

*Research Article*

## **Utilization of banana peel as a functional ingredient in yellow noodle**

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### **Abstract**

Banana peel (BP) noodles prepared by partial substitution of wheat flour with green Cavendish banana peel flour were characterized for physicochemical properties and *in-vitro* starch hydrolysis. Cooked noodles were assessed for pH, colour, tensile strength and elasticity and *in-vitro* hydrolysis index (HI) and estimated glycemic index (GI). BP noodles had lower L\* (darker) and b\* values (less yellow) than the control noodles. The tensile strength of BP noodles was similar to control but their elasticity was higher. Following *in-vitro* starch hydrolysis studies, it was found that the GI of BP noodles was lower than control noodles. Partial substitution of banana peel into noodles may be useful for controlling starch hydrolysis of yellow noodles.

**Keywords:** yellow noodles; banana peel, *in-vitro* starch hydrolysis, glycemic index, Malaysia

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### **Introduction**

As the fruits of the banana trees are consumed at green, average ripe and ripe stages [1], the amount of fruit waste from the peels is expected to increase with the development of processing industries that utilize the green and ripe banana. Like its pulp flour counterpart, banana peel flour can potentially offer new products with standardized composition for various industrial and domestic uses [1]. The peel of banana represents about 40% of the total weight of fresh banana [2] and has been underutilized. Various studies have been conducted to investigate banana peel, including the production of banana peel flour [3], the effects of ripeness stage on the dietary fibre components and pectin of banana peels [4] and the chemical composition of banana peel, as influenced by the maturation stage and varieties of

banana [1]. As these studies indicated a high content of dietary fibre in the peel, it would be possible to utilize the peel as a functional ingredient in starch-rich products such as the yellow noodles.

Yellow noodles are typically made by adding alkaline salt to the ingredients. The alkaline salt added imparts the unique features of Chinese noodles with pH 9.0-11.0 [5], whereas the yellowness of the noodles is produced when the flavones react with the alkaline water. The grade of yellow noodles can be evaluated from their colour, shape, texture and eating qualities. High quality yellow noodles should be free from discolouration, having symmetrical dimensions, should not be sticky after being cooked, as well as showing sufficient firmness and springiness [5].

It is considered desirable if the rate of ingestion and absorption of carbohydrates in noodles is reduced because this could be beneficial in the dietary management of metabolic disorders such as diabetes and hyperlipidaemia [6]. Noodles prepared using plantain starch has been shown to exhibit limited digestibility due to their relatively high resistant starch content and a moderate *in-vitro* glycemic index [7]. Since low glycemic index food release glucose at a slower rate compared to a higher glycemic index food, banana peels that contain a high amount of dietary fibre have potential to slow the rate of starch hydrolysis in yellow noodles.

The objective of the present study was to assess the physicochemical properties and *in-vitro* starch digestibility of cooked yellow noodles prepared by partial substitution of wheat flour with banana peel flour.

## **Materials and methods**

### ***Materials***

Basic ingredients for noodle preparation (wheat flour and *kansui* reagent) were obtained from a local supermarket.

Other chemicals and reagents used in the analysis were of analytical grade. Anhydrous sodium acetate, anhydrous sodium dihydrogen phosphate and acetic acid were purchased from System. GOD-PAP solution was purchased from Randox, disodium hydrogen phosphate was purchased from Fluka and sodium chloride was purchased from Lab Guard. All other chemicals for GI and HI analysis were purchased from Sigma Aldrich.

### ***Preparation of banana peel flour***

Green (stage 2 of ripening: all green) [8] Cavendish (*Musa acuminata L, cv cavendshii*) bananas were purchased from a local supermarket. The fruit was washed and separated into pulp and peel. To reduce enzymic browning, peels were dipped in 0.5% (w/v) citric acid solution for 10 min, drained and dried in an oven (AFOS Mini Kiln, at 60°C overnight). The dried peels were ground in a Retsch Mill Laboratory (Retsch AS200) to pass through 40 mesh screens to obtain banana peel (BP) flour. Flour was stored in airtight plastic packs in cold storage (15±2°C) for further analyses.

**Noodle preparation**

Formulations for the noodles are shown in Table 1 and noodles were prepared using the method described by Kruger, *et al* and Gan, *et al* [9, 10]. Noodles produced were coated with a thin layer of flour to avoid them from sticking together. All noodles were cooked by placing a small amount of noodles into a saucepan of boiling water (at a ratio of 1:10, one part noodles to 10 parts water) and were left to boil for 15 min. Cooked noodles were left to cool at room temperature prior to analysis.

**Table 1. Formulation of noodle samples.**

Ingredients (g)	Types of noodle	
	Control	Banana peel noodles
Wheat flour	100	90
Distilled water	50	50
Salt	1	1
Kansui: alkaline salt water	1	1
Banana peel flour	-	10

**Physicochemical measurements**

The pH was measured using Mettler-Toledo Delta 320 pH meter calibrated with buffer solution of pH 4.0 and 10.0 respectively. Colour analysis of noodles was carried out using Minolta Chromameter colourimeter equipped with D65 illuminant using the CIE 1976 L\*, a\* and b\* color scale as described by Kruger, *et al* [11].

Tensile strength and elasticity of noodles were determined using a Texture Analyzer, TA-TX2 model (Stable Micro Systems, Surrey, England) fitted with a 2.5 kg load cell as described by Gan, *et al* [10].

**Starch hydrolysis index (HI) of noodles 'as eaten' (chewing/dialysis test)**

The in-vitro rate of starch analysis in noodles was assessed with the protocol developed by Granfeldt, *et al* [6], and glucose determination procedures by Goni, *et al* [12]. Three healthy subjects participated in the chewing phase of experiments which was followed by pepsin digestion and further incubation with porcine pancreatic amylase in a dialysis bag. Subjects were instructed to avoid eating for 1.5 to 2 hrs prior to the experiment. Subjects were instructed to rinse their mouths with water before chewing approximately 1 g of noodle samples for 15 times in about 15 s. The chewed products were then expectorated into beakers containing 50 mg pepsin from porcine-stomach mucosa (ref. P7125, Sigma) in 6 ml of 0.05 M Na phosphate buffer (containing 0.4 g/l NaCl) adjusted to pH 1.5 with HCl. The subjects rinsed their mouths with 5 ml of Na phosphate buffer (pH 6.9) for 60 s and expectorated the buffer into the beaker. The contents were stirred and pH was readjusted to pH 1.5. All samples were then incubated at 37°C for 30 min with gentle mixing during incubation. After incubation with pepsin, pH was readjusted to pH 6.9 with NaOH and the samples were transferred to dialysis bags (13 cm strips Spectra Por No.2, width 45 mm, cut-off 12-14000). Porcine pancreatic  $\alpha$ -amylase (A-3176, Sigma) was then added. The enzyme (1100 sigma units) was dissolved in 10 ml Na phosphate buffer and 1 ml of this solution was transferred into the dialysis tubes. The sample was then brought to the volume of 30 ml with Na phosphate buffer and each bag was incubated for 3 hrs in a container containing 800 ml of 0.05 M Na phosphate buffer at 37°C. Aliquots (0.1 ml) were taken every 30 min from 0 to 180

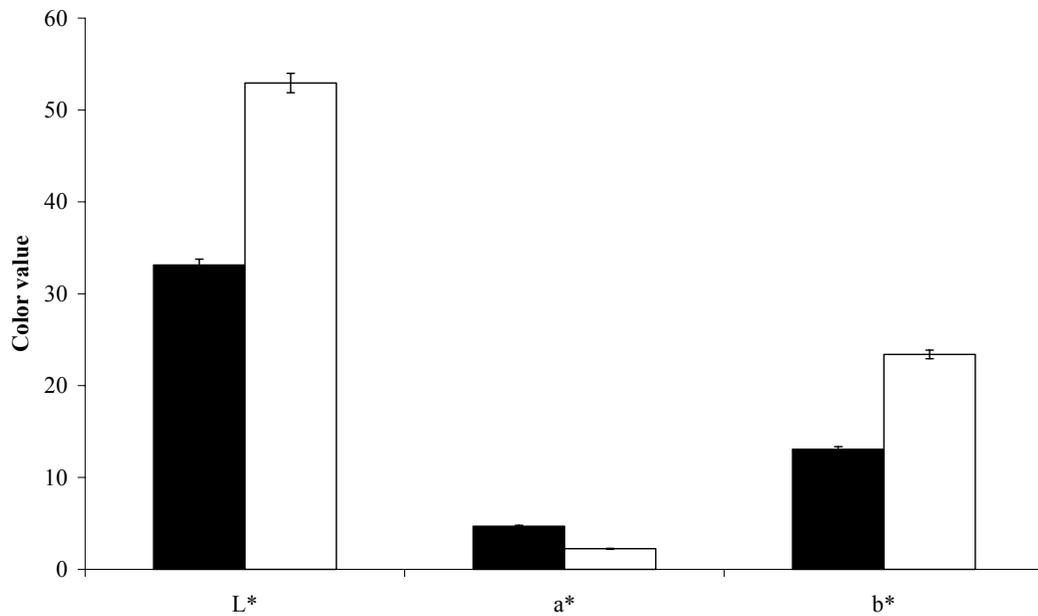
min into test tubes.  $\alpha$ -amylase was inactivated immediately by placing the tubes containing the aliquots in a boiling water bath for 5 min. 1 ml of 0.4 M sodium-acetate buffer, pH 4.75 and 30  $\mu$ l of amyloglucosidase from *Aspergillus niger* (ref. A9913, Sigma) were added. Samples were incubated at 60°C for 45 min to hydrolyze digested starch into glucose. Glucose concentration was measured using the glucose oxidase-peroxidase kit (ref. GL 2614, Randox). Rate of starch digestion was expressed as g/100 g total starch hydrolyzed at different times (30, 60, 120, 150 and 180 min) and data were plotted as hydrolysis degree versus time curves and the hydrolysis index (HI) was calculated as the area under the curve (Sigma Plot 2002 for Windows version 8.02) (0-180 min) for the test noodles expressed as a percentage of the corresponding area for a commercial white bread (reference), chewed by the same person. The average HI was calculated from the three digestion replicates run for each sample. The formula for HI calculation was,  $HI = (AUC_{\text{sample}} / AUC_{\text{reference}}) \times 100 \%$ , where AUC is area under the curve. The estimated glycemic index (GI) was calculated from HI values, using the formula proposed by Goni, *et al* [12];  $pGI = 0.549HI + 39.71$ .

## Results and Discussion

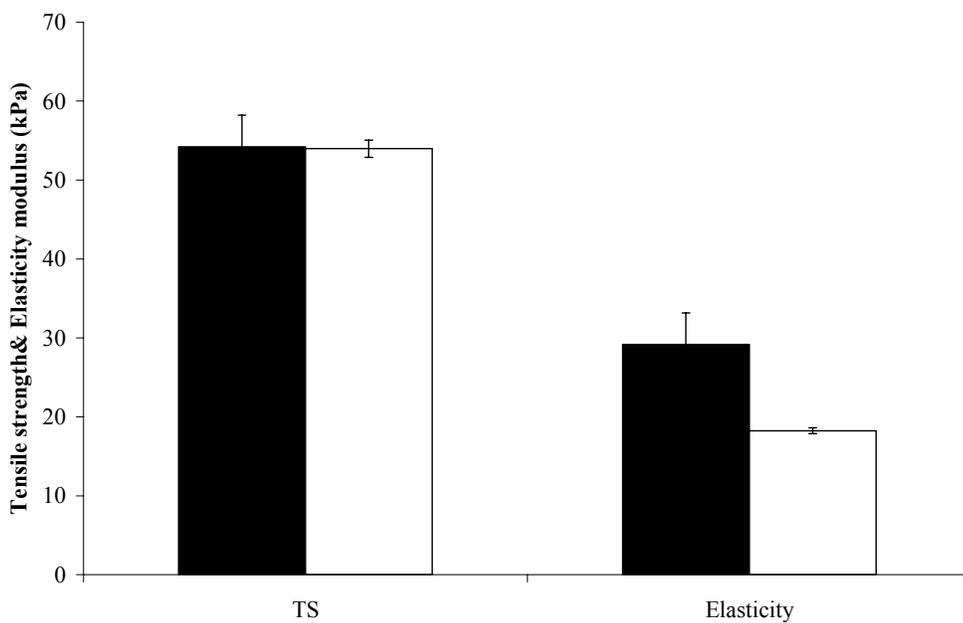
Banana peel (BP) flour produced in this study was brownish in colour with visible dark spots scattered about the flour samples and presented banana flavour. Banana peel (BP) noodles produced in this study were considered different from noodles that are typically produced in the industry. The dimension of the BP noodles was designed to be flat to ease textural evaluation. BP noodles were dark brown in colour and had distinctive banana aroma. The thickness of the noodles ranged from 1.8 to 2.2 mm, while the length of each noodle strand was longer than 15 cm, with a width of 8 mm. The control noodles produced were rather creamy with yellowish colour.

Noodles were cooked in the same way as might be done by a normal consumer in the home. The original pH of control noodle was 8.0 before cooking, which was consistent with the addition of alkaline salt, even though typical pH of yellow noodles is around 9-11 that produces the yellow colour. The pH values of control (7.64) and BP (7.13) noodles dropped slightly following cooking. This may reflect leaching and loss of the salts into the boiling water. The colour analysis indicated that BP noodles were darker (lower  $L^*$  value) than control noodles. As the pH of noodles produced in this study was lower than 9, the yellowness of the control noodles was low, however these noodles exhibited a higher yellowness value ( $b^*$ ) as compared to BP noodles (Fig. 1a). Visually, it was possible to differentiate the colour appearance of these noodles to point out which of the noodles were incorporated with BP. The darkened appearance of BP noodles was expected since the BP used was initially dark in appearance. As banana peel contains glucose, fructose and protein [1], an extension of the Maillard reaction could have occurred during production of banana flour, while certain enzymes such as polyphenol oxidase may be present in banana peel that could contribute a certain degree of enzymatic browning [13]. This is acceptable since the enzymatic browning of banana is a well known problem. Since a certain amount of yellow colour develops as a result of natural pigments in wheat flour, the changes in colour of BP noodles were due partly to dilution of these coloured pigments as a result of wheat flour partial

substitution with banana flour. Chemical changes that had occurred during production of BP flour had also contributed to final colour of BP noodles.



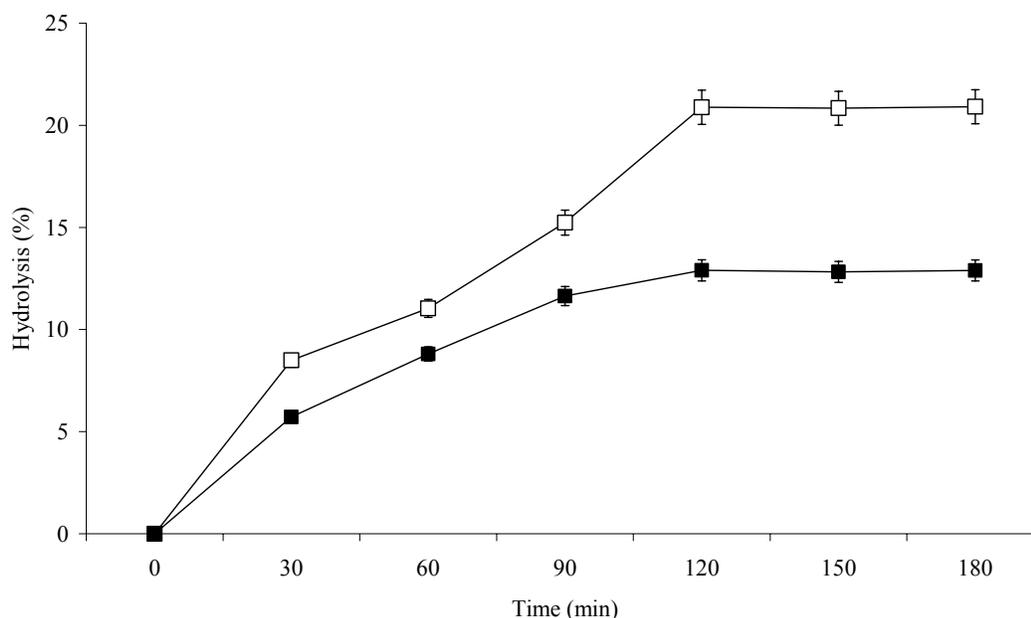
**Figure 1(a). Colour values of control (□) and BP noodles (■).**  
 Values are means ± standard deviations of triplicate samples.



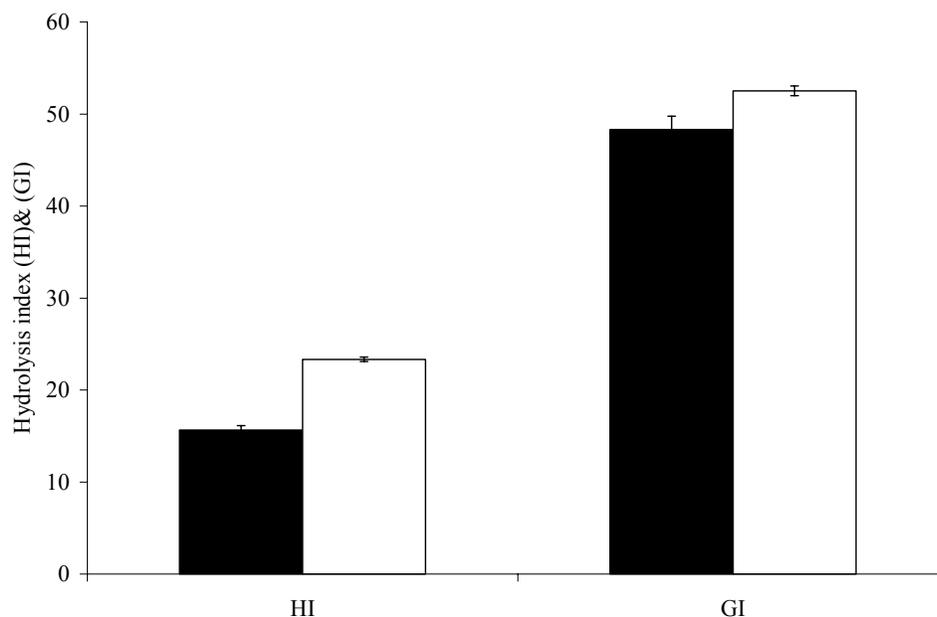
**Figure 1(b). Tensile strength and elasticity modulus of control (□) and BP noodles (■).**  
 Values are means ± standard deviations of triplicate samples.

The overall network that holds noodle structure may consist primarily of protein and starch matrices. These matrices gradually disintegrate during a long period of extensive cooking [14] that results in the absorption of water followed by swelling up of starch granules [15] and softening of texture. The results of tensile strength (TS) and elasticity of noodles are shown in Fig. 1 (b). It is evident that BP noodles had similar values of TS, but a higher elasticity than the control noodles. This suggests that the texture of the modified noodles was slightly altered by incorporating BP. This however, needs further verification in future studies.

Noodles were analyzed on the rate of *in-vitro* starch digestion ‘as eaten’ with comparison against reference white bread. Curves for combined digestion/dialysis process for the different noodles are depicted in Fig. 2(a). During the first 120 min of reaction, the hydrolysis percentage increased progressively for all samples studied. Thereafter, the hydrolysis increased slowly before a plateau is reached. In general, control noodles were digested more rapidly than BP noodles. HI’s calculated from the hydrolysis curves and corresponding GI’s are given in Fig. 2(b). BP noodles exhibited lower GI than the control. This could be attributed to the presence of a quantity of dietary fibre, such as hemicelluloses and pectin polysaccharides in the peel [16]. Certain indigestible polymers and some associated non-fibrous compounds may reduce the rate of starch digestion *in-vitro* and *in-vivo*, resulting in low metabolic responses [6]. Studies on other starch-based food such as bread with added banana flour, revealed a low hydrolysis percentage that was in agreement with high resistant starch and dietary fibres of banana flour [17]. Therefore partial substitution of wheat flour with banana peel may exert similar effects by means of high dietary fibre and to some extent resistant starch content in the flour.



**Figure 2(a).** Rate of starch hydrolysis of control (□) and BP noodles (■) following chewing, incubation with pepsin and subsequent incubation with pancreatic  $\alpha$ -amylase in noodles. Values are means  $\pm$  standard deviations of three chewing and digestion experiments. Areas under curves were used for calculation of HI.



**Figure 2(b). Hydrolysis Index (HI) and estimated glycemic index (GI) of starches from control (□) and BP noodles (■).**

Values are means  $\pm$  standard deviations of three chewing and digestion experiments.

### Conclusion

BP noodles had a lower estimated glycemic index, similar tensile strength but higher elasticity values as compared to control noodles. The modified noodle product described in this study may broaden the range of low glycemic index food products and increase utilization of waste products from banana agro-industries.

### Acknowledgement

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