Journal of Food and Nutrition Research, 2018, Vol. 6, No. 8, 492-496
Available online at http://pubs.sciepub.com/jfnr/6/8/1

DOI:10.12691/jfnr-6-8-1

Chemical and Functional Properties of Local Banana Peel Flour

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Received June 28, 2018; Revised August 01, 2018; Accepted August 20, 2018

Abstract Tone of banana peel is produced by improper handling during post-harvest and the consumption of its pulps becomes a concern. However the usage of banana peel is limited because of the limited knowledge on its properties. This study was carried out to investigate the chemical and functional properties of local banana peel flour (BPF) between Nangka, Tanduk, Berangan and Rastali. BPF was treated for anti-browning agent and dried at 60°C for ±12 hours. Results showed that yield of BPF range from 4.52-6.84 % with slightly acidic pH. The highest value of moisture, ash and crude lipid were exhibited by Nangka PF. Crude protein content of all BPF were less than 10% and the total carbohydrate content ranged from 64.6-72.8 %. Berangan PF contained the highest value of total dietary fiber with a higher amount of insoluble fraction compared to soluble fraction. The highest value of total phenolic content was found in Tanduk PF. As for functional properties, water holding capacity and oil holding capacity value lies between 5.8-6.4 g/g and 1.8-2.3 g/g, respectively. The water absorption index, water soluble index and swelling power were ranged from 6.5-8.1 g/g, 0.1-0.2 g/g and 3.6-7.3 g/g, respectively. BPF contain significant amount of nutritional properties, hence it has potential benefit to be used as functional ingredient in food product development.

Keywords: *banana peel, dietary fiber, total phenolic, functional properties*

Cite This Article: Syarifah Khadijah Syed Abu Bakar, Noorlaila Ahmad, and Fadhilah Jailani, “Chemical and Functional Properties of Local Banana Peel Flour.” *Journal of Food and Nutrition Research*, vol. 6, no. 8 (2018): 492-496. doi: 10.12691/jfnr-6-8-1.

1. Introduction

Banana is the most popular fruit in the world’s market not only for its texture, aroma, easy to peel and eat factor, but also for its nutritious value obtained at low cost especially in developing areas [1]. Therefore, the demand for banana keeps increasing annually. The massive consumption of banana pulp generates tones of banana peel and this peel renders 40 % of the total weight of fresh bananas [2]. Banana peel is obtained not only by the consumption of its pulps, but is also generated by post-harvest loss. According to [3], the production of unripe banana flour is an alternative because of the large amount of bananas are loss for commercialization due to improper handling during post-harvest. Hence, the amount of banana peels might be increased too. Since fruit waste can perish easily, converting banana peel into flour is necessary to extend it shelf life for further usage.

Similar to banana pulp flour, banana peel also has ability to impart a new product to several of domestic and industrial uses [4]. The potential usage of banana peel is depend on it chemical compositions and physicochemical [4]. According to [5] banana peel has been discovered to have nutrients and compounds including protein, dietary fiber, potassium, polyunsaturated fatty acids and essential amino acids as well as antioxidant compounds such as carotenoids, catecholamines and polyphenols. Banana peel is also a good source of antioxidant and dietary fiber. [6] reported that phenolic compound is believed to be a good source of antioxidant in which this compound found in banana peel. In addition [7] mentioned that, peels are rich in total phenolics than in pulp of Musa Cavendish. [2] and [8], reported that dietary fiber in banana peel exhibited 50 g/100g dry matter. Since banana peel contained high valuable compounds, including the dietary fiber fractions, it is a great potential in preparation of foods and functional foods.

As well as chemical compositions, functional properties also important in ascertaining the application of banana peel especially in food industry. Functional properties of food are used to determine the characteristic of foods during processing, production, consumption and storage. In addition, functional properties also control the parameter of food quality. Examples of functional properties are oil holding capacity, water holding capacity, foam capacity, emulsification, whipping capacity, viscosity and gelation. Hence, functional properties play important role formulation of food product and product processing [9].

The chemical and functional properties of BPF are expected to vary with different banana varieties. Most of previous studies reported for well-known banana cultivar such as Cavendish functional and chemical properties. Therefore, in this study dessert banana (Berangan and Rastali) and plantain (Tanduk and Nangka) were chosen based on their common availability in Malaysian market and highly consumed by local people. Analyzing BPF for the chemical and functional properties may increase the knowledge BPF behavior especially in its application as functional ingredient in product development.

2. Materials and Method

2.1. Preparation of BPF

Four types of banana (Nangka, Tanduk, Berangan and Rastali) were collected from banana orchards at Klang and Hulu Selangor. The bananas were washed and the peel separated from the pulp. The peel was soaked in combination of a 0.2 % sodium metabisulfite and 0.2 % of a citric acid for 30 minutes to reduce enzymatic browning. The peel was then dried in a cabinet dryer (Vision Scientific) at 60°C for twelve hours. The dried banana peel was then ground and sieved through a 40 mesh screen using an American Standard Test Sieve (ASTM) series. The powder obtained was kept in an air tight plastic container for further analysis.

2.2. Yield of BPF

The sieving yield represents the flour that passed through the 40 ASTM mesh screen. The yield of the banana PF was determined using this formula;

$$\%\ sieving\ yield = \frac{\text{mass of sieved flour}(g)\text{x}100}{mass\ of\ grind\ flour(g)}. \quad (1)$$

2.3. Determination of Proximate Analysis

Moisture, ash, fat, crude protein content of the BPF was determined using a method described by [10]. The carbohydrate (TC) content of the BPF was calculated by difference. The results were expressed as percentage.

2.4. Determination of pH Value

The pH value of the BPF was measured using pH meter (Hanna Instrument, HI-2211). Accurately, 8 % (w/v) of flour suspension was stirred for 5 minutes and allowed to stand for 30 minutes. The filtrate was measured after the suspension was filtered [4].

2.5. Determination of Total Phenolic Content

Banana PF was extracted using 80 % ethanol and placed in a shaking incubator at 57.5°C at 80 rpm. Then, it was filtered using a muslin cloth and centrifuged for 15 minutes at 3000 rpm. The supernatant was concentrated using a rotary evaporator and kept in a dark bottle at -20°C. The total phenolic content of the BPF was determined using Follin-Colcateau procedure. About 0.5 mL of extracted polyphenolic compound from BPF was weighed and mixed with 0.5 mL reagent and swirled. Then, 10 mL of sodium carbonate was added after 3 minutes and mixed thoroughly well. Ater 1 hour, the assay absorbance was measured using UV-VIS at 750nm. The result was recorded and expressed as gallic acid equivalents [11].

2.6. Determination of Total Dietary Fiber (TDF), Soluble Dietary Fiber (SDF) and Insoluble Dietary Fiber (IDF)

Total, Soluble and Insoluble Dietary Fiber determination was carried out using the enzymatic-gravimetric method 991.43 [12]. The BPF was digested using heat stable α-amylase, protease and amyloglucosidase to remove protein and starch. For TDF, enzyme digestate were treated with alcohol to precipitate the SDF before filtering and TDF residue was washed with alcohol and acetone, dried and weighed. For SDF and IDF, enzyme digestate was filtered and residue IDF was washed with warm water, dried and weighed. TDF, IDF and SDF residue values were corrected for protein, ash and blank.

2.7. Determination of Water Holding Capacity (WHC) and Oil Holding Capacity (OHC)

The water and oil holding capacity was determined using the centrifugal method [14] For WHC, 0.5 g of BPF and 5 mL of distilled water was spun in pre-weighed tube then centrifuged for 30 minutes at 1000g. The tube was weighed after the supernatant was poured out. The WHC was calculated by difference. The procedure for OHC similar to WHC distilled water but was substituted with 5 mL of oil.

$$\text{WHC and OHC} = \frac{\text{wet sample }(g) - \text{dry sample }(g)}{dry\ sample(g)}. \quad (2)$$

2.8. Determination of Water Soluble Index (WSI) and Water Absorption Index (WAI)

The water solubility index and water absorption index of BPF was determined as recommended by [13]. For WSI, 1 g of sample was mixed with 35 mL distilled water and homogenized using the Digital Ultra Turrax (T-25) homogenizer for 5 minutes at level 8. Then, the sample was transferred into a pre-weighed centrifuge tube and incubated for about an hour before being centrifuged for 20 minutes at 3000g in the Gerber Centrifuge Machine. The supernatant in the mixture was drained into a pre-weighed petri dish for 10 minutes at 45°C and dried at 105°C for 12 hours until a constant weight was achieved. WSI was obtained from the sample residue of BPF (soluble g / dry sample g) while WAI was obtained by calculating the mass of precipitation from centrifuge over the sample used in the test (wet sample g/drysampleg).

2.9. Swelling Power (SP)

Swelling power was performed as suggested by [14], by weighing 200 mg of sample into a tube and mixed with 5 mL of distilled water. Then mixture was spun for 10 seconds and incubated for 20 minutes at 65 °C in water bath with frequent shaking. The mixture was cooled down at 20°C for 5 minutes in a water bath. Then the mixture was centrifuged for 10 minutes at 3000 g. The BPF was calculated using the formula given below:

$$SP\ (g/g.d.m) = \frac{\text{Weigh of swollen residue}(g)}{\textit{Weight of dry sample}(g)}. \quad (3)$$

2.10. Statistical Analysis

The obtained data was analysed using a one way Analysis of Variance (ANOVA) exploiting Statistical Package for Social Science (SPSS) to test the level of significance ($p<0.05$). Duncan New Multiple range Test was used to separate the means where significant differences existed.

3. Results and Discussion

3.1. Yield and pH Value

The percentage yield of Rastali (6.63 %), Berangan (6.84 %) and Tanduk (6.27 %) BPF were not significantly different. Nangka BPF (4.52 %) yielded less flour compared to other BPF after passing through 40 mesh screen siever. Table 1 depicts, the Nangka variety PF obtained highest pH value followed by the Berangan, Tanduk and Rastali banana PF variety. According to [4], the pH value for ripe peel between 4.86 and 5.69 and for unripe between 4.30 and 5.33. In this study, pH value for BPF were 5.79 to 6.18 which indicates that pH value for stage three banana PF approaching neutral and hence might be less sour in taste. The factors that might affect the pH value of plants were the genetic of banana varieties, soil, weather and geographical factor [15].

Table 1. Yield and pH values of banana peel flour

Sample	Yield (%)	pH value
Nangka	$4.52^b \pm 0.16$	$6.18^a \pm 0.02$
Tanduk	$6.27^a \pm 0.58$	$5.92^c \pm 0.02$
Berangan	$6.84^a \pm 1.09$	$6.05^b \pm 0.01$
Rastali	$6.63^a \pm 0.45$	$5.79^d \pm 0.03$

Values represent mean ± standard deviation. Different superscript letters indicate Significant differences ($p<0.05$).

3.2. Chemical Compositions of BPF

The chemical composition of BPF is presented in Table 2. The moisture content in Nangka (6.74 %), Tanduk (6.86%) and Berangan (7.31 %) BPF was not significantly ($p<0.05$) different while Rastali (4.67 %) BPF had the lowest moisture content. The results are in agreement with the result reported by [16] that the moisture content of BPF stands at 6.70 %. Moisture content plays an important role in determining the storability and the quality of flour. Flour with low moisture content is more stable, while flour with more than 14.5 % moisture content can deteriorates easily in storage because of high moisture can attracts insect, mold and bacteria [17].

Ash or also known as mineral content is a substance obtained after it is burned at high temperature. Table 2 shows that the ash content of Nangka BPF had significance difference with Tanduk (11.52 %), Berangan (11.51 %) and Rastali BPF (9.36 %). According to [8], banana peel is rich in potassium followed by phosphorus, calcium and magnesium. The present findings depicts that the ash content of BPF are within the range of the study reported by [2] that the ash content of BPF at stage 1 (unripe) is 15.25 % and [16] stated that the ash content of BPF in his study was 8.50 %.

The Nangka BPF has a significantly ($p<0.05$) higher fat content compared the other varieties. The fat content for Cavendish banana peel and Berangan banana peel is between 4.81 % and 5.96 % [18] and the Awak banana peel is 13.1 % [2]. Based on previous studies, there are no standard trends of fat content. Factors that may contribute to the difference of fat content in banana peels are the area of banana being planted and its type of cultivar. According to [19], low fat content in flour reduce the risk of oxidation and prevent off-flavour due to rancidity. In addition, low fat flour suits the need of health concern individuals.

There was no significant ($p<0.05$) difference of protein content between all the BPF in this study. The amount of crude protein in this study was in the range stated by [8] with the crude protein of different varieties of banana peel at stage 1 and 5 were between 6.3% and 9.8 % and 6.6 %-11.2 % respectively. In Table 2, carbohydrate content in Rastali BPF was significantly ($p<0.05$) higher compared to others. The range of total carbohydrate for this study was between 64.62 % and 72.84 %. Carbohydrates are a good source of energy. High carbohydrate content is beneficial in breakfast meal and can be good source of energy for breakfast formulations [20]

In Table 2, the total phenolic content is highest in Tanduk (54.60 mg GAE/ g), followed by Rastali (37.69 mg GAE/g), Berangan (33.61 mg GAE/g) and Nangka (28.63 mg GAE/g) BPF. However, total phenolic content in this study was relatively higher than a previous study. There was no standard trend of total phenolic content in banana peel in previous studies. This may due to the different type cultivars affecting the nature and concentration of phenolic compounds in banana peel. The success of the total phenolic extraction is contributed by the drying process. In addition, dehydration might also influence the phenolic compounds of banana peel. During the drying process, the phenolic compounds in the vacuole are separated from the oxidative enzyme and make the structures to collapse. This allows the release of more phenolic compounds and the hydrolytic and oxidative enzymes presence might deteriorate the phenolic compounds. However, the enzymes can be denatured via oven drying at 60°C and preserved phenolic compounds [21].

Table 2. Chemical Compositions of banana peel flour

Sample	MC (%)	Ash (%)	Fat (%)	CP (%)	CHO (%)	TPC (mg GAE/g)
Nangka	$6.74^a \pm 0.39$	$12.50^a \pm 0.06$	$7.45^a \pm 0.97$	$8.69^a \pm 0.05$	$64.62^c \pm 1.43$	$28.63^d \pm 0.10$
Tanduk	$6.86^a \pm 0.72$	$11.52^b \pm 0.08$	$4.64^b \pm 0.74$	$8.57^{ab} \pm 0.01$	$68.40^b \pm 0.19$	$54.60^a \pm 0.10$
Berangan	$7.31^a \pm 0.15$	$11.51^b \pm 0.05$	$3.95^b \pm 0.99$	$8.61^{ab} \pm 0.13$	$68.63^b \pm 0.79$	$33.61^c \pm 0.05$
Rastali	$4.67^b \pm 0.08$	$9.36^c \pm 0.02$	$4.83^b \pm 0.28$	$8.49^{ab} \pm 0.05$	$72.84^a \pm 0.26$	$37.69^b \pm 0.03$

Values represent mean ± standard deviation. Different superscript letters indicate Significant differences ($p<0.05$). MC= moisture content, CP= crude protein, CHO= total carbohydrate, TPC= total phenolic content.

3.3. Dietary Fiber Content

Dietary fiber mainly consists of soluble (beta glucan, inulin, fructooligosaccharides, pectin, gums, etc) and insoluble (cellulose, lignins, some hemicellulose, etc) fiber fractions [8]. Consumption of soluble dietary fiber can lower the serum cholesterol and helps in reducing the risk of colon cancer while insoluble dietary fiber has been shown to be beneficial for intestinal regulation and increasing stool volume [18]. Table 3 shows the amount of dietary fiber fractions in Nangka, Tanduk, Berangan and Rastali BPF. Nangka BPF was significantly (p<0.05) higher in soluble dietary fiber compared to other varieties whereas the Berangan BPF was significantly (p<0.05) richer in insoluble dietary fiber varying from 31.53 g/100g to 37.40 g/100g. [8] cited that IDF and SDF of banana peel from stage one to seven are between 27.3 to 42.9 % and 5.6 to 13.7 %. Therefore, the results of IDF and SDF in these findings were in accordance to previous study.

Table 3. Dietary fiber fractions of banana peel flour

Sample	TDF (g/100g)	SDF (g/100g)	IDF (g/100g)
Nangka	$31.77^{d} \pm 0.06$	$0.23^{c} \pm 0.06$	$31.53^{d} \pm 0.06$
Tanduk	$33.43^{c} \pm 0.21$	$1.10^{a} \pm 0.10$	$32.33^{c} \pm 0.21$
Berangan	$37.63^{a} \pm 0.15$	$0.23^{c} \pm 0.06$	$37.40^{a} \pm 0.20$
Rastali	$31.77^{d} \pm 0.06$	$0.23^{c} \pm 0.06$	$31.53^{d} \pm 0.06$

Values represent mean ± standard deviation. Different superscript letters indicate Significant differences (p<0.05). TDF= total dietary fiber, SDF= soluble dietary fiber, IDF= insoluble dietary fiber.

3.4. Functional Properties

Functional properties of food are used to determine the characteristics of food during processing, production, consumption and storage. It also controls the parameter of food quality such as nutritional, sensory, organoleptic and physicochemical properties as well as food processed indices which include slicing of processed meat or cookie dough machinability [9]. Table 3 shows the functional properties of different varieties of BPF. There were no significant (p<0.05) difference in the water holding capacity (WHC) and oil holding capacity (OHC) among Nangka, Tanduk and Berangan BPF. Even though the Rastali BPF had the lowest value of OHC amongst the others, it was higher when compared to those recorded in previous studies. [4] stated that the WHC and OHC for BPF were between 4.14 and 6.10 g/g and 0.69 and 0.76 g/g respectively. According to [22], high WHC in flour has the ability to modify viscosity and texture in food promoting the effects of bulking, thickening and gelling. Ingredients with high OHC can be added into the food system to improve texture and viscosity of formulation food as well as to stabilize food with high fat content.

In Table 4, no significant (p<0.05) difference in water absorption index (WAI) of the Nangka, Tanduk and Berangan BPF was noted. The Nangka BPF had a significantly (p<0.05) lower water soluble index (WSI). According to [23], the WAI and WSI for the Pakistani rice flour were 5.38 g/g – 6.26 g/g and. 1.95 g/g - 4.94 g/g, respectively. The difference in WAI might be to various factors, such as method of milling, level of starch damage and processing temperature. In addition, major factors that might influence the WAI include the chemical composition of the flour itself namely in its protein, dietary fiber and amylose contents. A research by [23] stated that Super Fine Basmati flour (9.77 %) with high protein content had highest WAI (6.26 g/g) while rice flour with 8.2 % protein content only had 5.38 g/g of WAI. This shows that high protein content increase the water absorption of rice flour. [24] also highlighted factor that may led to high WSI includes the degradation of starch granule while the presence of starch lipid complex and protein reduces the solubility of flour.

According to [25], swelling power is a measure of hydration capacity because the determination is by measure the weight of swollen starch granule and their included water content. Swelling power and pasting viscosities are positively correlated in which high swelling power of the sample give higher pasting viscosities [19]. In Table 3, the swelling power is the highest in the Rastali (7.33 g/g) while the Tanduk (3.94 g/g) BPF had the lowest swelling power. Previous study recorded that the swelling power for wheat-tiger nut flour was between 5.75 g/g and 7.64 g/g [25], and the Pakistani rice flour was between 5.74 g/g and 7.64 g/g. According to [20], high swelling power is beneficial for development of product where swelling is required.

4. Conclusion

Based on the results, we can conclude that BPF can be kept for a long time since they have low moisture content. The results also showed that each variety of bananas PF has slightly different nutritional content and functional properties. BPF has 28.63 to 54.60 mg GAE/g of total phenolic content and 31.77 to 37.63 g/100 g of total dietary fiber content. These could be an added value to the food industry especially in developing a high fiber product by exploiting a cheap and continuous source of ingredient. BPF in WHC and OHC can be used to improve the viscosity, texture and stabilize food with high fat content. Data in this study hence may provide the basis for future research.

Table 4. Functional properties of banana peel flour

Sample	WHC (g/g)	OHC (g/g)	WAI (g/g)	WSI (g/g)	SP (g/g)
Nangka	$6.19^{ab} \pm 0.02$	$2.24^{a} \pm 0.05$	$8.11^{a} \pm 0.36$	$0.14^{c} \pm 0.01$	$5.61^{b} \pm 0.14$
Tanduk	$6.35^{a} \pm 0.14$	$2.09^{ab} \pm 0.15$	$7.58^{a} \pm 0.14$	$0.24^{a} \pm 0.03$	$3.62^{c} \pm 0.13$
Berangan	$5.92^{ab} \pm 0.17$	$2.22^{a} \pm 0.13$	$7.76^{a} \pm 0\ .15$	$0.19^{b} \pm 0.01$	$5.39^{b} \pm 0.12$
Rastali	$5.76^{b} \pm 0.19$	$1.90^{b} \pm 0.14$	$6.49^{b} \pm 0.78$	$0.20^{ab} \pm 0.01$	$7.34^{a} \pm 0.24$

Values represent mean ± standard deviation. Different superscript letters indicate Significant differences (p<0.05). WHC=water holding capacity, OHC=oil holding capacity, WAI=water absorption index, WSI=water solubility index.

Acknowledgements

The authors would like to acknowledge Universiti Teknologi MARA (UiTM) Shah Alam for granting this project (Grant No: 600-RMI/FRGS 5/3 (27/2015).

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