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Comparison of Physico-Chemical and Sensory Attributes in Plant-Based Meat Analogue Patties and Chicken Patties

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study aims to elucidate the differences between PBMA and chicken meat patties by comparing their physico-chemical and sensory attributes.
Study Design and Methodology: The plant-based meat analogue (PBMA) market is expanding rapidly alongside the burgeoning alternative protein sector. To enhance marketability, the sensory

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and textural attributes of PBMA must closely mimic those of traditional meat products. Commercial PBMA patties from three brands and chicken patties from two brands available in the Indian market were analysed. The frozen samples were thawed at refrigeration temperature (4±1℃) before laboratory analysis of various physico-chemical and sensory properties.

Results: Qualitative analysis indicated that PBMA patties had lower moisture content but higher fat, crude fiber and total ash content compared to chicken patties. Notably, the cholesterol content of PBMA patties was negligible. Linoleic acid was the most abundant fatty acid in PBMA samples, with significant amounts of oleic and palmitic acids also present. The predominant saturated fatty acid (SFA) in all samples was palmitic acid (C16:0). Sensory evaluation revealed that chicken patties scored higher for overall acceptability than PBMA patties.

Conclusion: Overall, the study demonstrates significant differences in proximate composition, texture and sensory qualities between PBMA and traditional meat patties, highlighting the distinct characteristics of PBMA as an alternative protein source. The texture and sensory evaluations showed that PBMA patties, while promising, still fall short in replicating the sensory qualities of chicken patties, particularly in appearance and flavour. The PBMA patties can be a good alternative to meat patties in terms of nutritional composition.

Keywords: Plant-based meat analogue patties; proximate composition; total phenolic content; cholesterol content; sensory analysis.

1. INTRODUCTION

The rising interest in plant-based meat analogues (PBMA) is driven by concerns related to human health, environmental sustainability and animal welfare. PBMAs are recognized as sustainable alternatives that can significantly reduce global greenhouse gas emissions [1,2]. A survey by [3] revealed that approximately 22% of the world's population adheres to a vegetarian diet. To meet the protein needs of vegetarians, protein-rich plant-based ingredients can be incorporated into meat analogues.

Modern PBMAs are specifically formulated to mimic the sensory attributes and macronutrient profiles of traditional meat using plant proteins (*e.g*., soy, pea, jackfruit, rice, wheat, mushroom), plant-based fats *(e.g.,* canola, coconut, sesame, mustard, soybean, sunflower oil) and other novel ingredients such as soy leghemoglobin, red-colored vegetable extracts and flavouring agents. Mushroom concentrate, for instance, is used as a substitute for monosodium glutamate (MSG) and hydrolyzed vegetable protein for flavour enhancement [4]. Additionally, essential vitamins and minerals typically found in meat, such as iron, zinc, and vitamin B, are being progressively added to PBMAs to enhance their nutritional value [5].

Comparative analyses between PBMAs and conventional meat products are crucial to scientifically substantiate the health benefits and nutritional quality of PBMAs. While PBMAs might be nutritionally inferior to minimally processed whole plant-based foods, their nutritional profile can be enhanced by incorporating various health-promoting components. Moreover, evaluating the extent to which PBMAs meet the nutritional and organoleptic properties of traditional meat products is essential to understand and bridge the existing gaps.

A survey by [6] indicated that a significant portion of the population (53%) consumes PBMAs at least once a week, with 35% consuming them sporadically and 12% roughly once every 15 days. Collaboration between the food industry and local municipalities can further promote the development of novel and improved PBMA products [7]. Strategies to increase PBMA consumption should consider dietary habits and lifestyles, focusing on improving sensory properties and providing consumer education [8].

This study aims to analyze the differences between plant-based meat analogues and chicken meat patties by comparing their physico-chemical and sensory characteristics. The goal is to determine how well current market-available PBMAs meet the nutritional and organoleptic standards of traditional meat products and to identify potential areas for improvement in PBMA products.

2. MATERIALS AND METHODS

2.1 Sample Collection

PBMA patties from three commercial brands and chicken patties from two brands were selected. Eight batches of sample from each of the three

PBMA and two chicken patty brands were collected. So, for each parameter eight samples were analysed. These frozen products were thawed at refrigeration temperature (4±1℃). Subsequently, various physico-chemical, nutritional and sensory qualities of both PBMA and chicken patties were analysed in the laboratory.

2.2 Proximate Composition

The moisture content was estimated by hot air oven, protein using automatic digestion and distillation unit, fat was estimated by ether extraction, crude fibre, total dietary fibre and ash content following standard procedure of [9]. The carbohydrate content was obtained by the differential method.

2.3 Fatty Acid Profile

Fatty acid methyl esters (FAMEs) of the samples were prepared following the method described by [10] for the profiling of the fatty acid constituents. The fatty acid composition of extract was determined by injecting 1µL of sample in to gas chromatograph on a SP™-2560 capillary column with an internal diameter of 0.25 mm (100 m × 0.25 × 0.2 μm film thickness). The analysis was performed on a Varian 450 gas chromatograph equipped with a flame ionization detector. Nitrogen was used as carrier gas. The injection port temperature was 220℃, and the detector temperature was 220℃. The oven temperature was increased to 175℃ for five min and ramped to 220℃ at 15℃/min; it was then held at 220℃ for 30 min. A software calculated retention times and peak area percentages. Fatty acids were identified by comparing sample retention times with standard retention times (Supelco 37 component FAME mix, Merck). The results of the fatty acid profile were expressed as relative percentage of the peak areas.

2.4 Cholesterol Content

The total cholesterol of the sample was determined by a method described by [11]. 100 µl of lipid extract (prepared from 2g of sample volume made to 5ml with chloroform) was pipetted and 50 µl of standard cholesterol solution was added separately into test tubes and evaporated to dryness in a water bath. The dried residue in each tube was dissolved in 2 ml of chloroform to which 1 ml $ZnCl_2$ reagent and 1 ml acetyl chloride were added. The samples were then heated in a water bath at 50℃ for 10 min. For blank, 2 ml of chloroform to which 1 ml $ZnCl_2$ reagent and 1 ml acetyl chloride were added. The colour complex formed (pink-red colour) was measured by reading the optical density at 528 nm in a spectrophotometer (UV-1700 PharmaSpec, Shimadzu, Japan), and cholesterol content was expressed as mg per 100g of sample.

$$Cholesterol\left(\frac{mg}{100g}\right) = \frac{OD\ of\ unknown \times Conc.of\ standard \times 5 \times 100}{OD\ of\ standard \times 0.1 \times 2 \times 1000}$$

2.5 Total Phenolic Content

The sum of the phenolic compounds of the samples was determined using the method of Folin and Ciocalteu [12] with modifications. Samples of 0.1 g were homogenized in 20 mL of ethanol and water (1:1). The extraction was kept in a shaking water bath (Kemi water bath incubator shaker, India) at 40℃ for 10 min and then centrifuged for 10 min at 5000 rpm in a centrifuge (Eppendorf centrifuge 5430 R, Germany). The filtered extract (1 mL) was mixed with 5 ml Folin-Ciocalteu solution (1ml of Folin-Ciocalteu reagent (Loba Chemie Pvt Ltd., India) in 10 ml water and 4 ml sodium carbonate (75 g/L) (Sigma Aldrich Inc., USA) and incubated in darkness for 30 min. The absorbance was measured spectrophotometrically at a wavelength of 765 nm (UV-1700 PharmaSpec, Shimadzu, Japan). The calibration curve was plotted by mixing 1 ml aliquots of 0.1, 0.5, 1.0, 2.5 and 5.0 mg/ml gallic acid solutions with 5.0 ml of Folin-Ciocalteu reagent (diluted tenfold) and 4.0 ml of sodium carbonate solution (75 g/l). The absorbance was measured after 30 min at 765 nm. The sum of phenolic compounds was expressed as mg/gallic acid equivalents (GAE)/g sample.

2.6 Texture Profile

A texture analyzer (Tinius Olsen, HIKF, United Kingdom) attached to software, texture expert which calculated the springiness, hardness, chewiness and cohesiveness ratio of the samples. Before the test, the frozen extrudates were cut in a cubical shape with dimensions of 24 mm (width) × 24 mm (length) × 14 mm (height) and thawed in an oven for 30 min at 40℃. The sample was placed on the platform and compressed to 80 per cent of its original height using a 75 mm diameter flat bottom probe. The compression was carried out at a crosshead speed of 0.5 mm per second through a two-cycle sequence to mimic chewing process [13].

2.7 Sensory Attributes

For the sensory evaluation, an affective test was carried out at the ICAR-National Meat Research Institute. A total of 50 participants were selected randomly among students and staff at the ICAR-National Meat Research Institute. In this case, consumers had to score how much they liked the different samples on a 8-point hedonic score card (1=extremely undesirable; 8 = extremely desirable). Samples were deep fried for 3 min on the day of the sensory analysis to finish the cook. Then, samples were cut into small pieces of 20 g each and served. All samples were coded with random three-digit numbers and water was provided to clean the palate between samples. The attributes evaluated by the consumers were appearance, flavour, juiciness, texture and overall acceptability.

2.8 Statistical Analysis

The experiment was replicated four times, each in duplicate. Data obtained for physico-chemical and sensory parameters was compiled and analyzed using SPSS (version 26.0 for windows, SPSS, Chicago, USA). The data was subjected to analysis of variance (ANOVA) and Duncan's *post hoc* test for for multiple comparisons among different groups.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

The proximate composition of different PBMA and chicken patties is presented in Table 1. Significant differences (P <0.05) were observed between PBMA and chicken patties in terms of moisture, protein, fat, crude fiber, total dietary fiber, carbohydrate and total ash content. These variations could be attributed to the heterogeneous nature of the different proteins and ingredients used during formulation.

The moisture content of PBMA and chicken patties differed significantly (P <0.05). The results were in accordance with [14] who emphasized that meat analogues displayed moisture content between 46.98 and 53.71 per cent. The moisture content of final product depends on the hydration capacity of basic ingrediants, temperature and different cooking conditions.

The protein content varied significantly (P <0.05) between PBMA and chicken patties. Among the samples, PBMA patty PP-3 had the highest protein content (P <0.05). The protein content in PBMA can be tailored to meet the nutritional needs of specific consumer groups, such as the elderly, pregnant women or children. There was a significant difference (P <0.05) in fat content between chicken and PBMA patties, with chicken patties having lower fat content. The addition of fat in PBMA recipes enhances juiciness, tenderness and flavour release [15]. Furthermore, fats help retain volatile flavour compounds, improving the sensory profile of PBMA [16].

The carbohydrate content of PBMA and chicken patties differed significantly (P <0.05). PBMA patty PP-3 had the lowest carbohydrate content among all samples (P <0.05). Crude fiber content varied significantly (P <0.05) between PBMA and chicken patties, with PBMA patties having higher crude fiber content. Similarly, total dietary fiber (TDF) content was significantly higher (P <0.05) in PBMA patties compared to chicken patties. Increased dietary fiber is beneficial for health as it reduces total cholesterol, particularly LDL cholesterol and helps limit glucose absorption [17].

The ash content, representing total mineral content, showed significant differences (P <0.05) between PBMA and chicken patties. PBMA patties had higher ash content compared to chicken patties. [18], reported significant difference in the proximate composition among different animal-based and plant based products.

3.2 Cholesterol Content

The cholesterol content varied significantly between chicken patties CP-1 and CP-2 (P <0.05), with CP-2 having higher cholesterol content. In contrast, PBMA patties had no detectable cholesterol content. This finding is consistent with [19], who reported zero cholesterol in market-available PBMA products such as the Beyond Burger and Impossible Burger. [20] found that the cholesterol content in chicken nuggets ranged from 125.50 to 32.58 mg per 100 g.

3.3 Fatty Acid Profile

The fatty acid profile of food products is crucial for understanding their nutritional implications, particularly their effects on cardiovascular health [21]. Substituting polyunsaturated fatty acids (PUFA) for saturated fatty acids (SFA) has been linked to reduced cardiovascular risk, emphasizing the importance of a higher PUFA/SFA ratio in dietary recommendations [22]. Table 2 presents the mean fatty acid compositions of PBMA and chicken patties, highlighting significant differences among samples. In all groups, palmitic acid (C16:0) was the predominant SFA. Notably, PP-3 exhibited the lowest SFA content, whereas CP-2 had the highest. Oleic acid (C18:1n9c) was significantly higher in CP-2, while linoleic acid (C18:2n6c) was notably higher in PP-3. PBMA samples predominantly featured linoleic acid, alongside substantial amounts of oleic and palmitic acids, consistent with common dietary sources of MUFAs and SFAs in human diets.

Oleic acid, a prevalent monounsaturated fatty acid (MUFA) in human diets, has been associated with favorable effects on lipid profiles and metabolic health, potentially mitigating the adverse effects of palmitic acid (C16:0) on insulin sensitivity and mitochondrial function [23].

Table 1. Values of nutritional parameters analyzed for different PBMA and chicken patties (mean±standard error)

Parameters	CP-1	CP-2	PP-1	PP-2	PP-3
Moisture (%)	58.39 ± 0.163^{a}	56.46 ± 0.079^{b}	51.46 ± 0.058^{c}	51.17 ± 0.176^{c}	56.77 ± 0.071^{b}
Protein (%)	12.29 ± 0.046^{b}	9.47 ± 0.026^{d}	9.65 ± 0.027^{c}	7.42 ± 0.051^{e}	17.34 ± 0.044^{a}
Fat (%)	10.70 ± 0.087^{b}	10.42 ± 0.058^{c}	9.70 ± 0.026^{d}	12.55 ± 0.066^{a}	8.37 ± 0.034^{e}
Carbohydrate (%)	16.44 ± 0.11^{c}	22.14 ± 0.09^{b}	25.63 ± 0.07^{a}	25.57 ± 0.08^{a}	13.41 ± 0.05^{d}
Crude fibre (%)	0.59 ± 0.02^{d}	0.51 ± 0.02^{e}	1.17 ± 0.02^{a}	0.98 ± 0.02^{b}	0.86 ± 0.02^{c}
Total dietary fibre (%)	1.15 ± 0.01^{e}	1.17 ± 0.01^{d}	1.97 ± 0.01^{c}	2.03 ± 0.01^{a}	1.99 ± 0.01^{b}
Ash (%)	1.60 ± 0.017^{c}	0.99 ± 0.020^{d}	2.38 ± 0.040^{b}	2.32 ± 0.014^{b}	3.25 ± 0.021^{a}
Cholesterol content (mg/100g)	46.21 ± 0.207^{b}	50.64 ± 0.228^{a}	0.00 ± 0.00^{c}	0.00 ± 0.00^{c}	0.00 ± 0.00^{c}

Values reported are mean values and standard errors (n=8). Same superscripts in a row does not differ significantly (p>0.05). CP-1: chicken patties-1; CP-2: chicken patties-2; PP-1: PBMA patties -1; PP-2: PBMA patties -2; PP-3: PBMA patties -3

Table 2. Fatty acid profiles of different PBMA and chicken patties (mean±standard error)

Fatty acids	CP-1	CP-2	PP-1	PP-2	PP-3
C8:0	0.01 ± 0.01^{d}	0.02 ± 0.01^{d}	1.32 ± 0.14^{a}	0.89 ± 0.06^{b}	0.28 ± 0.04^{c}
C10:0	ND	0.01 ± 0.01^{d}	1.14 ± 0.07^{a}	0.89 ± 0.04^{b}	0.24 ± 0.02^{c}
C12:0	0.03 ± 0.01^{c}	0.14 ± 0.03^{c}	10.89 ± 0.28^{a}	9.14 ± 0.17^{b}	0.16 ± 0.02^{c}
C14:0	0.43 ± 0.01^{d}	0.72 ± 0.03^{c}	4.38 ± 0.16^{a}	3.97 ± 0.05^{b}	0.16 ± 0.01^{e}
C16:0	16.22 ± 0.30^{b}	29.84 ± 0.21^{a}	13.12 ± 0.20^{c}	14.22 ± 0.11^{c}	8.25 ± 0.72^{d}
C17:0	2.48 ± 0.04^{b}	2.90 ± 0.15^{a}	0.10 ± 0.02^{c}	0.10 ± 0.03^{c}	0.04 ± 0.01^{c}
C18:0	4.25 ± 0.06^{cd}	4.71 ± 0.11^{bc}	5.14 ± 0.45^{ab}	5.73 ± 0.17^{a}	3.66 ± 0.29^{d}
C18:1n9c	34.13 ± 0.17^{b}	41.38 ± 0.36^{a}	26.01 ± 0.33^{d}	30.06 ± 0.30^{c}	32.41 ± 1.13^{b}
C18:2n6c	38.53 ± 0.27^{b}	17.55 ± 0.40^{d}	35.66 ± 0.55^{bc}	32.03 ± 0.32^{c}	51.90 ± 3.17^{a}
C18:3n3	0.93 ± 0.03^{a}	0.20 ± 0.11^{c}	0.48 ± 0.05^{b}	0.52 ± 0.03^{b}	0.51 ± 0.01^{b}
C21:0	ND	0.43 ± 0.13^{a}	0.51 ± 0.16^{a}	0.10 ± 0.09^{b}	ND
C22:0	0.23 ± 0.02^{c}	0.54 ± 0.01^{b}	0.22 ± 0.02^{c}	0.28 ± 0.01^{c}	0.60 ± 0.04^{a}
SFA	23.64 ± 0.35^{c}	38.82 ± 0.12^{a}	36.81 ± 0.49^{b}	35.31 ± 0.21^{b}	13.39 ± 1.13^{d}
MUFA	34.13 ± 0.17^{b}	41.37 ± 0.36^{a}	26.01 ± 0.33^{d}	30.06 ± 0.30^{c}	32.41 ± 1.30^{b}
PUFA	39.46 ± 0.29^{b}	17.75 ± 0.36^{d}	36.14 ± 0.49^{bc}	32.56 ± 0.30^{c}	52.40 ± 3.18^{a}
MUFA/SFA	1.44 ± 0.01^{b}	1.07 ± 0.01^{c}	0.71 ± 0.02^{e}	0.85 ± 0.01^{d}	2.46 ± 0.10^{a}
PUFA/SFA	1.67 ± 0.04^{b}	0.46 ± 0.01^{c}	0.98 ± 0.02^{c}	0.92 ± 0.01^{c}	4.11 ± 0.48^{a}
UFA	73.60 ± 0.22^{b}	59.13 ± 0.16^{d}	62.15 ± 0.60^{c}	62.61 ± 0.20^{c}	84.82 ± 1.89^{a}
UFA/SFA	3.12 ± 0.05^{b}	1.52 ± 0.01^{c}	1.69 ± 0.04^{c}	1.77 ± 0.01^{c}	6.57 ± 0.57^{a}

Values reported are mean values and standard errors (n=8). Same superscripts in a row does not differ significantly (p>0.05).
MUFA: monounsaturated acids, SFA: saturated fatty acids, UFA = sum of PUFA and MUFA, ND: not detected. CP-1: chicken patties-1; CP-2: chicken patties-2; PP-1: PBMA patties -1; PP-2: PBMA patties -2; PP-3: PBMA patties -3

The presence of specific medium-chain fatty acids (C8:0, C10:0, C12:0, C14:0) in PP-1 and PP-2 suggests the incorporation of coconut oil in these formulations. Conversely, higher levels of palmitic acid (C16:0) and lower levels of linoleic acid (C18:2n6c) in CP-2 likely indicate the use of palm oil, either added during processing or as a frying medium. PP-3, characterised by lower palmitic acid (C16:0) and higher linoleic acid (C18:2n6c), likely reflects the use of soybean oil in its preparation. These findings underscore the variability in fatty acid profiles among different product formulations, influencing their nutritional quality and potential health implications.

3.4 Total Phenolic Content

The total phenolic content (TPC) of various PBMA and chicken patties was assessed, and the results are summarized in Table 3. Significant differences (*P* <0.05) were observed among all groups, likely attributable to the distinct ingredients used in their formulations. A diet rich in plant polyphenols has been documented to enhance health and reduce the risk of cardiovascular diseases [21]. Polyphenolic antioxidants mitigate the detrimental effects of reactive oxygen species, which is beneficial for overall health and may help prevent dementia and memory loss [24].

Given the strong antioxidant properties and potential health benefits of phenolic compounds, there is an increasing emphasis on incorporating these compounds into food products to promote health and combat age-related diseases.

As shown in Table 3, the chicken patties exhibited lower total phenolic content compared to the PBMA samples. Specifically, CP-1 and CP-2 had TPC values of 0.934 ± 0.033 mg GAE/g and 0.781 ± 0.014 mg GAE/g, respectively. The PBMA samples, PP-1, PP-2, and PP-3 demonstrated higher TPC values of 1.567 ± 0.020 mg GAE/g, 2.253 ± 0.013 mg GAE/g, and 2.873 ± 0.019 mg GAE/g, respectively. These results highlight a notable gap in phenolic content between meat-based and plant-based patties.

3.5 Texture Profile Analysis

Texture is a fundamental quality attribute of food products, influencing consumer acceptance and satisfaction. The instrumental texture characteristics between chicken patties and PBMA patties differed significantly (*P* <0.05), as displayed in Table 4.

The hardness values of the PBMA patties were significantly higher (*P* <0.05) than those of the chicken patties. The increased hardness in PBMA patties can be attributed to better cross-linking of the protein, thus resulting in a firmer structure [25]. This trend is consistent with previous findings where meat analogs exhibited distinct textural properties compared to their meat counterparts [26].

Chewiness, which indicates the energy required to chew the food, also varied significantly (*P* <0.05) among the samples. The differences in chewiness could be influenced by water content and retention during the extrusion process, with higher water retention typically leading to decreased mechanical properties [27, 28].

In terms of cohesiveness, CP-1 and CP-2 had similar cohesiveness ratios. Among the PBMA patties, PP-1 had a significantly lower (*P* <0.05) cohesiveness ratio, while PP-2 and PP-3 exhibited higher ratios. The higher cohesiveness in certain PBMA patties may be due to the addition of binding agents designed to replicate the meat-like structure.

Springiness, which measures the extent to which a sample returns to its original shape after compression, was consistent among the samples. The springiness values of the chicken patties were consistent with previous studies [29], while the slightly higher values (*P* <0.05) in PBMA patties may be due to the incorporation of certain binding agents. These findings highlight the significant textural differences between chicken and PBMA patties. Understanding these differences is crucial for food manufacturers aiming to create meat analogs that closely mimic the texture of traditional meat products.

3.6 Sensory Analysis

Sensory attributes play a crucial role in determining consumer acceptance of food products. Table 5 presents the sensory evaluation scores of chicken patties (CP) and PBMA patties, assessed based on appearance, flavour, juiciness, texture, and overall acceptability.

The appearance values varied significantly (*P* <0.05) between chicken and PBMA patties, as shown in Table 5. CP-1 had the highest appearance score, while PP-3 had the lowest. The appearance scores of CP-2, PP-1, and PP-2 did not differ significantly (*P* >0.05), likely due to similar enrobing techniques used in both chicken and PBMA patties. The appearance of PBMA patties was designed to mimic traditional meat products, with ingredients such as beetroot juice used to replicate the reddish color of meat patties [30,31].

Flavour scores showed significant variation (*P* <0.05) between chicken and PBMA patties. CP-1 had the highest flavour score, indicating a preference for the flavour of chicken patties. PBMA patties, particularly PP-3, received lower flavour scores. The slight bitterness and less appealing flavour of PBMA patties highlight the challenge in replicating the taste of chicken patties.

Juiciness scores also differed significantly (*P* <0.05) between the samples. CP-1 and CP-2 had similar juiciness scores, while PBMA patties PP-2 and PP-3 did not differ significantly (*P* >0.05) in their juiciness scores. The juiciness of PBMA products may be influenced by the moisture content of the initial formulation and the cooking method employed.

Texture or tenderness scores varied significantly (*P* <0.05) between the samples. CP-2 and PP-2 had the highest texture scores, indicating a preference for their tenderness. In contrast, PP-3 had the lowest texture score. The texture of PBMA patties is affected by the use of binding agents and the specific mechanical energy applied during processing.

Overall acceptability scores showed significant variation (*P* <0.05) between chicken and PBMA patties. CP-1 had the highest overall acceptability score, followed by CP-2. Among the PBMA patties, PP-1 and PP-2 had lower acceptability scores, while PP-3 had the lowest score.

These results highlight the necessity of optimising sensory attributes-particularly appearance, flavour and texture, in the development of PBMA products to enhance consumer acceptance. Although PBMA patties demonstrate potential, there remains a notable gap in matching the sensory qualities of traditional chicken patties.

Table 3. Total phenolic content of different PBMA and chicken patties (mean±standard error)

Parameters	CP-1	CP-2	PP-1	PP-2	PP-3
Total phenolic content (mg GAE /g)	0.934 ± 0.033^{d}	0.781 ± 0.014^{e}	1.567 ± 0.020^{c}	2.253 ± 0.013^{b}	2.873 ± 0.019^{a}

Values reported are mean values and standard errors (n=8). Same superscripts in a row does not differ significantly (p>0.05). CP-1: chicken patties-1; CP-2: chicken patties-2; PP-1: PBMA patties -1; PP-2: PBMA patties -2; PP-3: PBMA patties -3

Table 4. Texture profile analysis of different PBMA and chicken patties (mean±standard error)

Parameters	CP-1	CP-2	PP-1	PP-2	PP-3
Hardness (N)	7.52 ± 0.062^{e}	9.30 ± 0.063^{d}	11.80 ± 0.056^{a}	10.28 ± 0.038^{b}	9.47 ± 0.402^{c}
Cohesiveness ratio	0.97 ± 0.008^{b}	0.97 ± 0.004^{b}	0.77 ± 0.004^{c}	1.18 ± 0.108^{a}	1.06 ± 0.006^{ab}
Chewiness (N cm)	6.60 ± 0.093^{d}	8.27 ± 0.026^{a}	7.43 ± 0.028^{c}	6.63 ± 0.034^{d}	7.63 ± 0.069^{b}
Springiness (cm)	0.97 ± 0.004^{c}	0.97 ± 0.006^{c}	1.04 ± 0.003^{a}	1.02 ± 0.004^{b}	1.04 ± 0.002^{a}

Values reported are mean values and standard errors (n=8). Same superscripts in a row does not differ significantly (p>0.05). CP-1: chicken patties-1; CP-2: chicken patties-2; PP-1: PBMA patties -1; PP-2: PBMA patties -2; PP-3: PBMA patties -3

Table 5. Sensory score values of different PBMA and chicken patties (mean±standard error)

Parameters	CP-1	CP-2	PP-1	PP-2	PP-3
Appearance and colour	7.19 ± 0.091^{a}	7.00 ± 0.00^{b}	7.00 ± 0.00^{b}	7.00 ± 0.00^{b}	6.13 ± 0.081^{c}
Flavour	7.00 ± 0.00^{a}	6.38 ± 0.081^{b}	6.13 ± 0.081^{c}	6.00 ± 0.00^{c}	5.00 ± 0.00^{d}
Juiciness	6.88 ± 0.081^{a}	7.00 ± 0.00^{a}	6.31 ± 0.091^{b}	6.00 ± 0.00^{c}	6.00 ± 0.00^{c}
Texture/tenderness	6.63 ± 0.081^{b}	7.00 ± 0.00^{a}	6.00 ± 0.00^{c}	7.00 ± 0.00^{a}	5.00 ± 0.00^{d}
Overall acceptability	7.25 ± 0.094^{a}	7.00 ± 0.00^{b}	6.00 ± 0.00^{c}	6.13 ± 0.081^{c}	5.00 ± 0.00^{d}

Based on eight point hedonic scale (1=extremely undesirable; 8 = extremely desirable).
Values reported are mean values and standard errors (n=8). Same superscripts in a row does not differ significantly (p>0.05). CP-1: chicken patties-1; CP-2: chicken patties-2; PP-1: PBMA patties -1; PP-2: PBMA patties -2; PP-3: PBMA patties -3

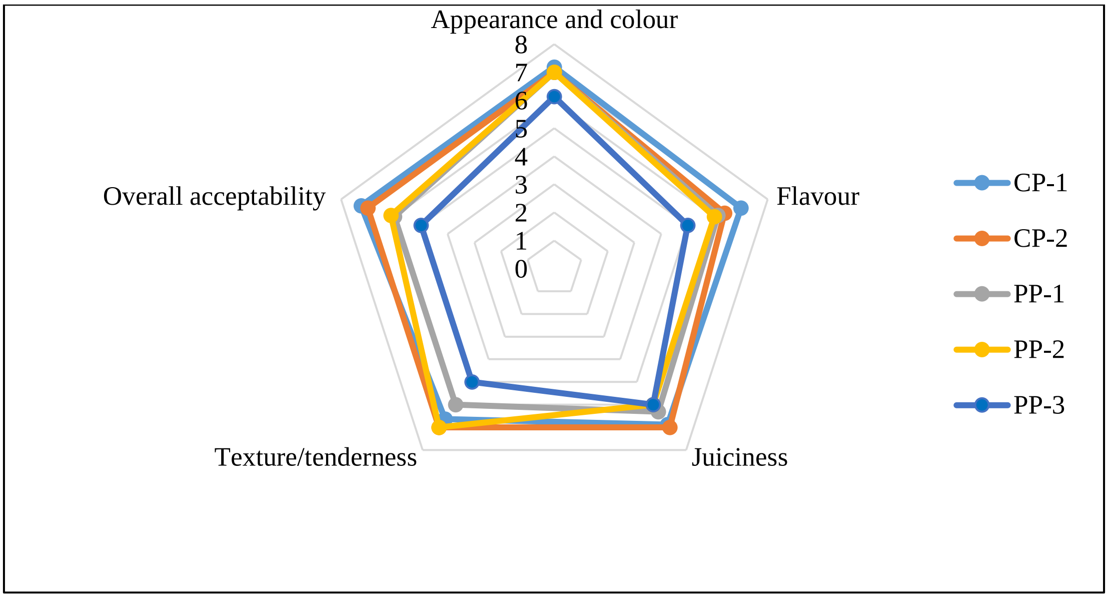

Fig. 1. Rador plot for sensory scores of different PBMA and chicken patties

4. CONCLUSION

This study highlights the significant differences between plant-based meat analog (PBMA) patties and traditional chicken patties in terms of proximate composition, texture, and sensory qualities. The proximate composition analysis revealed notable variations in moisture, protein, fat, crude fiber, total dietary fiber, carbohydrate and total ash content between PBMA and chicken patties. These differences underline the current gaps in nutritional and sensory attributes that need to be addressed to enhance the acceptance of PBMA products.

The texture and sensory evaluations showed that PBMA patties, while promising, still fall short in replicating the sensory qualities of chicken patties, particularly in appearance and flavour. This gap can be bridged by exploring more suitable colouring and flavouring ingredients that can better mimic the sensory profiles of meat. Additionally, understanding the structure formation mechanism during extrusion and shear processes is crucial. Advances in these areas will enable the development of PBMA products with improved textural and sensory characteristics.

To produce meat substitutes with superior resource efficiency and the desired nutritional and sensory qualities, there is a need for continued development of analytical techniques and structural procedures. Enhancing the extraction and detailed characterization of unique protein fractions will provide better insights into the functionality of raw materials, leading to improved PBMA products. Physicochemical, thermal, chemical or enzymatic treatments of legume and oilseed meals, concentrates or isolates can yield products with qualities suitable for food applications. Further scientific research is essential to substantiate the nutritional quality and health benefits of PBMA compared to conventional meat products.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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