Research Article

The Effects of *Polod* (*Arenga undulatifolia*) Powder towards Physicochemical Properties and Sensory Attributes of Chicken Patties

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ABSTRACT

Meat products have high biological value protein and essential nutrients needed for human sustenance, but it is deficient in complex carbohydrates like dietary fibre. Thus, various strategies have been explored to increase the dietary fibre content in meat products because plants are potentially rich sources of dietary fibres and bioactive compounds. *Arenga undulatifolia*, commonly known as *polod*, is a member of the family *Arecaceace* and grows natively in Borneo. This study examined how incorporating *polod* powder produced from the stem pith of *Arenga undulatifolia* affects nutritional, physicochemical, and sensory aspects of chicken patties. The *polod* powder showed comparable functional properties to other plant powders. The chicken patties were formulated as control samples F0 (0% *polod* powder), F1 (2% *polod* powder), F2 (4% *polod* powder), F3 (6% *polod* powder). Adding 4% *polod* powder significantly increased ($p > 0.05$) the patty's protein, ash, lipid, crude fibre, dietary fibre, and energy contents. Increasing the level of *polod* powder considerably lowered the moisture content ($p < 0.05$). The chewiness of the patties decreased significantly ($p < 0.05$) at 4% and 6% *polod* powder levels with no significant changes in other textural parameters ($p > 0.05$). Compared to the control sample (F0), the chicken patties with *polod* powder showed greater cooking yield and lower cooking loss. Compared to other formulations, F1 was most liked by sensory panellists. In conclusion, *polod* powder is potentially useful as a functional ingredient in the production of chicken patties.

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1. Introduction

Meat provides both macro- and micronutrients, including minerals and vitamins, with a higher bioavailability compared to those from plant sources (Das *et al.,* 2020). In recent years, the global development of industrialization has caused a worldwide increase in meat-based diets, including processed meat (Kang *et al.,* 2022). Chicken-based products have become a popular choice among the various types of meat due to their high-quality protein, supplying a good balance of essential amino acids with high biological value (Manassi *et al.,* 2022). Therefore, the habit of consuming processed meat has become extremely common for many people (Feng *et al.,* 2022).

Despite being nutritious and providing all the above health benefits, meat products have some drawbacks as they are deficient in dietary fibre (DF). DF is part of a plant consisting of a mixture of polysaccharides and includes cellulose, non-cellulosic polysaccharides like mucilages, pectic substances, hemicellulose, and non-carbohydrate components such as lignin and gums (Sztupecki *et al.,* 2023). DF is naturally present in most fruits and vegetables, but the quantity and composition differ (Das *et al.,* 2020). Additionally, DF is resistant to enzymatic absorption and digestion with complete or partial fermentation in the large intestine (Sztupecki *et al.,* 2023). Therefore, the lack of DF in our diet is associated with various health problems such as colon cancer, cardiovascular diseases, and obesity (Das *et al.,* 2020).

The era of globalization, coupled with rapid urbanization, has been a driving force for shifting an increased number of women's workforce and consumers towards convenient fast food products, including meat (Manassi *et al.,* 2022). However, most meat products, such as patty, lack the minimum amount of DF required to fulfil the recommendations for daily fibre intake. Hence, ongoing research is being conducted to incorporate plant-based ingredients in meat products. Previously, Mohd Zaini *et al.* (2021) and Munsu *et al.* (2021) added banana peel flour and seaweed, respectively, to chicken sausages. The authors observed an increase in the dietary fibre content with improved water holding and oil binding capacity.

Arenga undulatifolia, also known as pokok polod, is a native plant found abundantly in Borneo. According to Tamalene (2017), the natives consider the stem pith of the Arenga undulatifolia tree, which is produced into powder form in the present study, as their staple food and typically consume it during ceremonial occasions. The stem pith is rich in carbohydrates and dietary fibre, which helps in reducing the risk of gastrointestinal disorders and coronary heart diseases (Evans, 2020). Furthermore, the stem pith of Arenga sp. contain an abundance of phytochemicals such as tannins, which can act as an antioxidants (Soldado *et al.,* 2021).

Therefore, this study aims to evaluate the physicochemical properties of polod powder. The ultimate aim is to investigate the functionality of polod powder in terms of water- and oil binding capacity, swelling power, and solubility for improving the textural and sensory properties of chicken patties.

2. Materials and Methods

2.1 Materials

Boneless chicken breasts and chicken skin were purchased from Desa Fresh Mart (Sabah, Malaysia) and kept frozen at -18 °C. *Polod* or the cortex of stem pith of *Arenga undulatifolia* plants were obtained from the local market in Kota Kinabalu. All chemicals used for analysis were of analytical grade and supplied by Rinitek Sdn Bhd (Sabah, Malaysia). Food-grade soy protein isolate was purchased from Mackessen Sdn. Bhd. (Selangor, Malaysia). Salt, black pepper, and white pepper used in the patty formulation were obtained from a supermarket in Kota Kinabalu.

2.2 Preparation of polod powder

The *polod* was washed thoroughly with tap water and cut into small cubes of 2 cm length. The cubes were boiled for 20 minutes to deactivate enzymes. Subsequently, the *polod* cubes were arranged spaced out at 1 cm on a tray and dried in a vacuum dryer (Thermoline, Malaysia) at 50 °C until the moisture content reached 7.5%. The dried *polod* cubes were ground into fine powder using a grinding machine (Panasonic, Malaysia) and sieved to particle size of 250 µm. The *polod* powder were stored in an airtight container and stored at 4 °C until further use.

2.3 Physicochemical properties of polod powder

2.3.1 Water holding capacity

The water holding capacity (WHC) of the *polod* powder was determined according to Shen *et al.* (2022). Approximately 3.0 g of *polod* powder was weighed (W1) and placed into a 50 mL centrifuge tube. Then, 30 mL of distilled water was added and shook for 30 sec. The centrifugation tube was left in vertical position for 2 h at room temperature to allow the hydration of *polod* powder. After that, the sample was centrifuged (5430R, Eppendorf, Germany) at 2800 rpm for 10 min. The supernatant was discarded, and the weight of remaining sample was recorded as W2. The WHC was calculated using the following formula:

$$Water\ holding\ capacity\ (g/g) = \frac{W2 - W1}{W1} \quad (1)$$

The W1 represents initial weight of *polod* powder while W2 represents the weight of *polod* powder and distilled water after centrifugation.

2.3.2 Oil binding capacity

Polod powder was weighed (W1) and placed into a 50 mL centrifuge tube. Then, 30 mL of cooking oil was added and shook for 30 sec. The centrifugation tube was left in vertical position for 2 h at room temperature. After that, the sample was centrifuged (5430R, Eppendorf, Germany) at 2800 rpm for 10 min. The supernatant was discarded, and the weight of remaining sample was recorded as W2. Following Shen *et al.* (2022), the oil binding capacity was calculated using the formula:

$$Oil\ binding\ capacity\ (g/g) = \frac{W2 - W1}{W1} \quad (2)$$

The W1 represents initial weight of *polod* powder while W2 represents the weight of *polod* powder and cooking oil after centrifugation.

2.3.3 Swelling power

Swelling power was measured as the weight ratio of sedimented gel to dried powder (Waseem *et al.*, 2021). Firstly, 0.1 g of *polod* powder was weighed (W1) and put into centrifuge tube. Distilled water (10 mL) was then added to the tube. The tube was then heated for 30 minutes in a water bath at each of the temperatures - 60 °C, 75 °C, and 95 °C with continuous stirring. The tube was centrifuged (5430R, Eppendorf, Germany) at 1600 rpm for 15 min. The supernatant was discarded, and the weight of the sediment was recorded as W2. The swelling power of *polod* powder was calculated using the equation:

$$Swelling\ power\ (g/g) = \frac{W2}{W1} \quad (3)$$

The W1 represents weight of dried sample while W2 represent the weight of sediment.

2.3.4 Solubility

The solubility of *polod* powder was determined according to Murayama *et al.* (2021). For this purpose, 0.5 g was weighed (W1) and put into centrifuge tube. After that, 10 mL of distilled water was added into the tube. The tube was then heated in a water bath for 30 minutes at each of the temperatures - 60 °C, 75 °C, and 95 °C. After that, the tube was centrifuged at 1600 rpm for 10 min. The supernatant (5 mL) was placed onto an aluminium plate and heated in an oven at 110 °C for 24 h to allow evaporation process. Weight of the dried sample was recorded as W2. The solubility of the *polod* powder was calculated using the equation below:

$$Solubility\ (\%) = \frac{W2}{W1} \times 2 \times 100 \quad (4)$$

The W1 represents the initial weight of *polod* powder while W2 represents the dried weight after evaporation.

2.4 Preparation of chicken patties with polod powder

Table 1 shows the formulation for the chicken patty used in this study based on Pindi *et al.* (2023a). Firstly, 65.0 g of chicken breast was minced in a meat mincer (Hobart, USA). After that, 1.5 g salt was added and processed for 90 seconds. To keep the temperature stable, ice water was added to the mixture, which was then processed for another 2 minutes. Then, 12.0 g of chicken fat was added and mixed for 4 minutes. Dry ingredients (5.0 g soy protein isolate; 0.5 g black pepper; 0.5 g white pepper) and *polod* powder (F0, 0 g; F1, 2.0 g; F2, 4.0 g; F3, 6.0 g) were added to the mixture and ground for 2 minutes. About 70 g of the meat batter was weighed and formed into patties using a motorized burger mould (Sirman, Italy). The patties were kept at 4 °C overnight for further analysis.

Table 1 Formulations of chicken patties containing *polod* powder.

Percentage (%)	F0	F1	F2	F3
Chicken meat	65.0	65.0	65.0	65.0
Chicken fats	12.0	12.0	12.0	12.0
Iced water	15.5	13.5	11.5	9.5
Soy protein isolate	5.0	5.0	5.0	5.0
Salt	1.5	1.5	1.5	1.5
Black pepper	0.5	0.5	0.5	0.5
White pepper	0.5	0.5	0.5	0.5
Polod powder	0	2.0	4.0	6.0
Total	100.0	100.0	100.0	100.0

2.5 Proximate analysis of patties

A hot air oven, Kjeldahl assembly (Kjeltec 2300 Analyzer Unit, Foss Tecator A, Sweden), Soxhlet extraction apparatus (Soxtec Avanti 2050 Auto System, Foss Tecator AB, Sweden), muffle furnace, fibre extraction unit, and a fibre analysis kit were used to determine the moisture, protein, lipid, ash, crude fibre, and total dietary fibre (TDF) of chicken patties. The carbohydrate content was determined by subtracting the percentage of moisture, protein, lipid, ash, and crude fibre contents. All analyses were carried out following the AOAC (1990) technique.

2.6 Determination of total energy content

Energy conversion factors for nutrients were used to determine the total energy content of the patties.

The calculation was based on the following equation:

$$Total\ energy = (a \times 4\ kcal) + (b \times 4\ kcal) + (c \times 9\ kcal) \quad (5)$$

The a represents carbohydrate content (g), b represents protein content (g) while c represents fat content (g).

2.7 Textural properties

The TA.XT Plus Texture Analyzer (Stable Micro System, United Kingdom) was used to analyse the texture profiles of the patties at room temperature. Each sample was cut into 1 cm^3 size. Hardness (N), cohesiveness (dimensionless), springiness (mm), and chewiness (N x mm) were the criteria assessed (Pindi *et al.*, 2023a).

2.8 Cooking yield and cooking loss

The cooking yield and cooking loss of chicken patties were determined according to Pindi *et al.* (2023b). Each sample was weighed and recorded as W1. After that, the patties were cooked and weighed (W2). The cooking yield and cooking loss of patties were expressed in percentage as shown below:

$$Cooking\ yield\ (\%) = \frac{W2}{W1} \times 100 \qquad (6)$$

$$Cooking\ loss\ (\%) = \frac{W1-W2}{W1} \times 100 \qquad (7)$$

The W1 represents the weight of raw chicken patty (g) while W2 represents the weight of cooked patty (g).

2.9 Sensory analysis of patties

Sensory evaluation was performed using the 7-point hedonic scale (1-dislike very much, 2-dislike moderately, 3-dislike slightly, 4-neither like nor dislike, 5-like slightly, 6-like moderately, 7-like very much). Sensory tests were carried out by 50 randomly picked untrained panellists. Patty samples were labelled with three-digit numbers and randomly handed to the panellists. The panellists were given a glass of water to cleanse their palate in between samples. The attributes evaluated by the panellists were colour, aroma, texture, taste, and overall acceptability.

2.10 Statistical analysis

All experimental data were analysed using SPSS v. 25.0 (IBM Corporation, United States) in a completely randomized study design, and all the values were reported as mean ± standard deviation. One-way analysis of variance (ANOVA) was used to determine whether the values for a particular variable were statistically significantly different between the control and different formulations while Tukey's HSD test was employed for multiple comparisons. Statistical significance was set at $p < 0.05$.

3. Results and Discussion

3.1 Physicochemical properties of polod powder

3.1.1 Water holding capacity and oil binding capacity

Water holding capacity (WHC) and oil binding capacity (OBC) are two important parameters that determine the textural properties of food. High of WHC results in juicier meat products, while ingredients that provide excellent OBC may act as emulsifiers (Mohd Zaini *et al.*, 2021). As compared to previous research by He *et al.* (2022), the WHC of *polod* powder (5.34 g/g) in this present study was comparable to papaya peel (5.26 g/g) and rice bran (6.23 g/g). According to Nagy *et al.* (2020), the ability of powder to retain water depends on its physical state of the starch, dietary fibre and protein content. Hence, the WHC of *polod* powder may be contributed by the presence of dietary fibre which holds water in its pore space during hydration process.

In terms of OBC, the *polod* powder showed lower OBC than soy protein isolate at 1.23 g/g and 3.20 g/g, respectively (Acosta-Domínguez *et al.*, 2021). The *polod* powder showed good functional properties as higher water hydration and lower OBC values are desired due to the moistness of the product, starch retrogradation, product staling, and to determine the storage stability (Çalışkan Koç & Özçıra, 2019). However, the low OBC may be due to the damaged structure of dietary fibre and its content decreased during processing (Li *et al.*, 2020).

3.1.2 Swelling power and solubility

Generally, the swelling power and solubility of powder are influenced by its amylose and amylopectin properties (Beech *et al.*, 2022). The swelling power of *polod* powder at different temperatures ranged from 7.07 g/g to 9.15 g/g (Table 2). Vamadevan & Bertoft (2020) reported that amylose can form a complex helix with lipids, resulting in lower swelling power. According to Mishra *et al.* (2023), higher temperature often leads to higher swelling power. However, the present study showed that the swelling power decreased at 95 °C which may be due to the disruption of granular structure in starch when exposed at higher temperature (Mishra *et al.*, 2023).

Meanwhile, the solubility of the *polod* powder was 44.25% - 61.71% (Table 2). The findings agreed with Kusumayanti *et al.* (2015) in which the lower swelling power resulted in higher solubility of tropical tubers powders. Moreover, the high solubility may be attributed to the high amylose content and WHC of *polod* powder (Li *et al.*, 2023).

Table 2 Swelling power and solubility of *polod* powder at different temperatures.

Temperature (°C)	**Swelling power (g/g)**	**Solubility (%)**
60	8.16 ± 0.67^{ab}	53.74 ± 2.94^{b}
75	9.15 ± 0.87^{b}	44.25 ± 1.28^{a}
95	7.07 ± 0.65^{a}	61.71 ± 3.07^{c}

$^{a\text{-}c}$ Same letters in the same column are not statistically different ($p > 0.05$).

3.2 Proximate composition and total dietary fibre

Moisture content indicates the ability of patty samples to retain water during cooking process. The control formulation (F0) showed significantly higher ($p < 0.05$) moisture content at 64.44% (Table 3), while F3 (6% *polod* powder) had the lowest moisture content (56.19%). F3 showed about 14.68% reduction in moisture content compared to F0. In general, the lower moisture content may be due to the differences in water added in the formulation which were 15.5% in F0 and 9.5% in F3. Furthermore, previous research also found that adding dietary fibre in dried form resulted in lower moisture content of meat products (Zaini *et al.*, 2020).

Based on Table 3, the protein content of patties ranged from 17.54% (F0) to 20.29% (F2). The protein content of F1 and F2 were significantly higher ($p < 0.05$) than F0, while F3 showed similar protein content ($p > 0.05$) with the control sample. *Arenga sp.* Employed in this study contained about 3.8% protein, which may increase the protein content of patties (Kassim *et al.*, 2017). Meanwhile, the lipid content of chicken patties (Table 3) increased with increasing concentration of *polod* powder. F3 (13.20%) showed significantly higher ($p < 0.05$) lipid content than F0 (8.71%) and F1 (9.97%). The results may be attributed to the the OBC of *polod* which helps to retain oil during the cooking process (Mohanan *et al.*, 2020). Khomola *et al.* (2021) also mentioned that adding moringa leaves powder increased the lipid content of mutton patties.

Table 3 Proximate composition of chicken patties.

Composition (%)	F0	F1	F2	F3
Moisture	64.44 ± 0.50[c]	60.93 ± 0.46[b]	57.22 ± 0.70[a]	56.19 ± 0.35[a]
Protein	17.54 ± 0.05[a]	20.09 ± 0.26[b]	20.29 ± 0.19[b]	17.55 ± 0.20[a]
Lipid	8.71 ± 0.93[a]	9.97 ± 0.24[a]	12.77 ± 0.68[b]	13.20 ± 0.44[b]
Ash	2.36 ± 0.11[a]	2.89 ± 0.08[b]	3.27 ± 0.10[c]	3.07 ± 0.05[bc]
Crude fibre	0.0053 ± 0.0005[a]	0.0085 ± 0.0003[a]	0.0122 ± 0.0006[b]	0.0221 ± 0.0025[c]
Carbohydrates	6.94 ± 0.87[a]	6.10 ± 0.71[a]	6.45 ± 0.17[a]	9.97 ± 0.52[b]
Total dietary fibre	0.0190 ± 0.0009[a]	0.0206 ± 0.0004[ab]	0.0213 ± 0.0004[b]	0.0244 ± 0.0010[c]

The treatments were formulated by: F0 (0% *polod* powder), F1 (2% *polod* powder), F2 (4% *polod* powder), and F3 (6% *polod* powder).
[a-c] Same letters in the same row are not statistically different ($p > 0.05$).

The ash content refers to inorganic residue that remains after the complete oxidation of organic substances and can also represent the mineral content in food products (Dunuweera *et al.*, 2021). The addition of *polod* powder significantly increased ($p < 0.05$, Table 3) the ash content in chicken patties. F3 showed the highest level of ash (3.27%) while F0 had the lowest ash content at 2.36%. The findings were in line with Munsu *et al.* (2021) who observed an increase in ash content due to the incorporation of seaweeds in chicken sausages. Furthermore, chicken patty incorporated with 6% *polod* powder showed the highest carbohydrate content (9.97%), followed by F0 (6.94%), F1 (6.45%), and F2 (6.10%). The results were supported by Suychinov *et al.* (2023), in which lower moisture content lead to higher carbohydrates in meat patties. The authors also reported that samples containing high protein had low carbohydrate content, as observed in F1 and F2 in the present study. The reduction in carbohydrate content can be attributed to the relative increase in other proximate parameters, including protein and fat contents (Nyaguthii *et al.*, 2023).

Generally, addition of *polod* powder increased the crude fibre content from 0.0053% (F0) to 0.0221% (F3). In terms of dietary fibre, F2 and F3 were significantly higher ($p < 0.05$, Table 3) than the control sample. The highest dietary fibre content was obtained in F3 (0.0244%) which showed 28.42% increment than F0 (0.0190%). According to Pindi *et al.* (2023a), adding edible plant can boost dietary fibre by up to 54%.

3.3 Energy content of patties

Patties incorporated with *polod* powder showed significantly higher ($p < 0.05$) energy value than the control sample (Table 4). The energy values were largely affected by the amount of water added in the formulation. The substitution of water by *polod* powder increased the energy value of patties due to the zero calorie of water. These results were in contrast with findings of Feng *et al.* (2022). They reported that incorporation of potato dietary fibre in chicken patties significantly reduced the calorie values (Feng *et al.*, 2022). According to the Recommended Nutrient Intakes for Malaysia (NCCFN, 2017), the recommended dietary energy for male and females aged between 19 and 29 is 2440 and 2000 kcal, respectively. The findings from this study indicated that consuming 100 g of *polod* chicken patties (6%) would provide 9.38 and 11.44% of the dietary energy requirement of adult males and females, respectively.

Table 4 Energy content of chicken patties containing *polod* powder.

Formulation	Energy value (kcal/100 g)
F0	176.33 ± 5.33[a]
F1	194.54 ± 0.42[b]
F2	221.85 ± 6.68[c]
F3	228.89 ± 1.38[c]

The treatments were formulated by: F0 (0% *polod* powder), F1 (2% *polod* powder), F2 (4% *polod* powder), and F3 (6% *polod* powder).
[a-c] Same letters in the same column are not statistically different ($p > 0.05$).

3.4 Textural properties of patties

Generally, the incorporation of *polod* powder reduced all the textural parameters measured with no significant difference ($p > 0.05$) on the hardness, springiness, and cohesiveness of chicken patties. Based on Table 5, the hardness of chicken patties decreased with increasing concentration of *polod* powder. The results may be associated with the high content of fibre in *polod* powder which resulted in excellent WHC (Pillai *et al.*, 2020). According to Cerón-Guevara *et al.* (2020), mushroom powders decreased the hardness of beef patties compared to the control. The authors attributed the findings with improved moisture retention due to the addition of fibre. Similarly, F0 had the highest ($p > 0.05$) springiness value (0.86 mm) while F2 showed the lowest springiness (0.80 mm). According to Bouaziz *et al.* (2020), addition of fibre in meat products significantly affected hardness, but did not affect the springiness, adhesiveness, and cohesiveness values.

Table 5 Textural properties of chicken patties.

Formulation	Hardness (N)	Springiness (mm)	Cohesiveness	Chewiness (N x mm)
F0	32.41 ± 1.37[a]	0.86 ± 0.06[a]	0.41 ± 0.01[a]	11.27 ± 0.75[b]
F1	30.94 ± 1.95[a]	0.81 ± 0.02[a]	0.39 ± 0.01[a]	9.70 ± 0.57[ab]
F2	30.49 ± 1.51[a]	0.80 ± 0.01[a]	0.35 ± 0.04[a]	8.55 ± 0.67[a]
F3	28.85 ± 1.39[a]	0.81 ± 0.03[a]	0.36 ± 0.01[a]	8.28 ± 0.37[a]

The treatments were formulated by: F0 (0% *polod* powder), F1 (2% *polod* powder), F2 (4% *polod* powder), and F3 (6% *polod* powder).
[a-b] Same letters in the same row are not statistically different ($p > 0.05$).

The control formulation showed the highest ($p > 0.05$) cohesiveness values at 0.41 mm, followed by F1 (0.39 mm), F3 (0.36 mm), and F2 (0.35 mm). The addition of dietary fibre could disrupt the protein gel network, consequently reducing the gel strength of meat products (Feng *et al.*, 2023). Sun *et al.* (2022) reported similar trends in which sausages incorporated with hempseed meal and lupin flour contributed to lower hardness, springiness, cohesiveness, and chewiness. Additionally, addition of *polod* powder significantly decreased ($p < 0.05$) the chewiness values from 11.27 N x mm (F0) to 8.28 N x mm (F3). According to Niu *et al.* (2020), the addition of dietary fibre may result in a loose protein network and lower fat-binding capacity, resulting in reduced chewiness in meat products.

3.5 Cooking yield and cooking loss of patties

In general, cooking yield and cooking loss are strongly dependent on the WHC and OBC of *polod* powder. The addition of *polod* powder at 4% and 6% significantly increased ($p < 0.05$) the cooking yield of chicken patties. Based on Table 6, F3 had the highest cooking yield (89.87%) while F0 showed the lowest cooking loss (82.81%). Mohd Zaini *et al.* (2021) observed a similar trend in cooking yield when banana peel powders were incorporated in chicken sausage. Similarly, the cooking loss of chicken patties showed a decreasing trend with increasing percentage of *polod* in the formulation. F2 (12.27%) and F3 (10.13%) significantly reduced ($p < 0.05$) the cooking loss as compared to the control sample (17.19%). This finding were supported by Jeong *et al.* (2021) who reported that addition of 1% winter mushroom powder reduced the cooking loss of beef patty due to the water holding and fat-binding capacity of dietary fibre.

Table 6 Cooking yield and cooking loss of patties.

Formulation	Cooking yield (%)	Cooking loss (%)
F0	82.81 ± 0.77[a]	17.19 ± 0.77[b]
F1	85.57 ± 2.53[ab]	14.43 ± 2.53[ab]
F2	87.73 ± 1.74[b]	12.27 ± 1.74[a]
F3	89.87 ± 2.04[b]	10.13 ± 2.04[a]

The treatments were formulated by: F0 (0% *polod* powder), F1 (2% *polod* powder), F2 (4% *polod* powder), and F3 (6% *polod* powder).
[a-b] Same letters in the same column are not statistically different ($p > 0.05$).

3.6 Sensory evaluation

Consumer acceptance of the chicken patty incorporated with *polod* powder was measured using a 7-scale Hedonic test (Table 7). All patties had slightly similar colour and aroma scores ($p > 0.05$). The F1 sample obtained the highest colour, aroma, and overall acceptance values of 5.88, 5.58, and 6.06, respectively. Meanwhile, F0 (6.04) received the highest score in taste, followed by F2 (5.78). F0 and F1 also showed no significant difference ($p > 0.05$) in texture.

Table 7 Consumer acceptance scores of patties.

Attributes	F0	F1	F2	F3
Colour	5.86 ± 1.11[a]	5.88 ± 0.94[a]	5.80 ± 0.95[a]	5.72 ± 1.01[a]
Aroma	5.52 ± 1.22[a]	5.58 ± 1.28[a]	5.30 ± 1.37[a]	5.34 ± 1.36[a]
Taste	6.04 ± 1.07[b]	5.78 ± 1.00[b]	5.28 ± 1.36[ab]	5.02 ± 1.25[a]
Texture	6.18 ± 0.83[c]	6.06 ± 0.74[bc]	5.70 ± 1.23[ab]	5.16 ± 1.43[a]
Overall acceptance	6.06 ± 0.84[b]	6.06 ± 0.84[b]	5.64 ± 1.01[ab]	5.14 ± 1.31[a]

The treatments were formulated by: F0 (0% *polod* powder), F1 (2% *polod* powder), F2 (4% *polod* powder), and F3 (6% *polod* powder).
[a-c] Same letters in the same row are not statistically different ($p > 0.05$).

There was no difference in colour score between samples with or without *polod* powder ($p > 0.05$), indicating that the *polod* powder did not cause visually significant colour differences. Likewise, Feng *et al.* (2022) reported that the degree of liking the colour of chicken patty containing potato dietary fibre did not differ from that of the control sample. Pindi *et al.* (2023a) also mentioned that the appearance of a food product is less important to consumers who buy products based on their perceived healthiness. Similarly, the samples showed no significant difference ($p > 0.05$) in aroma. However, adding 4% and 6% of *polod* powder significantly decreased ($p < 0.05$) the taste scores. This finding may be attributed to the high amount of *polod* powder added, which masked the original frying flavour of the patties.

The texture of patties prepared with 0% and 2% *polod* powder were most accepted by the panellists in this study. Meanwhile, F3 earned the lowest scores for texture, which could be attributed to its low hardness and chewiness (Table 5). Among the formulations, F1 received the greatest overall acceptance rating, which was likely due to its high colour, aroma, taste, and texture scores. Generally, low overall acceptance for patties containing high *polod* percentage could be caused by the unique taste of *polod* powder, which the panellists were unfamiliar with.

4. Conclusion

Polod powder possesses physicochemical properties suitable for use as functional powder in patty production. This study found that adding 2, 4, and 6% *polod* powder to chicken patties reduced moisture but increased protein, lipid, ash, and energy contents. *Polod* could provide health benefits by increasing the dietary fibre of the patty. Furthermore, *polod* powder reduced the textural parameters but F1 (2% *polod*) and the control sample showed no differences in terms of hardness, springiness, cohesiveness, and chewiness. The current findings also demonstrated that various concentrations of *polod* powder increased the cooking yield, resulting in lower cooking loss. Compared to other formulations, F1 (2% *polod* powder) obtained the greatest overall acceptability scores due to the highest scores obtained for acceptance of colour, aroma, taste, and texture. Hence, the study demonstrated the potential of *polod* powder in the production of healthier patties. In the future, the capacity of *polod* powder as animal fat substitute should be studied to formulate low-fat meat products without compromising the textural and sensory attributes.

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