Article

Functional and Sensorial Properties of Chicken Sausage Supplemented with Banana Peel Flours of Different Varieties

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Abstract: Meat products are widely consumed worldwide and, as a result, they may be an exciting supplier of health benefits due to the need for better formulations, such as reduced fat and increased fibre in processed meats. This study was carried out to determine how the banana peel (BP) flour of Saba (*Musa balbisiana*) and Berangan (*Musa acuminata*) affect the functional properties and sensory acceptance of chicken sausage. Berangan BPs showed better water- and oil-holding capacity than Saba BP flour. Conversely, Saba BP flour exhibited better swelling power, but was less soluble than Berangan BP flour. Sausages containing high BPs, especially Saba banana, had a more rigid texture, a high storage modulus, and a darker colour. The ability to retain more water in Berangan peel positively affected the sausage's textural and rheological properties. With 2%, chicken sausage received the highest sensory score, with Saba BP-containing sausage following closely behind. However, adding >2% BP of both varieties negatively affected the sausage texture and colour, resulting in reduced sensory acceptance. Thus, the BP from Saba and Berangan bananas showed promise as a potential value-adding ingredient in the formulation of functional meat products. In addition, it has potential health benefits, such as increased dietary fibre.

Keywords: banana peel; meat emulsions; dietary fibre; functional meat product; sausages

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1. Introduction

Meat is a typical source of protein, vitamins, minerals and essential fatty acids required by the human body. The growth in urbanisation and per capita income alters eating patterns, thus increasing the utilisation of animal-derived foods. According to the United Nations Food and Agriculture Organization projections, global meat consumption is expected to increase by up to 0.4 kg per capita by 2028, with developing countries undergoing the fastest growth. Recent years have seen a surge in interest in developing meat and meat products with physiological functions that promote health and reduce disease risk. Therefore, the enrichment of meat products with health-enhancing ingredients are widely studied.

In tropical and subtropical regions, one of the most cultivated and consumed fruit is banana. However, only 12% (*w/w*) of the plant is considered edible, and banana cultivation and commercialisation produce considerable waste. Furthermore, 38% of the total banana weight is constituted by the banana peel (BP). Often, BP is discarded without further utilization, thus causing environmental an issue and industrial concern.

BP contains various vitamins, minerals, phytonutrients, dietary fibre (DF) and antioxidants [1]. In addition, several bioactive compounds, such as tannins, phlobatannins, alkaloids, glycosides and terpenoids, could be found in the BP, and they are beneficial in terms of specific pharmacological and biological aspects.

DF is naturally found in cereal, vegetables, nuts and fruits. DF has been demonstrated to deliver health benefit to the human digestive system, such as preventing constipation, absorbing harmful substances in the gut, providing satiety, controlling body weight, and reducing the concentration of glucose and triglycerides in blood. The DF's recommended daily intake should be at least 30 g a day, regardless of gender [2]. However, rapid urbanisation has changed the current food intake habit as people are more likely to consume more fast foods and an unbalanced diet, and have an excessive calorie intake [3]. As a result, most people worldwide are unable to achieve the daily recommended DF intake.

Therefore, the DF supplementation in foods, especially meat products, has been widely studied to provide a solution to increase the DF intake without extensively changing current eating habits [4]. Moreover, considering the nutritional benefit of a BP, it could be an excellent vehicle to improve the nutritional value of food, especially meat products. From a technological perspective, DF incorporation in meat products offer improved functional properties, such as water and oil binding, and gelling capacity in meat products [5]. In turn, this incorporation can boost the emulsion stability, viscosity and rheological properties, and sensory aspects, of meat products. The present study aimed to apply BP from two varieties as fibre sources and filler in the production of chicken sausage.

2. Materials and Methods

2.1. BP Flour Preparation

The ripening stage of banana was assigned according to a seven-stage scale (Table 1) reported in previous studies [6].

Table 1. Maturity stage of bananas.

Stage	Skin Colour
1	All green
2	Green with trace of yellow
3	More green than yellow
4	More yellow than green
5	Yellow with trace of green
6	All yellow
7	All yellow with brown speckles

Ripe (stage 7) *M. balbisiana* and *M. acuminata* were selected for this study. The debris was removed by washing before the peel was separated from its pulp with a knife. Next, the peels were treated with a 0.5% (*w/v*) citric acid solution to minimize enzymatic browning. After the solution was drained, the sliced peels were dried for 48 h at 40 °C in a drying cabinet (Thermolite, Malaysia). Then, the peels were ground and screened using 60-mesh screens (250 µm). Table 2 show the proximate composition and total dietary fibre (TDF) of prepared BP flour.

Table 2. Proximate composition and TDF of banana peel flour.

Composition (%)	Saba Banana Peel	Berangan Banana Peel
Moisture	11.11 ± 0.36	8.81 ± 0.14
Ash	9.00 ± 0.32	8.54 ± 1.74
Protein	4.85 ± 0.10	8.60 ± 0.05
Fat	7.06 ± 1.40	4.08 ± 1.51
Crude Fibre	11.75 ± 0.55	10.09 ± 0.06
Carbohydrate	56.68 ± 2.04	59.41 ± 1.38
Total Dietary Fibre	44.03 ± 1.53	39.04 ± 1.27

2.2. Chicken Sausage Production

The boneless chicken breast was purchased from Desa Hatchery Sdn. Bhd. The constituents of the sausage (chicken breast, fat, ice water, potato starch, isolated soy protein,

sugar, pepper, and salt) were thoroughly mixed with a cutter to obtain a homogeneous mixture, which was then mixed with each BP at three different compositions (2%, 4% and 6% dry matter). Next, the cellulose casing (2.5 cm in diameter) was filled with meat batter by using a sausage stuffer. Two chicken sausages were prepared from each treatment, where each sausage weighed 10 g. Then, the samples were labelled before being steamed for 30 min at 75 °C. Afterwards, the sausages were dipped in cold water at 15 °C for 20 min. Finally, the water was drained, and the sausages were stored in airtight bags at 4 °C.

2.3. Functional Properties of BP Flour

2.3.1. Water-Holding Capacity (WHC) and Oil-Holding Capacity (OHC)

The methods in [7] were employed to obtain the WHC and OHC of BP flour samples. The results were expressed follows:

$$\text{WHC, \%} = \frac{\text{Sample weight after centrifuged with distilled water} - \text{Initial sample weight}}{\text{Initial sample weight}} \times 100 \quad (1)$$

$$\text{OHC, \%} = \frac{\text{Sample weight after centrifuged with corn oil} - \text{Initial sample weight}}{\text{Initial sample weight}} \times 100 \quad (2)$$

2.3.2. Swelling Power

The swelling power of the BP flours was determined in accordance with [8]. A 0.1 g sample was heated in 10 mL distilled water for 30 min in a water bath at 60, 75 and 90 °C separately with constant mixing. For 15 min, the samples were centrifuged at $365 \times g$. The precipitated portion was weighed and calculated using the following equation:

$$\text{Swelling Power} = \frac{\text{Weight of sedimental paste, g}}{\text{Weight of sample in dry basis, g}} \quad (3)$$

2.3.3. Water Solubility

The method in [9] was used to determine the solubility of water. Samples (0.5 g) in a 10 mL distilled water were heated in a water bath at 60, 75 and 90 °C separately for 30 min. Then, they were centrifuged at $365 \times g$ for 10 min. The supernatant (5 mL) was separated, dried and weighed using the following equation:

$$\text{Water solubility} = \frac{\text{Weight of Soluble starch, g}}{\text{Weight of sample in dry basis, g}} \quad (4)$$

2.4. Functional Properties of Chicken Sausage Added with BP Flour

2.4.1. Texture Profile Analysis

The TA.XT Plus Texture Analyzer was used for texture analysis (Stable Micro System, Surrey, UK) [10]. Each sample had six replicates in the present study. The samples were standardised in size, measuring 20 mm in height and 25 mm in diameter, and they were compressed to 50% of their original size. Cohesiveness, springiness, stiffness and chewiness were the attributes measured in this study.

2.4.2. Colour

A Konica Minolta chromameter (CR400, Tokyo, Japan) [11] was used to determine the colour of the samples. Six measurements were taken perpendicularly, with images of the sausage's various surfaces. CIE L* (lightness), a* (redness) and b* (brightness) were used to represent the values (yellowness).

2.4.3. WHC

WHC was determined using the centrifugation technique with modifications [12]. A 10 g sample was mixed with 15 mL of 0.6 M NaCl solution and centrifuged for 15 min at 4 °C at 1280× g inside a tube. The following formula was used to determine WHC:

$$\text{Sausage WHC, \%} = \frac{\text{Weight after centrifuge} - \text{Weight before centrifuge}}{\text{Weight after}} \times 100 \quad (5)$$

2.4.4. Rheology

A rheometer (AR500 TA Co., Ltd., New Castle, DE, USA) was used to measure the rheological aspects, which included a measuring temperature of 10 °C in a stainless-steel cone plate with a diameter of 60 mm and a gap width of 2 mm, and a sweep stress test from 0.1 to 100 Pa at 1 Hz frequency. The samples were analysed in triplicate.

2.4.5. Microstructure

The sausage samples were grilled with an electric grill until they reached 71.5 °C and left to cool for 30 min before being refrigerated for 24 h. The samples were then freeze-dried (−50 °C) for 24 h prior to analysis. Scanning electron microscopy (SEM, Carl Zeiss MA10, Oberkochen, Germany) was used to determine the microstructure of the samples which were prepared following [13]. The working distance ranged from 5 to 9 mm with a working voltage of 15 to 20 kV using a solid-state secondary electron detector and a backscattered electron detector. Observations were conducted under different magnifications (from 100× to 1000×) and the most representative image analysis and micrographs were selected.

2.5. Sensory Profiling

For sensory evaluation, a seven-point hedonic scale was used in this assessment (from 1 = extremely despise, 7 = extremely like). The sausages were sliced evenly and distributed in random order. The sensory panellists were selected among the faculty's 40 untrained students. The parameters evaluated in the experiment were taste, aroma, appearance, hardness, colour, juiciness and overall acceptability.

2.6. Statistical Analysis

The *t*-test was used to evaluate the BP flour properties of the two varieties. One-way ANOVA was also used to evaluate the effects of BP on chicken sausage's physicochemical and sensory properties. The trial was replicated twice (two independent batches), each replication corresponding to a different production day. Data were analysed using SPSS version 24.0 statistical processor software (IBM corp., Armonk, NY, USA). The Tukey test was used to evaluate the significant difference between the means for the various attributes ($p < 0.05$).

3. Results and Discussion

3.1. Functional Properties of BP Flour

3.1.1. Water-Holding and Oil-Holding Capacity

Table 3 shows the WHC and OHC of Saba and Berangan BP flours.

Table 3. Water-holding capacity and oil-holding capacity of Saba and Berangan BP flour.

	Saba Banana Peel	Berangan Banana Peel
WHC (g water/g dry sample) *	0.85 ± 0.04	1.08 ± 0.04
OHC (g oil/g dry sample) *	0.23 ± 0.02	0.26 ± 0.01

* Marked a significantly different in WHC and OHC of banana peel flours ($p < 0.05$).

Although the Berangan peel flour showed a better WHC than the Saba peel flour, the current finding was still lower than those reported by [14], who obtained an WHC of 3.48 g/g from Berangan BP. The flour's ability to retain water may be linked to the

BP's starch, DF and protein content. Fibre holds water through its pore space as the particle is hydrated [15]. According to [16], the presence of amylose also contributed to the water-binding ability of BP flour.

In terms of OHC, Berangan BP flour also showed an excellent trait compared with Saba BP. However, the dry-mill processing to obtain the flour may represent a significant drawback for the OHC. The modification of the physical structure of the flour may affect the surface properties, the surface charge density and the hydrophobic properties [17].

The ability to hold water and oil is one of the essential characteristics of functional foods. For example, a high WHC ensure a juicy meat product following culinary treatment prior to consumption [18]. Furthermore, ingredients that can hold oil act as emulsifiers in food products that have a high fat content.

3.1.2. Swelling Power and Solubility

The swelling power (Figure 1a) and solubility properties (Figure 1b) of Saba and Berangan BP flours are shown in Figure 1.

Figure 1. (a) Swelling power and (b) water solubility of banana peel flour.

The obtained findings showed that Saba BP flour's swelling power was better than that of Berangan BP flour. In addition, Berangan BP solubilised more in water than Saba BP.

The mouth-taste quality of food is frequently connected to the water retention of swelled starch granules [19]. The good swelling power in Saba BP flour indicated its soft starch granule with high amylopectin content [20]. Moreover, the low swelling power in Berangan BP flour may be explained by its high amylose content, which also contributed to its better solubility [21]. Amylose can form a complex helix with lipid, which causes a lower swelling power. Disruption of the granular structure of starch occurs when it is subjected to high heat [22]. This rheological property affects the high viscosity at certain temperatures, and this feature is vital for industrial applications in ready-to-cook products.

3.2. Functional Properties of Chicken Sausage Added with BP Flour

3.2.1. Texture Profile Analysis

Table 4 shows the changes in the textural aspect of the sausages as a feature of BP levels.

Table 4. Texture profile analysis of chicken sausage incorporated with BPF.

Treatment	Hardness (N)	Cohesiveness	Springiness (mm)	Chewiness (N × mm)
Control	46.60 ± 10.60 ^d	0.64 ± 0.56 ^a	0.87 ± 0.03 ^a	18.07 ± 4.06 ^c
SBF2	60.20 ± 1.49 ^c	0.60 ± 0.05 ^{a,b}	0.85 ± 0.02 ^a	28.43 ± 2.56 ^b
SBF4	60.98 ± 0.55 ^c	0.54 ± 0.05 ^{b,c}	0.86 ± 0.01 ^a	30.57 ± 2.80 ^b
SBF6	84.99 ± 3.17 ^a	0.47 ± 0.04 ^c	0.82 ± 0.03 ^a	46.65 ± 1.71 ^a
BBF2	55.48 ± 3.90 ^{c,d}	0.62 ± 0.03 ^{a,b}	0.86 ± 0.03 ^a	28.66 ± 1.26 ^b
BBF4	60.82 ± 8.65 ^c	0.59 ± 0.08 ^{a,b}	0.84 ± 0.03 ^a	29.57 ± 4.32 ^b
BBF6	71.91 ± 5.36 ^b	0.55 ± 0.04 ^{a-c}	0.82 ± 0.02 ^a	34.24 ± 3.39 ^b

^{a-d} Mean ± Standard Deviation in the same column with different superscripts indicates that there are significant difference ($p < 0.05$). Abbreviations: SBF2: Added 2% Saba banana peel; SBF4: Added 4% Saba banana peel; SBF6: Added 6% Saba banana peel; BBF2: Added 2% Berangan banana peel; BBF4: Added 4% Berangan banana peel; BBF6: Added 6% Berangan banana peel. Data for SBF2, SBF4 and SBF6 adapted from [4].

After BP was added, the chewiness, hardness and cohesiveness were significantly affected ($p < 0.05$). However, in terms of springiness, no significant difference was found ($p > 0.05$). The involvement of nonmeat proteins results in a more robust protein network that is more resistant to compression [23]. Hardness was predominant in sausage with Saba BP, and increased up to 45% with the addition of 6% Saba BP flour. This finding may be linked with the OHC of the BP flour itself. Berangan BP has better OHC, thus enhancing the formulated foods' texture and viscosity [24]. Interestingly, compared with Saba BP-treated sausages, Berangan BP flour did not negatively affect the cohesiveness. The presence of insoluble DF may contribute to the decrease in cohesiveness. The crystalline component in insoluble DF gives the food a brittle trait [25]. High chewiness energy is required for SBF6, and no significant effect of chewiness was found among the BBF-treated sausages. According to [26], the hardness factor affects chewiness; the harder the food sample, the more energy is required to chew it.

3.2.2. Colour and Water-Holding Capacity

According to [22], the WHC of meat can be described as its ability to maintain its water content even when subjected to external pressure (gravity and temperature). This feature is vital in meat products because water-holding ability affects cooking loss and meat sensory quality [17]. Table 5 shows that adding BP increased the WHC, and this was more significant with the Berangan BP addition. For instance, 6% BBF increased the WHC up to 50% compared with only an increment of 29% in WHC in the SBF6 sample. However, the sausages darkened after BP was added ($p < 0.05$).

Table 5. Water-holding capacity and colour properties of chicken sausage incorporated with BPF.

Treatment	WHC (%)	Colour		
		L* (Lightness)	a* (Redness)	b* (Yellowness)
Control	6.54 ± 1.08 ^d	73.48 ± 0.29 ^a	1.13 ± 0.76 ^e	13.40 ± 0.14 ^a
SBF2	6.67 ± 0.66 ^d	60.32 ± 0.32 ^c	1.36 ± 0.58 ^d	9.48 ± 0.28 ^d
SBF4	7.97 ± 0.64 ^{d,c}	53.13 ± 0.56 ^e	2.18 ± 0.17 ^{a,b}	9.31 ± 0.31 ^d
SBF6	9.28 ± 0.33 ^{b,c}	49.72 ± 0.34 ^f	2.36 ± 0.17 ^{a,b}	9.25 ± 0.48 ^d
BBF2	9.67 ± 1.39 ^{b,c}	63.40 ± 0.36 ^b	1.59 ± 0.10 ^c	12.74 ± 0.60 ^{a,b}
BBF4	10.48 ± 1.44 ^b	60.20 ± 0.31 ^c	2.14 ± 0.07 ^b	11.97 ± 0.85 ^b
BBF6	13.25 ± 1.49 ^a	58.07 ± 0.61 ^d	2.40 ± 0.17 ^a	11.09 ± 0.04 ^c

a–f Mean ± Standard Deviation in the same column with different superscripts indicates that there are significant differences ($p < 0.05$). Abbreviations: SBF2: Added 2% Saba banana peel; SBF4: Added 4% Saba banana peel; SBF6: Added 6% Saba banana peel; BBF2: Added 2% Berangan banana peel; BBF4: Added 4% Berangan banana peel; BBF6: Added 6% Berangan banana peel. Data for SBF2, SBF4 and SBF6 adapted from [4].

The increase in WHC may be attributed to BPF's DF content. As the DF is hydrated, water molecules occupy the pore space in fibre particles. In addition, the observed increase in WHC in the treated sample may result from the gelatinisation of hydrated BP at high temperatures [27]. Thus, a good water retention capacity is necessary for a reasonable cooking yield. Nonetheless, it is vital to counter the exudation inside the sausages' package during storage and commercialisation to ensure a juicy meat product following culinary treatment prior to consumption [18].

Colour influences a consumer's acceptance of a product. According to [28], the colour of Frankfurter-type products is usually influenced by the amount of water and fat content, as long as myoglobin was kept constant. The present study's findings supported the earlier statement, implying that adding BP to sausages caused them to darken. The dry BP had a standard brownish colour, which was theoretically passed to the studied samples; the lightness of the meat batter and sausage decreased extensively ($p < 0.05$), causing a difference in the sausage and batter. The current results also supported the findings of [29], who found that precooked browning can be caused by a nonenzymatic reaction between the amino acids in meat and the carbohydrates in the BP.

3.2.3. Rheology

The effects of adding Saba and Berangan BP on the viscoelastic properties of chicken sausage were studied using dynamic rheology. Figures 2 and 3 shows the rheological properties (strain-sweep) of chicken batter incorporated with BP flour.

Figure 2. Rheological properties (strain-sweep test) of chicken batter with the addition of Saba banana peel. Data for SBF2, SBF4 and SBF6 adapted from [4].

Figure 3. Rheological properties (strain-sweep test) of chicken batter with the addition of Berangan banana peel. Abbreviations: SBF2: Added 2% Saba banana peel; SBF4: Added 4% Saba banana peel; SBF6: Added 6% Saba banana peel; BBF2: Added 2% Berangan banana peel; BBF4: Added 4% Berangan banana peel; BBF6: Added 6% Berangan banana peel. Data for SBF2, SBF4 and SBF6 adapted from [4].

Comparing storage modulus (G') and loss modulus (G'') showed that the G' was higher than G'' , implying a gel-like sample. Compared with the control samples, which had a low G' value (suggesting a smoother texture than the treated samples), the BP-containing sausages significantly increased ($p < 0.05$) in viscous and elastic moduli, especially in Berangan banana peel-containing sausage. Furthermore, the G'' values for meat emulsion increased as the BP level increased. Because of its filler nature, BP flour may have considerably stabilised the solubilised protein gel and inhibited protein shrinkage, but only when limited to a 2% addition of BP flour of both varieties [30]. BP flour only existed as granules at high concentration ($>2\%$), which acted as a filler between the protein matrix linkage. Although Berangan banana peel-containing sausage show the largest G' increase, the plateau value is more constant than the Saba BP-containing sausage. The linearity limit of Saba BP-sausage shows the weak protein-protein myofibrillar linkage with the presence of Saba BP. According to [31], adding fibre to meat products increased the viscous and elastic moduli. Ref. [32] found that emulsified sausage replaced regenerated cellulose, which may explain the higher gel elasticity and network. Interestingly, the hardness of chicken sausage, which was previously discussed, showed a similar pattern of findings.

Emulsions containing 6% Saba BP and Berangan BP, respectively, showed a very high G' . This occurred due to the high intermolecular interactions or chain complexation due to the presence of non-meat component [33]. Furthermore, the reduction in moisture content as the BP content increased contributed to the G' increment [34].

3.2.4. Microstructure

SEM was conducted on cooked chicken sausages to study the addition of BP flour to the sausage's microstructure. Figure 4 shows the microstructure of chicken sausage.

The SEM micrographs demonstrated no noticeable difference in the appearances between the control and treated samples. The rough texture showed only the protein matrix. The presence of BP granules was not detected, although the particle size was quite large ($<200\ \mu\text{m}$). The spongy appearance in SBF6 may have been due to the expansion of water and air constituent [35]. A chemical treatment was suggested to be imposed on the meat sample prior to analysis to differentiate the protein component, fat globule and pore.

Figure 4. Microstructure of chicken sausage added with banana peel flour. (A) Control; (B) Sausage with 2% Saba banana peel flour; (C) Sausage with 4% Saba banana peel flour; (D) Sausage with 6% Saba banana peel flour; (E) Sausage with 2% Berangan banana peel flour; (F) Sausage with 4% Berangan banana peel flour; (G) Sausage with 6% Berangan banana peel flour.

3.3. Sensory Profiling

The colour, taste, aroma, texture, juiciness, hardness and overall acceptability of chicken sausage formulations were evaluated. The sensory properties of BP-containing sausage are described in Table 6.

Table 6. Sensory profiling of chicken sausage incorporated with BPF.

	Appearance	Colour	Aroma	Taste	Hardness	Juiciness	Overall Acceptance
Control	4.78 ± 1.23 ^a	4.46 ± 1.53 ^{a,b}	5.21 ± 1.07 ^a	5.15 ± 1.49 ^a	3.73 ± 1.85 ^c	3.93 ± 1.80 ^b	4.64 ± 1.19 ^{b,c}
SBF2	3.91 ± 0.93 ^b	3.91 ± 0.90 ^b	4.42 ± 1.06 ^b	4.59 ± 1.31 ^a	4.67 ± 1.22 ^{a,b}	4.09 ± 1.24 ^b	4.57 ± 1.02 ^{b,c}
SBF4	3.37 ± 1.29 ^c	2.80 ± 1.52 ^{c,d}	3.67 ± 1.29 ^c	3.60 ± 1.36 ^b	3.62 ± 1.39 ^c	3.57 ± 1.63 ^b	3.54 ± 1.52 ^d
SBF6	3.07 ± 1.13 ^c	2.26 ± 1.20 ^d	3.32 ± 0.97 ^c	2.59 ± 1.03 ^c	2.70 ± 0.96 ^d	2.43 ± 1.14 ^c	2.73 ± 0.93 ^e
BBF2	4.80 ± 1.08 ^a	4.87 ± 1.52 ^a	4.70 ± 1.32 ^b	5.05 ± 1.41 ^a	5.11 ± 1.24 ^a	4.76 ± 1.78 ^a	5.26 ± 1.40 ^a
BBF4	4.64 ± 1.22 ^a	3.98 ± 1.30 ^b	4.67 ± 0.89 ^b	4.90 ± 1.33 ^a	4.82 ± 1.13 ^a	4.91 ± 1.11 ^a	5.02 ± 1.08 ^{a,b}
BBF6	3.94 ± 1.44 ^b	3.07 ± 0.99 ^c	3.75 ± 0.48 ^c	3.98 ± 0.93 ^b	4.16 ± 1.22 ^{b,c}	3.91 ± 1.06 ^b	4.16 ± 0.96 ^c

^{a–d} Mean ± Standard Deviation in the same column with different superscripts indicates that there are significant differences ($p < 0.05$). Abbreviations: SBF2: Added 2% Saba banana peel; SBF4: Added 4% Saba banana peel; SBF6: Added 6% Saba banana peel; BBF2: Added 2% Berangan banana peel; BBF4: Added 4% Berangan banana peel; BBF6: Added 6% Berangan banana peel. Data for SBF2, SBF4 and SBF6 adapted from [4].

It is worth noting that supplementation of Berangan banana peel had an additional advantage on sensory attributes than sausages formulated with Saba banana peel and control. The control sample had a significantly ($p < 0.05$) higher appearance score than Saba banana peel treatments at all concentration levels. In contrast, sausage with Berangan banana peel, BBF2 and BBF4 were comparable with the control sample.

Colour acceptance was significantly ($p < 0.05$) reduced in the treatments SBF4, SBF6, and BBF6, which may be due to the lower yellowness found in these treatments (Table 6). The results are in agreement with those of [36], where the inclusion of 4–6% of banana peel led to a decrease in the colour acceptance of the fish patties.

On the other hand, all treatments showed a significant reduction in aroma acceptability compared to the control. This outcome agrees with those reported by [37], who noticed that adding banana peel flour in cereal reduced the aroma acceptability.

The addition of SBF2, BBF2, and BBF4 resulted in almost similar scores on taste ($p > 0.05$), indicating that low concentrations of banana peels had little or no impact on the typical taste of sausage (2–4% of banana peel). However, an increase in banana peel level 6%, decreased ($p < 0.05$) the taste score of cooked sausage. Ref. [36] also reported results in line with the abovementioned, where the inclusion of banana peel did not affect the taste of fish patties.

Moreover, the hardness and juiciness decreased with the increasing concentration of both Saba and Berangan banana peels. A similar trend was observed by [38], who noticed that adding dietary fibre to meat products decreases hardness and juiciness because dietary fibre may disturb the protein-protein or protein-water gel network.

Generally, overall acceptance showed that berangan banana peel had a higher score than saba banana peel ($p < 0.05$). Berangan banana peel may be accepted by the panelists because it has better water holding capacity (WHC) and oil holding capacity (OHC) than the saba banana peel (Table 3). Water-and-oil binding properties are important for determining the quality of texture and sensory properties of meat product [39].

Moreover, the treatments BBF2 and BBF4 scored significantly ($p < 0.05$) higher overall acceptability; meanwhile, SBF2 had a slightly ($p > 0.05$) lower score than the control. This outcome is in line with those observed by [40], who found that the incorporation of green banana flour did not deteriorate the sensory properties of the low-fat sausages.

4. Conclusions

This study found that adding BP flour to chicken sausage has functional aspects such as WHC and improved textural properties. However, the sensory aspects of the final

product were negatively affected when more than 2% BP flour was added to it, regardless of the variety. The sensory and textural properties of chicken sausage prepared with 2% BP of both varieties was found to be organoleptically and texturally comparable with those of the other samples. As a result, the role of BP concentration on the technical functionalities of the chicken sausage was established in this study. Thus, although a high percentage of banana enhanced the hardness properties of chicken sausage, a high concentration of BP weakened its cohesiveness. A compromise between nutritional properties and textural acceptability is critical to maintaining the sensorial consistency of chicken sausage. Optimising BPs and their combination with other binding substances in emulsified meat products warrants further research.

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