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Original Research Article

Utilising Banana Peel as a Food Ingredient for Enhancing Nutritional Value of Yellow Noodles and Beef Patties

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Abstract: Bananas are one of the most popular fruits around the world. There are more than 150 different countries that have banana plantations. Most of the bananas can be either eaten raw or processed to become tasty banana products such as banana chips, banana cake or banana milk. However, a lot of consumption will make a lot of waste at the same time. Therefore, the high demand for bananas in the market causes the problem of environmental pollution due to the higher production of banana peel waste which is becoming serious nowadays. The wastes derived from bananas can be transformed into other useful products. Based on the result from proximate analysis, the chemical compositions of the banana peel are ash (7.0%), carbohydrate (71.0%), moisture content (8.9%), fat (13.0%), dietary fibre (35.9%), crude fibre (16.6%), and finally the protein (6.5%). From its chemical composition, the carbohydrate content of the banana peel is the highest among other components. Because of this high carbohydrate and fibre content, banana peels have the potential to become a nutritional ingredient to produce healthy food or beverage products. In this paper, the fibre content can be observed by the increase in the carbohydrate content. The results show that the addition of banana peel powder had helped to improve the nutritional value of fibre content for yellow noodles from 19.4% to 21.3% after 10% of banana peel powder (BPP) was added. However, the results of fibre content for each beef patties sample were not consistent and this may be due to the agglomeration of BPP in the patties. Nevertheless, the fibre content of patties which contain the highest value of BPP (6%) achieved the highest fibre content at the same time. In short, the pollution issue caused by the banana peel can be solved efficiently if humans can learn to manage the banana peel as a material, not a waste.

Keywords: banana peel; food waste; application of banana peel; nutritional food; healthy food

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1. Introduction

One of the most economical fruits that grow all over the world is the banana, which belongs to the genus *Musa* and family *Musaceae.* The banana is a fruit that is grown in the tropics (Arias, 2003). Nevertheless, even though it is consumed to the greatest extent in tropical areas, the banana is consumed all over the world for its flavour, nutritional content, and availability throughout the year. For dessert bananas such as Cavendish banana are typically consumed in their fresh form. They can also be utilised to impart flavour to baked goods such as muffins, cakes, or breads. For cooking types of plantains, also known simply as plantains, are starchier than the dessert banana (Onojah & Emurotu, 2017). They are cultivated extensively as a source of staple food in tropical countries; they may be cooked whether they are ripe or immature. A fully ripened fruit can have as much as 22% of its total weight come from carbohydrates, and it also has a high concentration of dietary fibre, potassium, manganese, and vitamins B6 and C.

The high consumption of bananas will bring a high amount of food waste at the same time. The peels, *pseudo stem*, leaves, inflorescence, and stalk are the common by-products of bananas. Among all these waste products, the most difficult waste to manage is the banana peel because it represents 40% of the total weight of the fresh banana (Arunakumara *et al*., 2013). Every year, there are approximately 36 million metric tonnes of banana peel produced, and its existing endpoint is related to negative effects on the environment as well as economic losses (Gomes *et al*., 2020). The peel of a banana is the protective covering for the banana. It is a by-product of both the domestic eating of bananas and their subsequent processing in the food industry (Espino, *et al*., 1991). They are the sources of nutrition and a useful component instead of waste. They have the potential to become the nutritional ingredients in food industries. The chemical composition of banana peels is the primary factor that determines whether they can be used as a source of supplemental nutrients in food. The high organic content of banana peel, which includes lipids, fibre, carbohydrates, and protein, makes it an important source of many different types of bioactive substances with a variety of functions (Munsu *et al*., 2022).

In an effort to reduce the environmental burden due to food waste, this study was conducted to determine the effect of utilising banana peel powder in the preparation of food products, specifically yellow noodles and beef patties. The studied effects include the chemical composition, texture and cooking yield of the food products that are made by partially substituting or adding banana peel powder (BPP). The findings of the study were useful for providing insights into the potential of BPP for enhancing the nutritional values of the food products, while simulations retain the important texture of the products.

2. Materials and Methods

2.1 Banana peel powder (BPP)

Bananas at stage 3 of ripening had been purchased from the supermarket. Before separating the pulp from the peel, bananas were first cleaned and washed with water to remove any dirt and foreign materials. Fruit pulp and fruit were separated manually using both hands and a knife. Then, the obtained peels were cut into small parts using a sharp knife and were spread in trays. The peels were immersed in 0.5% of citric acid solution for 10 min to prevent enzymatic browning. After that, the prepared peel was dried in the oven at a temperature of 60˚C for 48 h to ensure that the banana peels were fully dried. This is due to the thickness of the banana peels, which take a long time to dry. The dried peel was cooled and ground into a fine powder using a kitchen grinder. The powder was sieved to avoid agglomeration before being packed in polyethylene plastic and stored at room temperature until subsequent use.

After that, the proximate analysis was conducted by using the BPP produced. The A&D MX50 moisture analyser was used to determine the moisture content. Next, the ash content was analysed by igniting the sample in a muffle furnace at 550˚C until a greyish colour is obtained. The protein content was determined by using the Kjeldahl method while the fat content was determined using the Soxhlet extraction method. In addition, the carbohydrate content was measured by using the subtracting method by which the contents of ash, moisture, protein and fat were subtracted from the total weight of the sample. Additionally, the crude fibre content was measured using the Weende method which was found suitable for determining the crude fibre content in pet food and animal feed. The dietary fibre was measured using the Enzymatic-Gravimetric method by phosphate buffer systems.

2.2 Application of banana peel powder (BPP)

2.2.1 Yellow noodle

2.2.1.2 Preparation steps

The formulations that were utilised for the noodles are presented in Table 1 below, and the procedure that was utilised for the preparation of the noodles is outlined according to Sirichokworrakit *et al*. (2015). The standard recipe for the control noodles was 100 g of wheat flour, 50 mL of distilled water, 1 g of salt, and 1 g of food additive called “Kansui”. For the other noodle samples, 10% of the banana peel powder was used to replace the wheat flour in the recipe. Mixing, rolling, slitting, and finally boiling the noodles were the processes involved in the preparation of noodles.

Table 1. Formula of different yellow noodle samples

Ingredients	Amount (g)	
	Control	**10% BPP**
Wheat Flour	100	90
Water	50	50
Food Additive (Kansui)	1	1
Salt	1	1
Banana Peel Powder	0	10

By using a kitchen aid mixer, the first step was to combine all the raw ingredients and turn them into noodles. The procedure steps began by mixing the ingredients at a slower speed (3 min), followed by a faster speed (3 min) to form the dough. After that, the mixer was gradually brought to a stop and this can assist in cleaning the bowl and the beater. After finishing the mixing process, the dough was set to rest for around 20 min. Thereafter, the dough was passed through a manual noodle maker several times while the spacing between the rollers was gradually decreased. Additionally, the dough sheet was folded in between each pass to ensure that their thickness was averaged. After the cutting process, the final dough sheet went through the noodle slitting roll to produce the noodle strands which had dimensions of 2 mm in width and 1 mm in thickness. The completed noodles were given a thin coating of flour to prevent them from sticking to one another.

After that, the noodles were boiled by placing them in a saucepan filled with hot water and allowing them to cook for 15 min . Then, the finished noodles allowed to cool at room temperature before being subjected to any further experiments. The procedure was carried out once more, but this time wheat flour was substituted with 10% powdered banana peel.

2.2.1.3 Proximate analysis

Same method with the proximate analysis of Banana Peel Powder (BPP)

2.2.1.4 pH value

The pH was measured using a pH meter and calibrated with a buffer solution of pH 4.0 and 10.0, respectively. All measurements were performed in triplicate to get the average accurate values.

2.2.1.5 Textural analysis

Texture profile analysis was conducted by using a Texture Analyser (TA). The model used was XT Plus Texture Analyser (Stable 578 Micro System, United Kingdom). The cooked food products will be cut into a height of 2 cm and 2.50 cm diameter and compressed to 50% of their actual size according to Zaini *et al*. (2021) by using a 36 mm diameter of cylindrical aluminium probe (Zaini *et al*., 2020). A compression force and cross-head speed of 25 kg and 2 mm/s will be used for the compression test. The attributes recorded during the analysis are hardness, cohesiveness, springiness, and chewiness.

2.2.2 *Beef patties*

2.2.2.2 Preparation steps

The preparation of beef patties was conducted according to Abdel-Fattah *et al*. (2016) with four different concentrations (0%, 2%, 4%, and 6%) of BPP powder. Necessary ingredients as in Table 2 were purchased from the supermarkets located in Seri Serdang, Selangor. According to Mahmoud *et al*., (2017), the ingredients will be mixed homogeneously for 5 min with a cutter and shaped by a commercial burger maker into a diameter and thickness of 9 cm and 1 cm, respectively. To maintain the shape of the sample, the beef patties will be wrapped with a plastic packaging film and stored in frozen storage (-18°C) until further use.

Table 2. Formula for different beef patties samples

Ingredients	**Amount (g)**			
	Control	**2% BPP**	**4%BPP**	**6%BPP**
Deboned Beef Meat	70.00	70.00	70.00	70.00
Salt	2.30	2.30	2.30	2.30
Ice	10.00	10.00	10.00	10.00
Starch	2.00	2.00	2.00	2.00
Garlic	0.50	0.50	0.50	0.50
Onion	2.00	2.00	2.00	2.00
Seasoning	1.20	1.20	1.20	1.20
Banana Peel Powder (BPP)	0.00	1.76	3.52	5.28

2.2.2.3 Proximate analysis

Same method with the proximate analysis of Banana Peel Powder (BPP).

2.2.2.4 pH value

Same method with the pH measurement of yellow noodles.

2.2.2.5 Textural analysis

Same method with theTextural analysis of yellow noodles.

2.2.2.6 Cooking Yield

The evaluation of the cooking properties of the food samples begins by weighing the weight of the raw food sample before cooking. After weighing, the samples of food products will be cooked in microwaves for 5 minutes and cooled to a temperature of 21°C before weighing. To evaluate the cooking yield (%), cooking loss (%) and shrinkage (%), the corresponding Equations (1), (2) and (3) were used:

$$\text{Cooking yield (\%)} = \text{Cooking weight (g)} - \text{Raw weight (g)} \times 100\% \quad (1)$$

$$\text{Cooking loss (\%)} = \frac{Raw\ weight\ (g) - Cooking\ weight\ (g)}{Raw\ weight\ (g)} \times 100\% \quad (2)$$

$$\text{Shrinkage (\%)} = \frac{Raw\ diameter\ (cm) - Cooked\ diameter\ (cm)}{Raw\ diameter\ (cm)} \times 100\% \quad (3)$$

3. Results and Discussion

3.1 Banana peel powder (BPP)

3.1.1 Proximate analysis

Table 3. Proximate analysis of banana peel powder

Parameter	Percentage (%)
Crude fibre	16.6
Dietary fibre	35.9
Carbohydrate	71.0
Moisture content	8.9
Ash content	7.0
Fat	13.0
Protein	6.5

Table 3 above shows the results of the proximate analysis of banana peel powder (BPP). According to the results, a major part of the banana peel comes from carbohydrate content which was around 71.0%. Since, the carbohydrate content was measured by subtracting the total (100%) with the content of ash, fat, protein, and moisture. Hence, in the carbohydrate content, which involves 35.9% of dietary fibre and other components such as starch, glucose and more. For the dietary fibre content in BPP, it can be separated into two parts, crude fibre (16.6%) and soluble fibre (19.3%). The second major composition of banana peel was fat content which was 13.0% followed by moisture content (8.9%), ash content (7.0%) and the most minor composition was the protein content (6.5%). By analysing the result, it can be said that banana peel powder is a healthy and nutritional ingredient due to its high fibre content.

3.2 Application of banana peel powder (BPP)

3.2.1 Yellow noodles

3.2.1.1 Proximate analysis

Proximate compositions of yellow noodles with partial substitution of 10% of banana peel powder and control noodles were determined in terms of protein, fat, carbohydrate, ash, moisture and energy. There were significant differences in the proximate composition as shown in Table 4 below.

Table 4. Chemical composition of yellow noodles with and without BPP

Component	Control	BPP10
Ash	0.150 ± 0.02%	0.150 ± 0.01%
Carbohydrates	19.4 ± 0.04%	21.3 ± 1.00%
Fat	1.00 ± 0.01%	0.28 ± 0.01%
Moisture	75.7 ± 0.07%	75.0 ± 0.02%
Protein	3.75 ± 0.05%	3.70 ± 0.55%
Energy, Kcal	152.1 (kJ)	101 (424 kJ)

The protein content in control and BPP10 noodles were 3.70% and 3.75%, respectively, demonstrating a small difference between banana peel and control noodles. The lower protein content in banana peel noodle was expected, due to the addition of banana peel powder in the noodle formulation. Vernaza *et al*. (2011) reported that the banana peel powder had a lower protein content than wheat flour which was 4.99% and 10.60% respectively. The protein content in flour was the key factor in creating the noodle structure. It also affected the texture of the noodles produced.

In addition, the fat content in banana peel noodles also showed a lower value than control noodles which was 0.28% rather than 1.0%. This value could be affected by the fat composition in the banana peel powder used. In terms of health, a lower consumption of fat is recommended especially in a daily diet.

For the carbohydrate content, banana peel noodles had 21.3% of carbohydrates when compared to control noodles which was 19.4%. Carbohydrates could be one of the factors in choosing a noodle. Healthy people should have enough intake of carbohydrates in their daily meals. As mentioned in the pyramid chart of food intake, it is suggested to take the food with carbohydrates first followed by others. Besides, the increase in carbohydrates also represented the increase in fibre content. Thus, to maintain a healthy diet, the consumer should take carbohydrates at higher percentages.

Furthermore, the moisture content of the control noodles was higher than the banana peel noodles which was 75.7% and 75.0%, respectively. Moisture contents of noodles with banana peel powder were affected by the concentration of banana peel powder, and as the concentration of BPP increased, moisture content decreased. In general, the moisture content in food affect the shelf life of the product. Food with lower moisture content can be consumed a bit longer rather than food that has higher moisture content. Thus, the control sample may have a longer shelf life if compared to the BPP10.

Respecting the moisture, the ash of banana peel powder obtained almost the same as control noodles, which is 0.150%. The ash content in banana peel noodles could contribute due to the mineral content such as potassium and magnesium in banana peel (Castelo-Branco *et al*, 2017), Ash content also depended on the quality of flour and thus corresponds to the higher mineral contents.

In terms of energy, banana peel noodles seem to have a lower value than control noodles (Table 4). This value could be obtained because of banana peel powder composition when compared to control noodles that only contain wheat flour. Finally, there were no significant differences between the formulation of control noodles and banana peel noodles and it was also reported by other researchers (Vernaza *et al*., 2011; Castelo-Branco *et al*., 2017).

3.2.1.2 pH value

Table 5. pH value of the control and 10% banana peel noodle

Sample	Average
Control	7.64
BPP10	7.13

The pH value of foods plays an important role in the food industry because it is used to indicate how acidic or alkaline a food is. In this particular experiment, the noodles were cooked by boiling in hot water. Both the type of flour and the amount of alkaline water ("Kansui") that was added to the mixture of components had an effect on the pH of the noodles. A common value for yellow noodles is estimated in the range between 9 and 11, which results in a yellow colour (Saifullah *et al*., 2009). The control noodles had a pH value that was greater than the banana peel noodles, which had a value of 7.64, while the control noodles had a pH value of 7.13.

Additionally, the replacement of wheat with banana peel powder will result in specific modifications to the pH of the finished noodles. However, during the cooking process, the pH value of both types of noodles decreased significantly due to reflected leaching and loss of salts in the boiling water. Saifullah *et al*. (2009) observed that the yellowness of noodles was low if the acquired pH value was lower than 9.

3.2.1.3 Textural Analysis

Table 6 presents a comparison between the breaking length and tensile strength of the control noodles and those of the noodles with banana peel powder substituted. The tensile strength of the noodle and the amount of time needed for it to break under maximum force are the primary emphasis of the textural parameters. It has been demonstrated that substitution of 10% banana peel powder in the preparation of the noodles results in a considerable reduction in both the tensile strength and the breaking length of the noodles. These drops in tensile strength and breaking length can be explained by the decrease in the viscoelastic characteristics that occurred when 10% of the wheat flour was substituted with powder made from banana peels.

Table 6. Tensile strength and breaking length of control noodle and banana peel noodle with 10% of BPP

Sample	Breaking Length (mm)	Tensile Strength
Control	14.58	0.18
BPP10	12.73	0.17

When banana peel powder was utilised in place of the original ingredient, both the tensile strength and the breaking length were reduced. It's possible that the qualities are the result of banana peel powder having a lower concentration of protein than wheat flour. In addition, the matrix structural network of starches, glutens, proteins, fibres, and other extra substances influences the textural features of noodles also (Kong *et al*., 2012). A lower protein concentration will result in a decrease in the thermostability of the synthesis of gluten, which will then contribute to the firmness and tensile strength of the noodle texture (Kovacs *et al*., 2004).

Furthermore, the incorporation of powdered banana peel led to a lower percentage of gluten, which resulted in the gluten's diminished strength and loss of its viscoelastic qualities (Vernaza *et al*., 2011). Because of this, the proteins included in banana peel powder are unable to contribute to the overall matrix of proteins that improve the noodle's textural features when it comes to dough sheeting.

3.2.2 Beef burger patties

3.2.2.1 Proximate analysis

Table 7 displays the moisture, ash, protein, fat, and carbohydrate content of beef patties at various BPP concentrations. The physical appearance, texture, and quality of meat products are strongly correlated with the moisture content. The moisture content is inversely related to the concentration of BPP, as demonstrated in Table 7.

Table 7. Chemical composition of beef patties at different concentrations of BPP

Sample	**Percentage (%)**				
	Moisture	**Ash**	**Protein**	**Fat**	**Carbohydrate**
Control	62.23	3.90	16.70	14.10	3.07
BPP 2	61.63	4.20	15.30	16.00	2.87
BPP 4	60.05	3.90	17.50	15.70	2.85
BPP 6	57.49	4.60	14.90	17.40	5.61

This is because as the concentration of BPP increases, the moisture content decreases. The control sample had the highest moisture content (62.23%), followed by samples treated with 2%, 4%, and 6% BPP with moisture levels of 61.63%, 60.05%, and 57.49%, respectively. This finding is consistent with the results of Zaini *et al*. (2021) which indicated a decrease in the moisture content of chicken sausage containing BPP. Zaini *et al*. (2021) further added that the decrease in moisture content was a result of the lower moisture content in BPP compared to the meat product, as well as the presence of dietary fibre in BPP, which causes a reduction in moisture in treated samples. This is because dietary fibre can absorb water thus reducing the moisture content in the treated beef patties. Similar findings were also reported by Sharma and Yadav (2020) where there was a decrease in the moisture content of chicken meat patties added with pomegranate peel and bagasse powder.

In terms of ash composition, samples treated with 6% BPP contained the highest level of ash (4.60%) followed by BPP2 samples with 4.20% ash. In comparison, the lowest levels of ash were reported in both control and BPP4 samples at 3.90%. Increased concentrations of total dietary fibres, minerals, and resistant starch in the BPP were responsible for the increase in ash levels in treated samples (Pereira & Maraschin, 2015). In contrast, BPP4 had a decreased ash concentration due to the agglomeration of the BPP, which causes tiny particles to adhere to one another and have poor solubility.

Similarly, in terms of protein content, the addition of BPP to beef patties follows the same pattern as the moisture content, as shown in Table 7 where a greater fraction of BPP results in lower protein content. For instance, the protein content of samples treated with 2% and 6% BPP is reduced to 15.30% and 14.90%, respectively, when compared to the protein content of the control sample (16.70%). In accordance with the findings of Zaini *et al*. (2020), the protein content of fish patties decreased from 16.11 % to 9.92 % when orange peel powder was added at a concentration of 6 %. Zaini *et al*. (2020) also reported that the declining trend of protein content was related to the loss of soluble protein in the meat which occurs when there is a loss in the beef patties water content. In other words, samples treated with BPP will have better water retention ability thus reducing the dripping of water from the beef patties. In contrast, the inclusion of 4% results in a protein concentration of 17.50% which is 0.80% higher than the control sample. Abdel-Naeem *et al*. (2022) obtained similar results, reporting an increase in the protein content of chicken patties when powdered lemon, orange, grapefruit, and banana peel were added. Compared to the control sample (18.71%), the addition of powdered lemon, orange, grapefruit, and banana peel raised the protein content to 19.71%, 19.89%, 19.80%, and 22.18%, respectively.

As illustrated in Table 7, the addition of BPP to beef patties has enhanced their fat content. The sample with the highest fat content (17.40 %) was BPP6, while the sample with the lowest fat content was the control (14.10 %). According to Sharma and Yadav (2020), the higher fat content in patties treated with BPP was related to increased fat retention and the presence of a greater quantity of fat. Additionally, the fat content in beef patties is closely related to the oil holding capacity (OHC). Based on Table 7, BPP4 has the lowest fat content among the treated samples. This is because a beef product with low OHC due to the presence of banana peel powder content will absorb less oil. However, higher fat content in meat does not indicate that treated samples are less healthy as compared to the control sample. This is because banana peels are rich in a good type of fat known as polyunsaturated fatty acids which include linoleic acid (Omega-6) and α-linolenic acid (Omega-3) (Zaini *et al*., 2022). Ando *et al*. (2017) also reported that α-linolenic acid is considered a beneficial dietary component for alleviating obesity. However, according to Hădăruga *et al*. (2016), Omega-3 fatty acids were easily degraded even at a low temperature of 50°C. Hence, the fat content in the beef patties may be disrupted.

Technically, meat contains no carbohydrates since the complex sugar glycogen contained in muscle is broken down during the conversion of muscle to meat. Typically, carbohydrates are determined by subtracting the quantity of protein, water, ash, and fat from the sample's total gram weight (100 g). According to Table 7, samples treated with 6% and 4% BPP had the highest and lowest carbohydrate content, with values of 5.61% and 2.85%, respectively. The results indicate that both BPP2 and BPP4 treated samples have more sum of protein, water, ash, and fat compared to BPP6 and control since carbohydrate is obtained using the subtraction method.

3.2.2.2 pH value

Table 8. pH values of raw beef patties at different concentrations of banana peel powder

Sample	pH value
Control	5.99 ± 0.021
BPP2	5.90 ± 0.023
BPP4	5.85 ± 0.044
BPP6	5.81 ± 0.025

The pH level plays a significant part in determining the quality of meat products since it affects the meat's water-holding capacity, texture, and cooking properties. Additionally, pH impacts the meat's freshness, flavour, and overall quality.

By referring to Table 8, it can be observed that the pH level of beef patties decreased for every increasing concentration of BPP with the control sample yielding the greatest pH (5.99) and the BPP6 sample yielding the lowest pH (5.81). Younis *et al*. (2021) obtained similar results, observing a decrease in the pH of sausages and patties when mosambi peel powder (MPP) was added. This is because banana peel powder and beef patties have different pH levels. In other words, the pH range for banana peel powder is 6.15 to 6.46 (Abdel-Naeem *et al*., 2022), but the typical pH range for beef is between 5.5 to 6.2. Therefore, adding powdered banana peel, which has a higher pH, would result in a decrease in the overall pH of the treated sample.

3.2.2.3 Textural Analysis

Texture Profile Analysis (TPA) is a double compression test utilised by the food industry to identify the textural features of food, as shown in Table 9, which include hardness, cohesiveness, springiness, chewiness, and gumminess. TPA has a close relationship with the sensory evaluation of a food product and is extremely useful in the development of novel food products.

Table 9. TPA of beef patties at different concentrations of banana peel powder (BPP)

Sample	Hardness (N)	Cohesiveness (%)	Springiness (%)	Chewiness (N x mm)	Gumminess
Control	9916.50 ± 7.20	0.38 ± 0.06	0.38 ± 0.02	1487.48 ± 20.24	3718.69 ± 16.00
BPP2	6339.70 ± 12.30	0.15 ± 0.04	0.33 ± 0.07	437.28 ± 18.32	932.31 ± 25.89
BPP4	9654.90 ± 9.80	0.31 ± 0.05	0.40 ± 0.06	1204.34 ± 23.40	2950.11 ± 11.34
BPP6	8331.70 ± 15.20	0.24 ± 0.08	0.33 ± 0.09	524.57 ± 15.87	2011.10 ± 9.87

Hardness is the amount of force necessary to deform a food item at a certain distance. According to Kadam *et al*. (2015), hardness, which is also known as firmness, is one of the most crucial factors used to identify the freshness of food. Table 9 of the TPA results revealed that the hardness value of the control sample, 9916.50 N, was much higher than the treated samples of BPP2 (6339.70 N), BPP4 (9654.90 N), and BPP6 (8331.70 N). The decrease in hardness with increasing BPP concentration was due to an increased elasticity resulting from the presence of dietary fibre in BPP (Zaini *et al*., 2021).

Cohesiveness is the measure of food product deformation prior to rupture. In addition, the ratio of the energy necessary for the second compression to the energy required for the first compression is calculated (Nishinari *et al*., 2019). By looking into Table 9, all treated samples have lower cohesiveness as compared to the control sample. The highest cohesiveness value was 0.38% (control) followed by 0.31% (BPP4), 0.24% (BPP6) and 0.15% (BPP2). This conclusion was reinforced by Zaini *et al*. (2019) who found that a higher concentration of BPP has decreased the cohesion of fish patties. Similar results were also obtained by Huda *et al*. (2014) which indicated that the inclusion of apple pomace lowered the cohesiveness of mutton nuggets. Zaini *et al*., (2021) stated that the presence of insoluble dietary fibre could contribute to the loss of cohesion by imparting a brittle quality to the beef product. In other words, beef products with lesser cohesion and more brittleness will be easier to chew.

In terms of springiness, all treated samples, except for BPP4, had a lower value than the control sample. The BPP4 treated sample had the maximum springiness (0.40%), followed by the control (0.38%), BPP2 (0.33%), and BPP6 (0.33%). Meat's springiness is closely related to food's elasticity. Higher food springiness generally requires greater digestion energy in the mouth. In other words, the samples treated with 2% and 6% BPP would require less energy for biting in the mouth. As for chewiness, it is the energy required to chew a solid food until it is ready to be swallowed and is determined by the correlation between hardness, cohesiveness, and springiness. Table 9 also indicates that there has been a great difference of 1050.2 N mm between the highest chewiness value (1487.48 N mm) in control and the lowest chewiness value (437.28 N mm) in BPP2 treated samples. According to Zaini *et al*. (2021), the decreased chewiness rating in treated samples was a result of the increased texture hardness.

The term "gumminess" refers to a food's thick and gooey texture. The gumminess of a food product is directly linked to its hardness and cohesiveness, just as chewiness is. In Table 9, it can be observed that samples with the highest gumminess also have the highest chewiness rating. In other words, the highest gumminess was obtained by the control sample with a value of 3718.69 Nm whereas the lowest gumminess was obtained by the BPP2 sample with a value of 932.31 Nm followed by BPP4 (2950.11) and BPP6 (2011.10).

3.2.2.3 Cooking Yield

Table 10 displays the cooking parameters of beef patties prepared with varying concentrations of banana peel powder (BPP), including cooking yield, cooking loss, and shrinkage value.

Table 10. Cooking properties of beef patties at different concentrations of banana peel powder (BPP)

Sample	Cooking Yield (%)	Cooking Loss (%)	Shrinkage (%)
Control	77.16 ± 0.35	22.84 ± 0.19	17.14 ± 0.12
2% BPP	77.64 ± 0.21	22.36 ± 0.26	12.05 ± 0.26
4% BPP	75.88 ± 0.33	24.12 ± 0.14	7.93 ± 0.12
6% BPP	80.85 ± 0.27	19.15 ± 0.14	7.67 ± 0.23

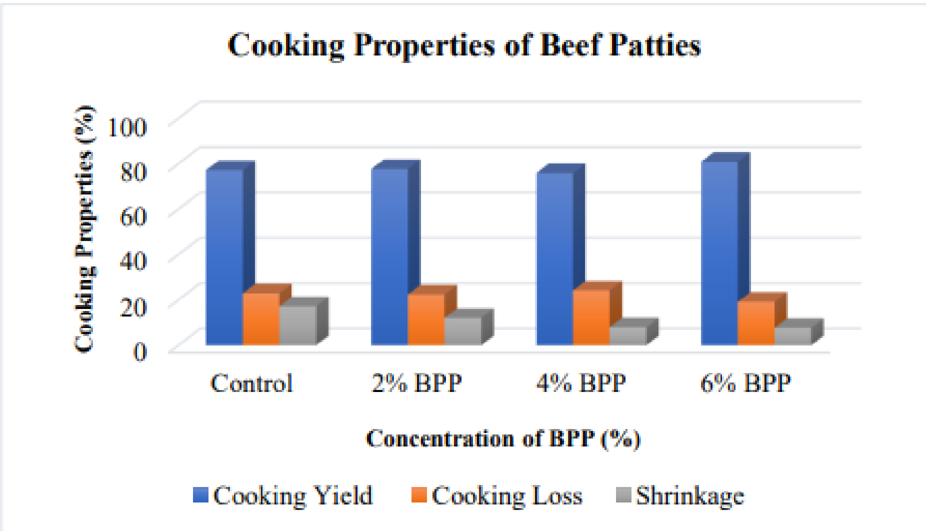

Figure 1. Cooking properties of beef patties with different concentration of BPP

As shown in Figure 1, the cooking yield of treated samples is much greater than that of the control samples. For example, beef patties with 2% BPP have a greater cooking yield of 77.64% compared to the control sample's cooking yield of just 77.16 %. However, the cooking yield for beef patties treated with 4% BPP is the lowest at 75.88%. In contrast, the highest cooking yield is achieved with the highest concentration (6%) of BPP with a value of 80.85 %. This finding is acknowledged by Mahmoud *et al*. (2017) and Ibrahim *et al*. (2018) which indicate a rise in cooking yield when orange and lemon peel powders are added to beef patties. Mahmoud *et al*. (2017) also highlighted that the improved fat and water retention of beef products contributed to the increased cooking yield. In other words, the cooking yield of beef with high water holding capacity (WHC) and OHC values will be greater. For instance, the BPP6 treated sample, which has a greater WHC than the BPP4 treated sample, also has a greater cooking yield than the BPP4 treated sample. Zaini *et al*. (2019) found an increase in cooking yield can be attributed to the enhanced water retention capacity of fish patties containing BPP.

Figure 1 demonstrates that the inclusion of BPP6 has improved the cooking loss of beef patties in comparison to the control sample. The BPP6 treated samples experienced the least amount of cooking loss (19.15%), followed by BPP2, the control, and BPP4 at 22.36%, 22.84%, and 24.12%, respectively. According to Ježek *et al*. (2019), the cooking loss of meat during heat treatment is driven by the contraction of muscle fibres and intramuscular connective tissue, the intensity of which is also dependent on the applied temperature and apparatus. Several elements of the BPP, such as starch and pectin, interact with the protein and restrict the ability for moisture migration during cooking, hence reducing cooking loss, as documented in Zaini *et al*. (2021). Zaini *et al*. (2019) further revealed that the decrease in cooking loss was linked to the fibre's greater stability throughout the freezing and thawing process, which controls the production of ice crystals and reduces moisture migration.

Surface shrinkage is crucial for sustaining burger quality standards by releasing fat and water because of protein denaturation. By examining Table 10, the shrinkage value of beef patties is decreasing over time. According to Table 10, the addition of BPP enhanced the shrinkage of meat products, with samples treated with BPP2, BPP4, and BPP6 shrinking by 12.05%, 7.93%, and 7.67%, respectively, compared to the control sample, which shrank by 927 17.14%. Meat shrinks because of water evaporating from its surface and when fat, water, and fluids leak out. Meat shrinkage has been linked to the denaturation of myofibrillar and connective tissue proteins in the muscle structure during cooking, and it can be affected by ionic strength and pH (Vaskoska *et al*., 2020). According to Aboul-Enein *et al*. (2016), a decrease in the pH level of meat will decrease its WHC value, resulting in an increase in meat shrinkage.

4. Conclusions

Based on this study, the banana peel powder can be utilised to produce nutritional and value-added food such as beef patties and yellow noodles according to the results of the proximate analysis. The tensile strength of noodles can be reduced with the low protein content of banana peel powder. However, the fibre content of the yellow noodle can be improved by substituting the banana peel powder. This is very useful for human health because the fibre content is very important in the human body, especially for the digestive system. Besides, the use of banana peel powder in processed foods can reduce Malaysian food products' reliance on wheat flour and improve the development of low-wheat products that depend on natural resources. As a result, the substitution of banana peel flour into noodles is acceptable to invent a healthy noodle.

By using banana peel in beef burger patties, the pH value, texture properties, cooking loss and shrinkage have decreased. At the same time, the banana peel also helps to improve the cooking properties and the nutrient value of beef burgers. Increasing the banana peel powder concentration will lead to a decrease in moisture and protein content and an increase in ash, fat, and carbohydrate content. However, the overall result shows an inconsistent trend, and this may be because of some errors during the experiment. Therefore, to reduce the error and increase the accuracy of the results, precautionary steps such as mixing the ingredients homogeneity and washing the equipment by using distilled water before using need to be followed through the experiments.

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