore, designed to investigate the effects of wet and dry processing on the proximate and mineral composition of *Moi-Moi* made from beans (*Vigna unguiculata*) and Bambara groundnut (*Vigna subterranea*). The research mainly focuses on the determination of protein, fat, fibre, ash, moisture, carbohydrate, magnesium, potassium, calcium, iron, zinc, and phosphorus contents. The results are anticipated to assist consumers, food processors, and food scientists in adopting appropriate processing techniques that can enhance the nutritional value of *Moi-Moi* and promote the use of underutilized Bambara groundnuts.

MATERIALS AND METHODS

This research was carried out in the Department of Nutrition and Dietetics, Faculty of Agricultural Sciences, Federal University of Agriculture, Mubi, Adamawa State, Nigeria. The proximate and mineral composition analyses were conducted at the nutrition laboratory department of Animal Production, Adamawa State University, Mubi, Mubi North Local Government Area, Adamawa State, Nigeria.

Raw Materials

Undamaged dry seeds of white cowpea (*Vigna unguiculata*) and cream-colored Bambara groundnut (*Vigna subterranea*) were bought from the grains market in Mubi, Mubi North LGA, Adamawa State, Nigeria. Refined vegetable oil, onion, fresh pepper, crayfish, and iodized salt, which are required for preparing *Moi moi*, were also bought from this market. Seeds were cleaned manually to eliminate stones, chaff, and any other damaged seeds.

Sample Preparation

Each legume (cowpea and Bambara groundnut) was divided into two batches and subjected separately to wet processing and dry processing, giving four *Moi-Moi* samples in total: wet-processed bean *Moi-Moi* (WB), dry-processed bean *Moi-Moi* (DB), wet-processed Bambara groundnut *Moi-Moi* (WBG), and dry-processed Bambara groundnut *Moi-Moi* (DBG). Each sample was prepared independently in triplicate using 500 g of the respective legume (Table 1).

Table 1: Formulation of Wet and Dry-processed Cowpea and Bambara Groundnut *Moi-Moi*

Ingredients (per formulation)	WC	DC	WB	DB
Cowpea (*Vigna unguiculata*)	500 g	500 g	–	–
Bambara groundnut (*Vigna subterranea*)	–	–	500 g	500 g
Water	1000 mL (soaking) + wet milling	1000 mL (soaking) + reconstitution (1:1.5, w/w flour:water)	1000 mL (soaking) + wet milling	1000 mL (soaking) + reconstitution (1:1.5, w/w flour:water)
Vegetable oil	30 mL	30 mL	30 mL	30 mL
Salt	5 g	5 g	5 g	5 g
Ground crayfish	2 g	2 g	2 g	2 g
Portion size	100 mL	100 mL	100 mL	100 mL
Steaming conditions	95–100°C, 45 min	95–100°C, 45 min	95–100°C, 45 min	95–100°C, 45 min

WC = Wet-Processed Cowpea Moi-Moi; DC = Dry-Processed Cowpea Moi-Moi; WB = Wet-Processed Bambara Groundnut Moi-Moi; DB = Dry-Processed Bambara Groundnut Moi-Moi.

Wet Processing

Wet processing of the legume paste was based on a modified procedure for preparing *Moi-Moi* in Nigeria, as reported by Omueti and Ashaye (1998), Owuamanam et al. (2013), and Otunola and Afolayan (2018). Specifically, 500g of either cowpeas or Bambara groundnuts' seeds were sorted, washed with potable water, and subsequently allowed to soak in 1000mL of water at room temperature (25–28 °C) for 8 h. Dehulling of the softened legumes was achieved by rubbing the soaked seeds between both hands and subsequent washing of the cotyledons to get rid of the seed coats. Wet-milling of the dehulled seeds into a paste was performed using a lab-manual wet grinder (Corona-type manual attrition mill on a Kenwood BLM800 blender), with water added incrementally during milling.

Dry Processing

The method for preparing dry-processed legume flour was based on the process of producing *Moi-Moi* flour discussed by Akinjayeju and Enude (2004), Owuamanam et al. (2013), and Otunola and Afolayan (2018). 500g of cowpea or Bambara groundnut seeds were separated, washed in tap water, and soaked in 1000 mL of water at room temperature (25-28 °C) for 8 hours to facilitate dehulling. Dehulled cotyledon was oven dried at 50 °C for 6 hours using hot air oven (Gallenkamp Plus II Oven, model OMT 297, Sanyo Gallenkamp PLC, Loughborough, UK) to reduce moisture to uniform levels after which the samples were milled into flour using laboratory hammer mill (Christy and Norris Laboratory Mill, model 8-inch, Christy Turner Ltd., Chelmsford, UK) that had a 0.5mm mesh sieve attached to it. Flour was mixed with tap water at a fixed ratio to form a paste of the same consistency as the wet-processed paste. Flour was packed in airtight polythene bags and stored at room temperature before preparing *Moi-Moi*.

***Moi-Moi* Formulation and Steaming**

Moi-Moi was prepared from either the wet-milled legume pastes or the dry legume flour. For the wet-processed samples, the freshly prepared paste was transferred into a clean mixing bowl. In contrast, for the dry-processed samples, the flour was reconstituted with potable water at a floor-to-water ratio of approximately 1:1.5 (w/w) to obtain a smooth batter. Each formulation contained 30 mL of vegetable oil, 5 g of salt, and 2 g of ground crayfish, which were thoroughly mixed using a kitchen blender (Kenwood BLM800, Kenwood Ltd., Havant, UK) to obtain a homogeneous batter. Sufficient water was added where necessary to achieve a thick but pourable consistency.

The batter was portioned (150 g per unit) into *Moi-Moi* wrapping foil (aluminum foil, food-grade), sealed, and steamed in an electric steamer/pot (Binatone Steamer, Model ST-2015, Binatone Electronics International Ltd.) at 100 °C for 45 minutes until fully set. Steamed samples were cooled to room temperature (25 ± 2 °C), then freeze-dried (Christ Alpha 1-4 LD Plus Freeze Dryer, Martin Christ Gefriertrocknungsanlagen GmbH, Osterode, Germany) to halt further biochemical change, milled into a fine composite flour using a laboratory blender (Waring Commercial Blender, Model 8011ES, Waring Products, Torrington, CT, USA), passed through a 0.5 mm sieve, and stored in airtight containers at 4 °C until analysis Figure 1.

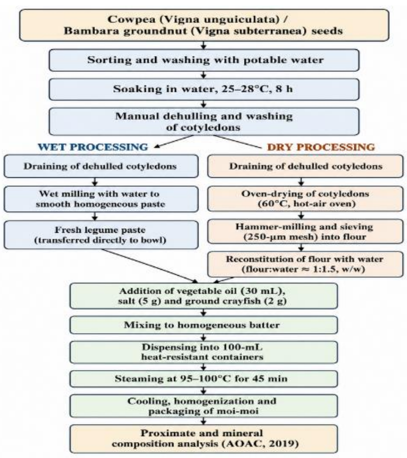

Figure 1: Process flow diagram for wet- and dry-processed cowpea and Bambara groundnut *Moi-Moi* preparation.

Proximate Composition Analysis

Proximate composition of the four *Moi-Moi* samples was determined in triplicate following the standard methods of the Association of Official Analytical Chemists (AOAC, 2019).

Moisture content was quantified using the gravimetric method, where each sample (2 g) was dried to a constant weight at 105 °C in a hot air oven (Gallenkamp Plus II Oven, Model OMT 297, Sanyo Gallenkamp PLC, UK) (AOAC Method 925.10). The ash content was determined by incinerating 2 g of each sample at 550 °C for 6 hours in a muffle furnace (Carbolite Muffle Furnace, Model CWF 1100, Carbolite Gero Ltd., Sheffield, UK) until white/grey ash was produced (AOAC Method 923.03). Crude fat content was quantified using the Soxhlet fat extraction system (Soxtec 2050 Auto Fat Extraction Unit, FOSS Analytical AB, Hillerød, Denmark). It involved continuous solvent extraction using 5 g of sample and petroleum ether (boiling range 40–60 °C) for 6 hours (AOAC Method 920.39). Crude protein content was measured using the micro-Kjeldahl method through digestion of samples in a Kjeldahl digestion and distillation system (Kjeltec 8400 Auto Analyzer, FOSS Analytical AB, Hillerød, Denmark), after which nitrogen content was converted to crude protein content using a conversion factor of 6.25 (AOAC Method 979.09). The amount of crude fibre was measured through acid and alkaline hydrolysis of the defatted sample using a fibre analyser (Fibretec 2010 Fibre Analysis System, FOSS Analytical AB, Hillerød, Denmark), and then ashing of the residue in the muffle furnace as explained earlier (AOAC Method 962.09). The carbohydrate content was obtained as the difference (% Carbohydrate = 100 − (% moisture + % ash + % crude fat + % crude protein + % crude fibre).

Mineral Composition Analysis

Regarding the mineral analysis, the digested 2 g samples of the dried and ground samples were then digested using diluted hydrochloric acid, after wet digestion using a mixture of concentrated nitric acid and perchloric acid (in a 2:1 ratio v/v) using a digestion block (Tecator Digestion System 40, FOSS Analytical AB, Hillerød, Denmark). The filtrate was passed through Whatman No. 42 filter paper and made up to volume with distilled water. Determination of Ca, Mg, Fe, and Zn was done using atomic absorption spectrophotometry (Buck Scientific Model 210 VGP Atomic Absorption Spectrophotometer, Buck Scientific Inc., East Norwalk, CT, USA) where specific element hollow cathode lamps were used to analyze samples in comparison to standard curves made from certified reference standards. Potassium (K) was analyzed using flame emission photometry (Jenway PFP7 Flame Photometer, Cole-Parmer/Jenway, Stone, UK) using a standard K solution for calibration. Phosphorus (P) determination was colorimetric using the vanadomolybdate (yellow) method, with absorbance measured at 420 nm on a UV-visible spectrophotometer (Jenway 6305 UV-Vis Spectrophotometer, Cole-Parmer/Jenway, Stone, UK). The analysis was based on a comparison to the standard P curve. All mineral analyses were done in triplicate, and concentrations were expressed as mg/100 g of sample.

Statistical Analysis

All analyses were done in triplicate, and values were presented as mean ± standard deviation (SD). All values were analyzed using the One-way Analysis of Variance (ANOVA) statistical method in IBM SPSS Statistics package (version 25.0, IBM Corp., Armonk, NY, USA). In case of significant differences, means were compared by Bonferroni-adjusted post hoc tests ($p<0.05$).

RESULTS AND DISCUSSION

Proximate Composition of Moi-Moi Prepared from Wet- and Dry-Processed Beans and Bambara Groundnut

Proximate compositions of the different samples of *Moi-Moi* are shown in Table 2. There were significant differences ($p<0.05$) between the four treatments for all proximate components. Protein values ranged from 16.67 ± 0.02% in wet-processed Bambara groundnut *Moi-Moi* to 24.23 ± 0.01% in dry-processed bean *Moi-Moi*, the latter having the highest protein level among the four treatments. There were also significant variations in fat content, with the highest being in wet-processed bean *Moi-Moi* (2.97 ± 0.02%) and the lowest in dry-processed bean and dry-processed Bambara groundnut *Moi-Moi* (2.01 ± 0.02%). The highest crude fiber content was observed in dry-processed Bambara groundnut *Moi-Moi* (1.87 ± 0.02%), and the lowest was in wet-processed bean *Moi-Moi* (1.64 ± 0.02%).

There were significant differences in ash content, ranging from 1.30 ± 0.08% in wet-processed bean *Moi-Moi* to 1.96 ± 0.01% in dry-processed Bambara groundnut *Moi-Moi*. Wet Bambara groundnut samples had the highest moisture content of 38.02-38.03%, which were not significantly different from each other, and dry-processed bean *Moi-Moi* had the lowest moisture content (37.01 ± 0.01%). There were also significant differences in carbohydrate content, with the highest observed in wet-processed Bambara groundnut *Moi-Moi* (39.62 ± 0.12%) and the lowest.

Table 2: Proximate Composition (%) of *Moi-Moi* Prepared from Wet- and Dry-Processed Beans and Bambara Groundnut

Parameter	Wet Beans	Dry Beans	Wet Bambara Groundnut	Dry Bambara Groundnut
Protein (%)	19.81 ± 0.04^{a}	24.23 ± 0.01^{b}	16.67 ± 0.02^{c}	21.35 ± 0.02^{d}
Fat (%)	2.97 ± 0.02^{a}	2.01 ± 0.02^{b}	2.32 ± 0.02^{c}	2.01 ± 0.01^{b}
Fibre (%)	1.64 ± 0.02^{a}	1.76 ± 0.02^{b}	1.67 ± 0.02^{ab}	1.87 ± 0.02^{c}
Ash (%)	1.30 ± 0.08^{a}	1.75 ± 0.00^{b}	1.71 ± 0.02^{b}	1.96 ± 0.01^{c}
Moisture (%)	37.57 ± 0.02^{a}	37.01 ± 0.01^{b}	38.03 ± 0.04^{c}	38.02 ± 0.02^{c}
Carbohydrate (%)	36.84 ± 0.03^{a}	33.21 ± 0.11^{b}	39.62 ± 0.12^{c}	34.81 ± 0.09^{d}

Values are expressed as mean ± standard deviation (SD) of triplicate determinations. Means within the same row with different superscript letters are significantly different at $p < 0.05$, based on Bonferroni-adjusted pairwise comparisons following one-way ANOVA.

Mineral Composition of Moi-Moi Prepared from Wet- and Dry-Processed Beans and Bambara Groundnut

The mineral composition of the *Moi-Moi* samples has been summarized in Table 3. There was a significant difference ($p<0.05$) in magnesium, potassium, calcium, iron, zinc, and phosphorus between all four treatments. Dry-processed Bambara groundnut *Moi-Moi* had the highest magnesium

(68.56± 0.02 mg/100 g) and calcium (88.97± 0.02 mg/100 g) contents in all the samples, while wet-processed bean *Moi-Moi* had the lowest mineral content for both these minerals. On the contrary, dry-processed bean *Moi-Moi* had the highest potassium (231.09±0.01 mg/100 g), iron (12.43±0.02 mg/100 g), zinc (8.24±0.02 mg/100 g), and phosphorus (119.22±0.02 mg/100 g) contents among all the samples.

Table 3: Mineral Composition (mg/100 g) of *Moi-Moi* Prepared from Wet- and Dry-Processed Beans and Bambara Groundnut

Parameter	Wet Beans	Dry Beans	Wet Bambara Groundnut	Dry Bambara Groundnut
Magnesium (Mg)	21.47 ± 0.02^{a}	33.40 ± 0.01^{b}	47.08 ± 0.02^{c}	68.56 ± 0.02^{d}
Potassium (K)	195.38 ± 0.01^{a}	231.09 ± 0.01^{b}	130.88 ± 0.01^{c}	190.58 ± 0.01^{d}
Calcium (Ca)	20.03 ± 0.01^{a}	31.24 ± 0.01^{b}	63.63 ± 0.01^{c}	88.97 ± 0.02^{d}
Iron (Fe)	8.83 ± 0.01^{a}	12.43 ± 0.02^{b}	1.65 ± 0.02^{c}	3.87 ± 0.02^{d}
Zinc (Zn)	6.14 ± 0.02^{a}	8.24 ± 0.02^{b}	5.43 ± 0.02^{c}	6.62 ± 0.02^{d}
Phosphorus (P)	72.85 ± 0.03^{a}	119.22 ± 0.02^{b}	61.93 ± 0.02^{c}	97.36 ± 0.02^{d}

Values are expressed as mean ± standard deviation (SD) of triplicate determinations. Means within the same row with different superscript letters are significantly different at $p < 0.05$, based on Bonferroni-adjusted pairwise comparisons following one-way ANOVA.

Discussion

From the findings, there was an impact on the composition of *Moi-Moi* caused by processing technique (wet and dry) and legume (cowpea and Bambara groundnut). This trend aligns with the general findings from legume processing studies, which typically show that both ingredients and processing affect the nutrient composition of Bambara groundnut, cowpea, and their processed forms (Yahaya *et al.,* 2022; Kamani *et al.,* 2024). The findings agree with previous studies on *Moi-Moi*, which indicate that the change in legumes used will cause a change in the composition of protein, fibre, ash, carbohydrate, and minerals (Linus-Chibuezeh *et al.,* 2025; Arukwe *et al.,* 2023).

Considering the high protein level found in the dry-processed bean *Moi-Moi*, this suggests that the process was effective at concentrating solids compared to wet processing, which may have allowed dilution of nutrients through soaking and washing (Mazahib *et al.,* 2013; Kamani *et al.,* 2024). In line with these results, it aligns with general information on Bambara groundnut, where the type of processing influences the protein levels positively or negatively based on the process used, such as steam, malt, germination, and some dry preparations (Yahaya *et al.,* 2022; Mashau *et al.,* 2025; Ukpong *et al.,* 2026). The presence of higher fibre and ash in samples that are dried is due to the fact that in water processing, soluble solids and materials that contain minerals are stripped off through leaching (Yahaya *et al.,* 2022). Similar observations are made in fortified *Moi-Moi* systems, whereby there is an increase in the levels of fibre and ash content in the presence of legumes with high fibre content, while wet processing causes ash content to decrease because soluble minerals move into the processing water (Arukwe *et al.,* 2023; Carpathian Journal of Food Science and Technology, 2024; Mazahib *et al.,* 2013). The increased fat content in wet-processed bean *Moi-Moi* shows that lipids did not behave the same way as proteins and ash. It is quite common during legume processing, as different methods distribute nutrient fractions in varying ways without necessarily increasing their concentrations simultaneously (Mashau *et al.,* 2025; Arukwe *et al.,* 2023). Increased carbohydrate content in wet-processed Bambara groundnut *Moi-Moi* suggests a negative correlation between carbohydrates and other fractions when calculated using the difference method: decreased amounts of protein, fiber, and ash correspond to increased amounts of carbohydrates (Mashau *et al.,* 2025; Arukwe *et al.,* 2023).

The mineral concentration results show trends described in the literature on legume processing rather than an unusual outcome. Dry-processed Bambara groundnut *Moi-Moi* had the highest levels of magnesium and calcium, suggesting that Bambara groundnut is rich in divalent minerals and that the dry processing method better retains minerals, whereas the wet processing method allows for leaching losses (Adeleke *et al.,* 2017; Mazahib *et al.,* 2013). Dry-processed bean *Moi-Moi* had the highest levels of potassium, iron, zinc, and phosphorus, suggesting that it was richer in these minerals during dry processing (Linus-Chibuezeh *et al.,* 2025; Dumoulin *et al.,* 2021). The generally lower mineral levels observed in wet-processed samples are owing to the well-known action of soaking and boiling water in dissolving and leaching minerals from legume matrices (Yahaya *et al.,* 2022; Mazahib *et al.,* 2013). Notably, the response to mineral processing was not homogeneous among the minerals examined, since some processing steps that reduce mineral levels might, at the same time, enhance mineral bioavailability by reducing antinutrients (Mashau *et al.,* 2025; Ukpong *et al.,* 2026). This is in agreement with previous works on Bambara groundnuts that demonstrated that mineral composition alteration through processing is selective and not uniform for all minerals, as dehulling may reduce the calcium, potassium, and iron levels, while different processing methods can increase phosphorus, magnesium, potassium, or iron (Yahaya *et al.,* 2022; Mashau *et al.,* 2025). In a broader context, legume fractionation studies suggest that wet and dry fractionation techniques differ in the partitioning of nutrients, so that while one approach can facilitate protein extraction, another one will provide more efficient extraction of fiber and mineral components (Schutyser *et al.,* 2025; Liu *et al.,* 2025). The results show that dry processing was more effective than wet processing for nutrient density of proteins, fibre, ash, and certain minerals in the two tested legumes (Silotolo *et al.,* 2026). Leaching may have been responsible for the low ash and mineral nutrient content in samples processed by wetting, as this treatment yielded good results for moisture and texture (Yahaya *et al.,* 2022; Mazahib *et al.,* 2013). The two legumes added various nutrients to the products: Bambara groundnut enriched the product with magnesium and calcium, whereas beans contributed potassium, iron, zinc, and phosphorus (Ajala *et al.,* 2024; Linus-Chibuezeh *et al.,* 2025).

One critical limitation worth mentioning is that the nutritional value of a food cannot be defined solely by its nutrient composition, because certain wet processing methods can increase mineral extractability and protein digestibility even when nutrient composition declines (Mazahib *et al.,* 2013; Mashau *et al.,* 2025). Thus, the low nutrient content noted in the wet processing method used in this study cannot be considered as inferior nutritional value without taking into account bioavailability data. Overall, the results support the conclusion that dry-processed bean *Moi-Moi* was nutritionally strongest for protein and several key minerals. In contrast, dry-processed Bambara groundnut *Moi-Moi* was distinguished by its fibre, ash, magnesium, and calcium content.

CONCLUSION

It has been shown in this study that both processing methods and types of legumes had a significant effect on the nutrient content of *Moi-Moi*. Dry processing yielded *Moi-Moi* with a higher content of protein, fibre, and ash compared to wet processing in both cowpea and Bambara groundnut, but wet processing had a higher fat and carbohydrate content. The dry processing of bean *Moi-Moi* showed the highest level of protein, potassium, iron, zinc, and phosphorus. In contrast, the dry processing of Bambara groundnut *Moi-Moi* was characterized by a higher fiber, ash, magnesium, and calcium content. Wet processing likely reduced mineral content due to the leaching of minerals into soaking and cooking water.

These results demonstrate the suitability of dry-processing methods for optimizing the nutrient density of *Moi-Moi* and also show the nutritional importance of the Bambara groundnut as an alternative legume whose mineral composition could help enrich *Moi-Moi* with minerals, especially magnesium and calcium. Those interested in improving the nutritional value of *Moi-Moi* should therefore consider adopting dry-processing methods and replacing cowpea partially or wholly with Bambara groundnut. Further investigations combining assessments of mineral bioavailability and antinutrients with those of proximate and mineral composition would be worthwhile to explore the nutritional implications of wet versus dry processing of legume steamed food products.

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