

Proximate Composition and Sensory Acceptability of Moi-Moi Produced from Selected Cowpea Varieties and Pigeon Pea

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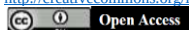
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ABSTRACT

This study investigated the proximate composition and sensory acceptability of moi-moi prepared from four legume materials: pigeon pea (*Cajanus cajan*), drum bean (*Vigna unguiculata*), honey bean or oloyin (*Vigna unguiculata*), and white cowpea/black-eyed bean (*Vigna unguiculata*). The work was designed to determine whether varietal choice could provide nutritionally valuable and consumer-acceptable alternatives for a traditional steamed legume pudding. The legumes were sorted, soaked, dehulled, wet-processed into paste, standardized with the same quantities of water, vegetable/palm oil, onion, pepper, salt, and seasoning, and steamed for 50 min. Moisture, ash, crude lipid, crude fibre, crude protein, and carbohydrate were determined in duplicate using AOAC procedures, while a 50-member consumer panel evaluated colour, appearance, aroma, texture, mouthfeel, and overall acceptability on a nine-point hedonic scale. Data were analysed by one-way analysis of variance and Duncan's Multiple Range Test at $p < 0.05$. Significant differences were observed among formulations. Protein ranged from 23.85% to 25.35%, with white bean moi-moi recording the highest value, while drum bean had comparatively high protein, ash, and fibre. Honey bean produced the highest carbohydrate value (63.73%) and achieved the highest scores for aroma (8.87), texture (8.98), and overall acceptability (8.88). White bean also showed strong overall acceptability (8.78), whereas drum bean received the highest colour score (8.62). The findings demonstrate that legume type meaningfully affects both nutritional composition and eating quality. Honey bean and white bean appear particularly promising for consumer-oriented production, while pigeon pea provides an opportunity to diversify legume utilization and broaden the raw-material base of moi-moi.

1. Introduction

Legumes are central to food and nutrition security because they provide relatively inexpensive plant protein, complex carbohydrates, dietary fibre, minerals, and several bioactive compounds. Their agronomic importance is equally substantial: many leguminous crops contribute biological nitrogen fixation, perform comparatively well under low-input systems, and support diversification of cereal- and root-dominated diets. These characteristics are especially important in sub-Saharan Africa, where affordability, climatic variability, and the need for locally adapted nutrient-dense foods shape household food choices. Cowpea (*Vigna unguiculata* L. Walp.) is one of the most important food legumes in the region and is valued for its adaptation to warm and relatively dry environments as well as for its role as a protein-rich staple (Gonçalves et al., 2016; Abebe & Alemayehu, 2022; Affrifah et al., 2022).

Cowpea seeds commonly contain substantial amounts of protein and carbohydrate with relatively low lipid content, although their composition varies by genotype, growing environment, maturity, storage history, and processing conditions. Contemporary reviews place cowpea protein broadly within the range expected of a protein-dense pulse and emphasize the crop's contribution of lysine, dietary fibre, potassium, polyphenols, and other nutritionally relevant constituents (Affrifah et al., 2022; Zolqadri & Li, 2025). Such compositional diversity is not merely a laboratory observation; it can

influence water absorption, paste viscosity, foaming, emulsion behaviour, gelation, flavour development, and texture during cooking. These functional responses ultimately shape the quality of traditional foods produced from cowpea.

Moi-moi (also written moin-moin) is a widely consumed steamed legume pudding in Nigeria and other parts of West Africa. It is traditionally produced by soaking and dehulling cowpea, wet-milling the cotyledons, mixing the paste with water, oil, pepper, onion, salt, and other seasonings, and steaming the mixture until a cohesive gel is formed. The food may be eaten as a meal, snack, accompaniment, or complementary protein source. Previous studies have demonstrated that the processing route, flour or paste system, degree of dehulling, variety, and inclusion of other plant materials can alter the proximate composition and sensory quality of cowpea products (McWatters et al., 1993; Uwaegbute et al., 2000; Henshaw et al., 2009; Otunola & Afolayan, 2018).

Varietal selection is particularly important because consumers judge moi-moi through an integrated set of sensory cues. Colour and appearance influence first impressions; aroma contributes to flavour expectation; texture reflects the structure created through starch gelatinization and protein denaturation; and mouthfeel determines smoothness, cohesiveness, grittiness, and ease of swallowing. Henshaw et al. (2009) showed that cowpea variety can affect the sensory properties of both akara and moinmoin, while more recent work on indigenous Nigerian cowpea varieties also reported significant differences in proximate, functional, and sensory characteristics among varietal formulations (Usman et al., 2026). The implication is that raw-material identity should be treated as a product-development variable rather than as an interchangeable ingredient choice.

Beyond conventional cowpea, the greater use of underutilized legumes offers a pathway for dietary diversification and improved resilience of food systems. Pigeon pea (*Cajanus cajan*) is a drought-tolerant legume with appreciable protein, carbohydrate, fibre, mineral, and bioactive compound content. It is consumed in several forms across tropical and subtropical regions but remains less intensively exploited in many value-added foods than major pulses. Recent reviews highlight its potential in diversified food products and its relevance to nutrition-sensitive and climate-resilient agriculture (Ayilara et al., 2022; Haji et al., 2024; Acheampong et al., 2025). Incorporating pigeon pea into familiar food formats such as moi-moi can therefore support wider utilization without requiring consumers to adopt entirely unfamiliar eating practices.

Existing moi-moi studies have explored germinated cowpea, cowpea flour, and composite systems involving water yam, Bambara groundnut, avocado pear seed, and other ingredients (Uwaegbute et al., 2000; Okwunodulu et al., 2019; Emelike et al., 2020). However, fewer studies have directly compared multiple locally available bean types under one standardized recipe and cooking protocol while simultaneously examining both proximate composition and a broad set of sensory attributes. This gap is relevant to households, caterers, processors, and nutrition programmes because a formulation that is nutritionally strong but poorly accepted is unlikely to achieve sustained consumption, whereas a highly preferred product with weaker nutritional attributes may not satisfy nutrition-oriented objectives.

Accordingly, this study evaluated moi-moi produced separately from pigeon pea, drum bean, honey bean, and white bean/black-eyed cowpea under standardized processing conditions. The specific objectives were to (i) determine the moisture, ash, crude lipid, crude fibre, crude protein, and carbohydrate contents of the four formulations; (ii) compare consumer ratings for colour, appearance, aroma, texture, mouthfeel, and overall acceptability; and (iii) identify varieties with the strongest combined nutritional and sensory performance. It was expected that varietal differences in seed composition and processing behaviour would produce measurable differences in both proximate composition and consumer perception.

2. Materials and Methods

2.1 Study Design

The investigation followed a comparative experimental design in which four single-legume moi-moi formulations were prepared under the same recipe and thermal processing conditions. Legume type was the principal treatment factor. The formulations were coded PP100, DB100, HB100, and WB100 to represent 100% pigeon pea, 100% drum bean, 100% honey bean, and 100% white bean, respectively. Proximate measurements were conducted in duplicate, and sensory evaluation was carried out with 50 familiar consumers. This design allowed direct comparison of the nutritional composition and

acceptability of the four raw-material options while minimizing differences attributable to recipe composition or cooking time.

2.2 Source of Raw Materials

Honey bean (locally known as oloyin), drum bean, and white bean/black-eyed cowpea were purchased from Oja-Oba Market in Owo, Ondo State, Nigeria. These market types are treated in this manuscript as forms of *Vigna unguiculata*, consistent with Nigerian varietal descriptions in the literature, including identification of oloyin and drum beans as *V. unguiculata* (Olopade et al., 2017). Pigeon pea (*Cajanus cajan*) seeds were sourced from Emure Market in Owo, Ondo State, Nigeria. Vegetable/palm oil, fresh onion, red pepper, salt, seasoning cubes, and potable water used for processing were obtained from local retail sources. All reagents used for proximate analysis were of analytical grade.

2.3 Preparation and Dehulling of Legume Seeds

The legumes were processed using the study procedure adapted from Arawande and Borokini (2010). Seeds were manually sorted to remove stones, broken grains, foreign materials, and visibly defective seeds. Drum bean, honey bean, and white bean samples were soaked in cold water at approximately 25 °C for 10 min to facilitate dehulling. The softened seed coats were removed manually and the cotyledons were washed thoroughly with clean water. Because pigeon pea possesses a comparatively hard seed coat, it was soaked for 48 h before manual dehulling. The extended hydration step was used to soften the hull and permit practical removal without excessive mechanical damage to the cotyledons.

2.4 Moi-Moi Formulation and Thermal Processing

For each treatment, 500 g of dehulled wet legume paste was used as the base material. The paste was mixed with 900 mL warm water, 50 mL vegetable/palm oil, 25 g fresh onion, 10 g red pepper, 5 g salt, and 40 g seasoning cubes. Ingredients were blended until a homogeneous slurry was obtained. Equal portions were transferred into heat-resistant packaging nylon bags and steamed in a tightly covered pot for 50 min using a gas cooker. After cooking, samples were removed and cooled to ambient temperature (28 ± 2 °C) before analytical and sensory evaluation. The use of a common formulation was intended to ensure that differences observed among treatments primarily reflected the legume material rather than variation in seasoning or processing intensity.

Table 1. Experimental formulations and standardized processing conditions

Code	Legume material	Scientific identity	Base paste	Processing condition
PP100	Pigeon pea	<i>Cajanus cajan</i>	500 g	900 mL water + standard seasonings; steam 50 min
DB100	Drum bean	<i>Vigna unguiculata</i>	500 g	900 mL water + standard seasonings; steam 50 min
HB100	Honey bean (oloyin)	<i>Vigna unguiculata</i>	500 g	900 mL water + standard seasonings; steam 50 min
WB100	White bean/black-eyed cowpea	<i>Vigna unguiculata</i>	500 g	900 mL water + standard seasonings; steam 50 min

2.5 Proximate Composition Analysis

Moisture, ash, crude lipid, crude fibre, crude protein, and carbohydrate were determined in duplicate using standard procedures of the Association of Official Analytical Chemists (AOAC, 2019). The analyses were conducted on each of the four moi-moi formulations using the same analytical basis. Moisture measurement provided an index of water retained in the analysed sample; ash represented the inorganic residue remaining after incineration and therefore served as a general indicator of total mineral matter; crude lipid represented the solvent-extractable fat fraction; crude fibre represented the conventionally determined fibrous fraction; and crude protein reflected total nitrogen converted to protein using the applicable AOAC procedure. Carbohydrate values were reported as supplied by the original analytical dataset. Results were expressed as percentage composition and summarized as mean ± standard deviation.

2.6 Sensory Evaluation

Sensory evaluation followed the consumer-acceptability approach described by Iwe (2017) and the general principles of hedonic testing used in food sensory science (Lawless & Heymann, 2010). Fifty panelists who were familiar with moi-moi evaluated the coded samples. The attributes assessed were colour, appearance, aroma, texture, mouthfeel, and overall acceptability. A nine-point hedonic scale was used, where 1 represented ‘dislike extremely’, 5 represented ‘neither like nor dislike’, and 9 represented ‘like extremely’. Samples were cooled before presentation so that evaluations reflected the intended eating condition rather than differences caused by extreme serving temperature. The mean score for each attribute was calculated for each formulation.

2.7 Statistical Analysis

Data were analysed using one-way analysis of variance (ANOVA) in SPSS Version 21.0. Where the ANOVA indicated treatment effects, Duncan’s Multiple Range Test (DMRT) was used for mean separation. Statistical significance was set at $p < 0.05$. In the tables, means within the same column carrying different superscript letters were interpreted as significantly different at the stated probability level. Proximate results are reported as mean $\pm$ standard deviation for duplicate determinations ($n = 2$), whereas sensory values are reported as mean $\pm$ standard deviation for the 50-member panel ($n = 50$).

2.8 Methodological Scope

The experimental design provides a useful side-by-side comparison of four legume materials under a controlled recipe. Nevertheless, the proximate analysis was based on duplicate determinations and the sensory panel was composed of familiar consumers rather than a formally trained descriptive panel. The study therefore supports comparative nutritional and acceptability conclusions, but it does not provide instrumental texture measurements, colourimetry, volatile-aroma profiling, shelf-life data, or detailed descriptive sensory profiles. These considerations are important when interpreting the findings and defining the next stage of product-development research.

3. Results and Discussion

3.1 Proximate Composition of the Moi-Moi Formulations

The proximate composition of the four formulations is presented in Table 2. The results indicate significant ($p < 0.05$) differences among treatments across the measured components, confirming that the choice of legume material influenced the chemical profile of the final product. This is consistent with the broader cowpea literature, which shows that genotype and processing conditions affect nutrient composition and the functional behaviour of legume-based foods (Gonçalves et al., 2016; Affrifah et al., 2022). In practical terms, the four formulations cannot be regarded as nutritionally identical even though the recipe and steaming procedure were standardized.

Table 2. Proximate composition of moi-moi formulations (%)

Sample	Moisture	Ash	Crude lipid	Crude fibre	Crude protein	Carbohydrate
PP100	7.86 $\pm$ 0.02 ^b	3.68 $\pm$ 0.21 ^b	2.75 $\pm$ 0.01 ^b	2.97 $\pm$ 0.03 ^b	23.94 $\pm$ 0.01 ^c	58.75 $\pm$ 0.31 ^c
DB100	9.81 $\pm$ 0.21 ^a	4.26 $\pm$ 0.01 ^a	2.18 $\pm$ 0.21 ^c	3.62 $\pm$ 0.01 ^a	25.05 $\pm$ 0.01 ^b	62.28 $\pm$ 0.16 ^a
HB100	8.02 $\pm$ 0.47 ^b	4.26 $\pm$ 0.01 ^a	2.31 $\pm$ 0.02 ^c	2.62 $\pm$ 0.02 ^c	23.85 $\pm$ 0.02 ^{cd}	63.73 $\pm$ 0.89 ^a
WB100	6.45 $\pm$ 0.02 ^c	3.15 $\pm$ 0.01 ^c	2.88 $\pm$ 0.01 ^a	2.78 $\pm$ 0.01 ^{bc}	25.35 $\pm$ 0.01 ^a	59.57 $\pm$ 0.44 ^c

Note. Values are mean $\pm$ standard deviation ($n = 2$). Within a column, means with different superscript letters are significantly different ($p < 0.05$). PP100 = pigeon pea; DB100 = drum bean; HB100 = honey bean; WB100 = white bean.

3.1.1 Moisture Content

Moisture values ranged from 6.45% in WB100 to 9.81% in DB100, with HB100 (8.02%) and PP100 (7.86%) occupying intermediate positions. The significant differences suggest variation in the amount of water retained by the analysed matrix after standardized steaming and cooling. Such variation can arise from differences in seed structure, starch characteristics, protein-water interactions, fibre content, and the extent to which the paste forms a water-holding network during heating. Cowpea processing research has repeatedly shown that raw-material composition and functional properties influence hydration and the physical characteristics of finished products (Affrifah et al., 2022; Zolqadri & Li, 2025). The comparatively higher moisture value of DB100 may therefore reflect stronger water

retention by the drum-bean matrix, whereas WB100 retained the least moisture under the analytical conditions used.

Moisture is important because it affects softness, perceived juiciness, structural stability, and the susceptibility of foods to spoilage. However, the absolute moisture values reported here should be interpreted strictly according to the analytical basis used for the original dataset. For final journal submission, the analytical basis (for example, whether results are expressed on an as-analysed or dry-weight basis) should be stated explicitly so that the data can be compared directly with published moi-moi studies, many of which report considerably higher water content for freshly steamed products (Otunola & Afolayan, 2018; Okwunodulu et al., 2019; Usman et al., 2026).

3.1.2 Ash Content

Ash content ranged from 3.15% to 4.26%. DB100 and HB100 recorded the highest value (4.26%), PP100 had 3.68%, and WB100 had the lowest value (3.15%). Ash is the residue of inorganic matter remaining after complete combustion and is commonly used as an overall index of mineral material in foods. The results therefore suggest that drum bean and honey bean may contribute a comparatively greater mineral fraction to the product, although individual minerals such as iron, calcium, zinc, magnesium, potassium, and phosphorus were not measured in this study. A higher ash value should not be interpreted as evidence for higher concentration of every individual mineral; mineral profiling would be required to establish that conclusion.

Differences in ash among legume varieties are expected because mineral accumulation is influenced by genotype, soil conditions, agronomic management, maturity, and postharvest handling. Reviews of cowpea and pigeon pea composition likewise report variation in mineral and ash fractions across cultivars and production environments (Abebe & Alemayehu, 2022; Haji et al., 2024). The relatively strong ash values of DB100 and HB100 may be useful where raw-material selection is intended to maximize the overall nutrient density of a traditional legume dish.

3.1.3 Crude Lipid Content

Crude lipid ranged from 2.18% in DB100 to 2.88% in WB100. PP100 contained 2.75%, while HB100 contained 2.31%. These values confirm the generally low-fat character of the legume base, although the standardized addition of vegetable/palm oil contributes to the final lipid fraction. Cowpeas are typically described as relatively low-lipid pulses compared with oilseeds, a characteristic that contributes to their role as a protein- and carbohydrate-rich staple (Gonçalves et al., 2016; Affrifah et al., 2022). Pigeon pea is also generally regarded as a low-fat legume, with composition varying by variety and processing history (Haji et al., 2024).

From a product-quality perspective, lipid contributes to flavour release, lubrication, mouth-coating, and the perception of richness. The highest lipid value in WB100 may have contributed modestly to its favourable mouthfeel score, although sensory response cannot be attributed to lipid alone because protein gelation, particle size, moisture distribution, seasonings, and starch behaviour also influence eating quality. The comparatively low lipid value of DB100 did not prevent it from achieving a high mouthfeel score, illustrating that sensory perception depends on the total food matrix rather than on a single proximate component.

3.1.4 Crude Fibre Content

Crude fibre was highest in DB100 (3.62%), followed by PP100 (2.97%), WB100 (2.78%), and HB100 (2.62%). The significant difference between treatments is relevant to nutritional quality because fibre contributes to gastrointestinal function and can modify the rate of digestion and postprandial metabolic response (Messina, 2014). Nigerian bean varieties have previously been shown to differ in fibre content, including drum, oloyin, and white cowpea types (Olopade et al., 2017). This supports the present observation that varietal identity can affect the fibre contribution of a legume-based meal.

The relatively high fibre value of DB100 is nutritionally attractive, although fibre may also influence textural properties by increasing water binding and modifying paste structure. In the current study, DB100 simultaneously achieved the highest crude fibre content and one of the highest texture and mouthfeel ratings. This indicates that the fibre level present in this formulation did not create an unacceptable coarse or gritty product under the processing conditions used. Pigeon pea also produced an intermediate fibre value, reinforcing its potential as a useful alternative legume for product diversification.

3.1.5 Crude Protein Content

Protein content was one of the strongest nutritional attributes of all formulations, ranging from 23.85% to 25.35%. WB100 recorded the highest protein value (25.35%), closely followed by DB100 (25.05%), while PP100 and HB100 contained 23.94% and 23.85%, respectively. Cowpea is widely recognized as an affordable plant-protein source, and recent reviews commonly report seed protein concentrations in the range expected for pulse crops, with variation arising from genotype and processing (Abebe & Alemayehu, 2022; Affrifah et al., 2022; Zolqadri & Li, 2025). The results of the present study are therefore consistent with the broader nutritional role of cowpea-based foods.

The comparatively high protein values of WB100 and DB100 are important for populations that rely heavily on cereal, root, and tuber staples, which may provide adequate energy but less protein per unit weight. The findings also show that PP100 remained strongly protein-dense despite being produced from pigeon pea rather than cowpea. Pigeon pea is recognized for its substantial protein contribution and for its potential to complement staple-food diets in tropical regions (Haji et al., 2024). Thus, all four formulations can be considered meaningful plant-protein foods, with WB100 and DB100 showing a slight quantitative advantage in the present dataset.

3.1.6 Carbohydrate Content

Carbohydrate values ranged from 58.75% in PP100 to 63.73% in HB100. DB100 recorded 62.28%, while WB100 contained 59.57%. Legumes provide both protein and carbohydrate, and the carbohydrate fraction contributes energy as well as starch-related functional properties that are important during steaming. In a heated paste system, starch gelatinization occurs alongside protein denaturation and aggregation, helping to create the characteristic structure of moi-moi. Differences in starch concentration, granule properties, and interactions with proteins and lipids may therefore affect both the measured carbohydrate fraction and sensory texture.

HB100 combined the highest reported carbohydrate value with the highest aroma, texture, and overall acceptability scores. This association should not be interpreted as proof that carbohydrate concentration caused greater preference; rather, it suggests that the overall composition and processing behaviour of honey bean created a product that performed well both nutritionally and sensorially. Previous research on cowpea-based foods similarly shows that acceptability reflects complex interactions among composition, processing, and functional properties rather than a single nutrient measurement (Henshaw et al., 2009; Otunola & Afolayan, 2018).

3.2 Sensory Acceptability of Moi-Moi Formulations

Sensory scores are presented in Table 3. All mean values were above the midpoint of the nine-point hedonic scale, indicating that each formulation was generally acceptable to the panel. Nevertheless, significant differences ($p < 0.05$) occurred among samples for the evaluated attributes. This confirms that consumers were able to distinguish the products prepared from different legumes even when the recipe, ingredient quantities, and steaming time were held constant. The result agrees with studies reporting varietal and processing effects on the sensory quality of cowpea-based foods (Uwaegbute et al., 2000; Henshaw et al., 2009; Usman et al., 2026).

Table 3. Sensory scores of moi-moi formulations

Sample	Colour	Appearance	Aroma	Texture	Mouthfeel	Overall acceptability
PP100	7.92 ± 1.08^b	8.85 ± 1.62^a	8.28 ± 1.95^a	7.76 ± 2.04^a	7.96 ± 2.35^a	7.24 ± 1.12^b
DB100	8.62 ± 1.15^a	7.26 ± 1.78^b	7.74 ± 2.11^b	8.68 ± 2.02^b	8.16 ± 2.04^a	7.06 ± 1.54^b
HB100	7.84 ± 1.05^b	8.79 ± 1.64^a	8.87 ± 1.86^a	8.98 ± 2.07^b	7.15 ± 2.42^b	8.88 ± 1.93^a
WB100	8.24 ± 1.28^{ab}	7.26 ± 1.85^b	7.38 ± 1.77^b	7.72 ± 1.17^a	8.02 ± 1.27^a	8.78 ± 1.24^a

Note. Values are mean $\pm$ standard deviation ($n = 50$). Within a column, means with different superscript letters are significantly different ($p < 0.05$). PP100 = pigeon pea; DB100 = drum bean; HB100 = honey bean; WB100 = white bean.

3.2.1 Colour and Appearance

DB100 received the highest colour score (8.62), followed by WB100 (8.24), PP100 (7.92), and HB100 (7.84). Colour is a powerful first-stage quality cue because it shapes expectations before a food is tasted. Seed-coat characteristics are largely removed during dehulling, but cotyledon pigments, oil colour, thermal reactions, and the interaction of seasonings with the legume matrix can still create visible differences in the finished product. The strong colour score of DB100 suggests that the drum-bean matrix developed a hue that panelists considered particularly desirable under the standardized recipe.

Appearance ratings followed a different pattern. PP100 recorded 8.85 and HB100 8.79, both substantially higher than DB100 and WB100 (7.26 each). This demonstrates that colour and appearance, although related, were not judged as identical attributes by the panel. Appearance can incorporate surface smoothness, shape, structural integrity, uniformity, gloss, and the absence of visible defects. The high appearance score of PP100 is particularly encouraging for the use of pigeon pea because it shows that an underutilized legume can be transformed into a visually appealing version of a familiar food. Consumer acceptance of alternative legumes is more likely when the product retains the expected visual identity of the traditional dish.

3.2.2 Aroma

HB100 achieved the highest aroma score (8.87), followed by PP100 (8.28), DB100 (7.74), and WB100 (7.38). Aroma in legume products is influenced by intrinsic volatile compounds, enzymatic reactions that occur before heating, lipid-derived compounds, seasonings, and thermal transformations during steaming. Cowpea can possess characteristic ‘beany’ notes that may vary by variety and processing history, and modern reviews identify flavour management as an important issue in expanding food applications of cowpea protein and flour (Affrifah et al., 2022; Zolqadri & Li, 2025). The high aroma score of HB100 indicates that the natural flavour profile of honey bean interacted favourably with the standardized onion, pepper, oil, salt, and seasoning system.

The comparatively high aroma score of PP100 is also noteworthy. Pigeon pea is sometimes underutilized because consumers have less familiarity with its sensory properties in certain prepared foods. Its strong score suggests that, when appropriately soaked, dehulled, seasoned, and steamed, pigeon pea can produce a familiar and appealing aromatic profile. This supports the broader strategy of introducing underutilized legumes through culturally established foods rather than relying only on completely novel products (Ayilara et al., 2022; Haji et al., 2024).

3.2.3 Texture and Mouthfeel

Texture scores were highest in HB100 (8.98) and DB100 (8.68), whereas PP100 and WB100 recorded 7.76 and 7.72, respectively. The strong performance of HB100 suggests efficient formation of a cohesive steamed gel. In moi-moi, texture develops through multiple simultaneous processes, including hydration, starch gelatinization, protein unfolding and aggregation, emulsion stabilization, and the immobilization of water within the cooked matrix. Cowpea proteins have important water-binding, foaming, emulsifying, and gelation properties, and these functions can differ with variety and processing conditions (Affrifah et al., 2022; Zolqadri & Li, 2025). The results therefore support the view that raw-material functionality is an important determinant of sensory texture.

Mouthfeel scores were highest in DB100 (8.16) and WB100 (8.02), followed by PP100 (7.96) and HB100 (7.15). Mouthfeel captures sensations that are not completely represented by texture alone, including smoothness, lubrication, mealiness, grittiness, adhesiveness, and coating of the oral surfaces. The fact that HB100 had the highest texture score but the lowest mouthfeel score illustrates why sensory evaluation benefits from separating these attributes. A sample can be structurally soft and cohesive yet produce a different oral sensation once chewed and mixed with saliva. Similarly, DB100 achieved both high texture and mouthfeel ratings despite having the highest crude fibre value, indicating that the fibre level did not translate into an unacceptable coarse sensation.

3.2.4 Overall Acceptability

Overall acceptability provides the most direct indication of whether consumers would generally prefer one formulation over another. HB100 achieved the highest mean score (8.88), closely followed

by WB100 (8.78). Both treatments shared the same significance grouping and were more highly accepted than PP100 (7.24) and DB100 (7.06). The superior overall performance of HB100 is consistent with its very high aroma, appearance, and texture scores. WB100, in contrast, achieved strong overall acceptance through a different sensory profile characterized by good colour and mouthfeel together with the highest protein content among the treatments.

The difference between attribute-specific scores and overall acceptability is instructive. DB100 was the highest-rated sample for colour and mouthfeel and had a strong texture score, yet it recorded the lowest overall acceptability. This implies that final preference was influenced by the balance among multiple attributes rather than by dominance in one or two characteristics. Such integrated responses are common in food sensory studies. Henshaw et al. (2009) similarly emphasized varietal effects on consumer-perceived properties of moinmoin, while composite-product studies show that changes improving one nutritional or physical characteristic may not automatically increase overall liking (Otunola & Afolayan, 2018; Okwunodulu et al., 2019; Emelike et al., 2020).

3.3 Integrated Nutritional and Sensory Interpretation

Considering the proximate and sensory results together provides a more useful basis for raw-material selection than examining either dataset alone. WB100 combined the highest protein content (25.35%) with strong mouthfeel and a very high overall acceptability score (8.78). It therefore represents a balanced option for both nutritional positioning and consumer preference. HB100, although slightly lower in protein (23.85%), achieved the highest overall acceptability and led in aroma and texture, while also recording the highest carbohydrate content and joint-highest ash value. For processors prioritizing broad consumer appeal, HB100 appears especially promising.

DB100 offered a different set of advantages: it was high in protein (25.05%), had the highest crude fibre value (3.62%), shared the highest ash value (4.26%), and performed strongly in colour, texture, and mouthfeel. Its lower overall acceptability suggests that formulation optimization may be necessary. Small adjustments to seasoning intensity, hydration, particle size, or steaming profile could potentially improve the balance of its sensory attributes without sacrificing its favourable nutritional characteristics. Such optimization should be tested experimentally rather than assumed.

PP100 did not lead the four formulations in overall acceptability or protein concentration, but it remained well accepted, with particularly high appearance and aroma ratings. This is significant from a diversification perspective. Pigeon pea is an underutilized but nutritionally valuable and drought-resilient crop, and its successful conversion into a familiar steamed pudding may provide an avenue for increasing utilization, farmer-market opportunities, and dietary diversity. The broader literature similarly supports development of culturally acceptable foods based on underutilized legumes as part of strategies for nutrition and food-system resilience (Ayilara et al., 2022; Haji et al., 2024; Acheampong et al., 2025).

3.4 Comparison with Previous Moi-Moi and Cowpea Studies

The present findings fit within a substantial body of evidence showing that cowpea variety and processing conditions affect both nutrient composition and sensory quality. Uwaegbute et al. (2000) demonstrated that germination altered the chemical composition and acceptability of cowpea products including moin-moin. Henshaw et al. (2009) directly compared moinmoin from different cowpea varieties and reported sensory differences attributable to the raw material. Otunola and Afolayan (2018) showed that blending cowpea with water yam changed proximate composition and sensory response, while Okwunodulu et al. (2019) documented compositional and acceptability changes in cowpea–Bambara groundnut moi-moi. Emelike et al. (2020) likewise found that substitution with avocado pear seed flour altered proximate and sensory properties.

More recently, Usman et al. (2026) reported significant differences among instant moi-moi flours produced from four indigenous Nigerian cowpea varieties, further reinforcing the importance of varietal selection for both nutritional adequacy and consumer acceptance. The present study extends that perspective by including pigeon pea alongside three cowpea market types under a standardized wet-paste processing system. Although direct numerical comparison across studies is limited by differences in recipes, moisture basis, processing conditions, panel composition, and analytical methods, the overall pattern is consistent: the identity of the legume raw material is a major determinant of final-product quality.

3.5 Practical Implications for Household and Commercial Production

For household preparation, the results indicate that consumers can select among different legumes according to the desired balance of nutrition and sensory quality. Honey bean offers particularly strong eating quality, while white bean combines high protein with excellent overall acceptability. Drum bean may be attractive where fibre and total mineral matter are emphasized, and pigeon pea offers a pathway for diversifying the household legume basket. The use of a familiar recipe and steaming technique also means that substitution can be achieved without requiring specialized equipment.

For small-scale caterers and commercial processors, varietal consistency becomes especially important. Differences in moisture retention, gel formation, aroma, and overall liking may affect batch standardization and consumer expectations. Processors should therefore identify and specify preferred bean varieties rather than purchasing mixed market lots whenever consistent quality is required. Future commercial work should also determine flour or paste yield, dehulling loss, cooking energy, cost per serving, packaging stability, and microbiological shelf life, because sensory preference alone does not establish commercial feasibility.

3.6 Study Limitations and Future Research

Several limitations should be considered. First, proximate analyses were conducted in duplicate ($n = 2$), which is sufficient for preliminary comparison but provides limited precision for estimating analytical variability. Increasing the number of independent determinations would strengthen confidence intervals and statistical inference. Second, the sensory panel consisted of 50 familiar consumers, but demographic characteristics, serving order, randomization, blinding, palate-cleansing procedures, and repeated-session design were not specified in the source protocol. Future studies should document these elements in detail and, where possible, combine consumer hedonic testing with trained descriptive sensory analysis.

Third, the study did not measure instrumental texture, colour coordinates, viscosity, water-holding capacity, foaming capacity, emulsion properties, starch pasting behaviour, anti-nutritional factors, mineral composition, amino-acid profile, microbial stability, or shelf life. These measurements would help explain why particular legumes produced specific sensory responses. Fourth, the analytical basis used for the reported proximate values should be explicitly confirmed in future reporting so that the values can be compared accurately with other steamed-pudding studies. Finally, the pigeon pea treatment used a much longer soaking time than the cowpea treatments because of its harder seed coat; future experiments could evaluate alternative pretreatments such as controlled hot soaking, germination, fermentation, or mechanical dehulling to improve processing efficiency while maintaining acceptable flavour and texture.

4. Conclusion

The study demonstrates that the legume material used for moi-moi production significantly influences both proximate composition and consumer-perceived quality. White bean moi-moi produced the highest crude protein content, while drum bean combined high protein with the highest crude fibre and joint-highest ash values. Honey bean recorded the highest carbohydrate value and was the most preferred formulation overall, leading particularly in aroma and texture. White bean was similarly highly accepted and showed strong mouthfeel, making it a particularly balanced option when both protein density and consumer preference are considered. Drum bean performed well for colour, texture, and mouthfeel but had lower overall acceptance, suggesting that further formulation optimization may improve its consumer appeal. Pigeon pea produced a generally acceptable moi-moi with strong appearance and aroma ratings, demonstrating that this underutilized legume can be incorporated into a familiar traditional product without obvious loss of acceptability. Collectively, the findings support varietal selection as an important tool for improving and diversifying moi-moi. They also highlight the need for future work combining larger analytical replication, detailed sensory protocols, functional-property measurements, mineral and amino-acid analyses, anti-nutritional assessment, and shelf-life evaluation. Such studies would provide a stronger basis for household nutrition guidance and for commercial development of standardized, nutrient-dense moi-moi products from both conventional cowpea varieties and underutilized legumes.

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