

Utilization of green banana flour as a functional ingredient in yellow noodle

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Abstract: Banana pulp (BP) noodles prepared by partial substitution of wheat flour with green Cavendish banana pulp flour were assessed pH, color, 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) but higher tensile strength and elasticity modulus than control noodles. Following an *in-vitro* starch hydrolysis studies, it was found that GI of BP noodles was lower than control noodles. Partial substitution of green banana pulp into noodles may be useful for controlling starch hydrolysis of yellow noodles.

Keywords: yellow noodles, banana pulp flour, *in-vitro* starch hydrolysis, glycemic index

Introduction

Cavendish (AAA) banana is a dessert type of banana that is different from Plantain (AAB), a cooking banana. The plantain is extensively produced in Africa, the Caribbean and Latin America, whilst Cavendish is distributed in all continents (Aurore *et al.*, 2008). New economical strategy to increase utilization of banana includes the production of banana flour when the fruit is unripe, and to incorporate the flour into various innovative products such as slowly digestible cookies (Aparicio-Saguilan *et al.*, 2007), high-fiber bread (Juarez-Garcia *et al.*, 2006) and edible films (Rungsinee and Natcharee, 2007). The clear advantage presented by green banana flour includes a high total starch (73.4%); resistant starch (17.5 %) and dietary fiber content (~ 14.5%) (Juarez-Garcia *et al.*, 2006). Due to the high content of these functional ingredients, regular consumption of green banana flour can be expected to confer beneficial health benefits for human (Rodriguez-Ambriz *et al.*, 2008). It would be possible to utilize the green pulp 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 (Shiau and Yeh, 2001) where 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 color, shape, texture and eating qualities. High quality yellow noodles should be free from discoloration, having symmetry dimensions, should not be sticky after being cooked as well as to show sufficient firmness and springiness (Shiau and Yeh, 2001).

It would be desirable if the rate of ingestion and absorption of carbohydrate in noodles is reduced because this could be beneficial in the dietary management of metabolic disorders such as diabetes and hyperlipidaemia (Granfeldt *et al.*, 1992). 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 (Osorio-Diaz *et al.*, 2008), however there is no published report on the use of green banana pulp flour to reduce *in-vitro* glycemic index of yellow noodles. Since

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low glycemic index foods release glucose at a slower rate compared to a higher glycemic index foods, banana pulp that contain high amount of resistant starch and dietary fiber have potentials to slow the rate of starch hydrolysis in yellow noodles.

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

Materials and Methods

Materials

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

Green (stage 2 of ripening: all green) (Aurore *et al.*, 2008) Cavendish (*Musa acuminata* L, *cv cavendshii*) banana was purchased from a local supermarket. The fruits were washed and separated into pulp and peel. To reduce enzymic browning, pulps were then dipped in 0.5 % (w/v) citric acid solution for 10 min, drained and dried in oven (AFOS Mini Kiln, at 60°C overnight). The dried pulps were ground in a Retsch Mill Laboratory (Retsch AS200) to pass through 60 mesh screens to obtain banana pulp (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.* (1994) and Gan *et al.* (2009). Noodles were made in triplicate and were prepared in random manner.

Kansui reagent, (9:1 sodium and potassium carbonates) was dissolved in water and added to 100 g of flour to yield a 1 g/100 g (w/w) alkaline dough. Materials for noodles were incorporated by a mixer (KitchenAid, USA). The mixture was then mixed at speed 1 and the speed was raised one level per subsequent minute up till speed 6. The speed of the mixer was then slowed down level by level for every min and was stopped totally at the 10th min. The dough was removed and placed in a plastic bag for sheeting with a pasta machine (Shule) at an initial gap setting of width 6 that corresponds to approximately 2 mm. One pass was made at this setting, followed by width 5 and 4 for the desired thickness using the noodle machine, and the noodle sheet was folded between passes to ensure homogeneity.

The same machine was used to slit the noodle pieces into a flat, rectangular shape. Noodles were slit in such that they would not be broken easily during tensile analysis. Noodles produced were coated with a thin layer of flour to prevent them from sticking together. All noodles were cooked in a saucepan of boiling water (at a ratio of 1:10, one part of noodles in 10 parts of water) for 15 min. Cooked noodles were left to cool at room temperature prior to analysis.

Physicochemical measurements

The pH was measured using Mettler-Toledo Delta 320 pH meter calibrated with buffer solution of pH 4.0 and 10.0

Table 1. Formulation of noodle samples

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

respectively. Color analysis of noodles was carried out using Minolta Chromameter colorimeter equipped with D65 illuminant using the CIE 1976 L*, a* and b* color scale as described by Kruger *et al.* (1998).

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.* (2009).

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.* (1992), and glucose determination procedures by Goni *et al.* (1997). 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 α -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. α -amylase was inactivated immediately by placing the tubes containing the aliquots in boiling water bath for 5 min. 1 ml of 0.4 M sodium-acetate buffer, pH 4.75, and 30 μ 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

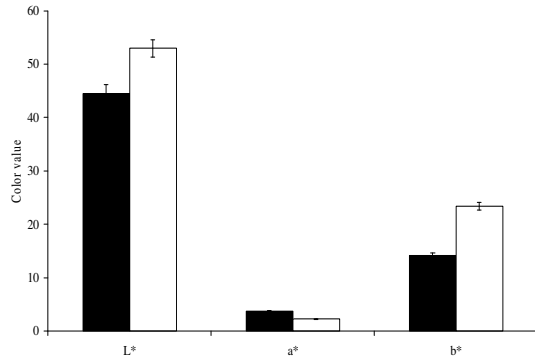


Figure 1(a). Color values of control (□) and BP noodles (■). Values are means \pm standard deviations of three samples

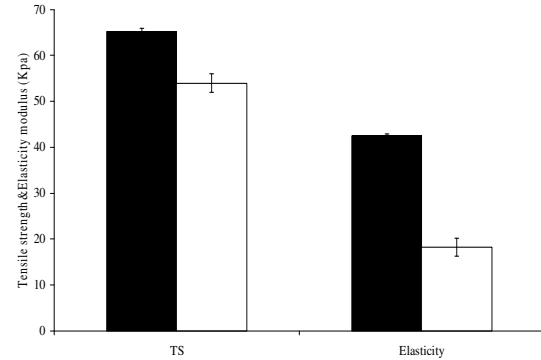


Figure 1 (b). Tensile strength and elasticity modulus of control (□) and BP noodles (■). Values are means \pm standard deviations of three samples

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.* (1997); $pGI = 0.549HI + 39.71$.

Results and Discussion

Banana pulp (BP) flour produced in this study was brownish in color with visible dark spots scattering about the flour samples, and presented banana flavor. 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 color, 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 in color.

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 a yellow color. The pH values of control (7.64) and BP (7.27) noodles dropped slightly following cooking. This may reflect leaching and loss of the salts into the boiling water. The color 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 (Figure 1(a)). Visually, it was possible to differentiate the color 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. Since certain amount of yellow color develops as a result of natural pigments in wheat flour, the changes in color of BP noodles were due partly to dilution of these colored pigments as a result

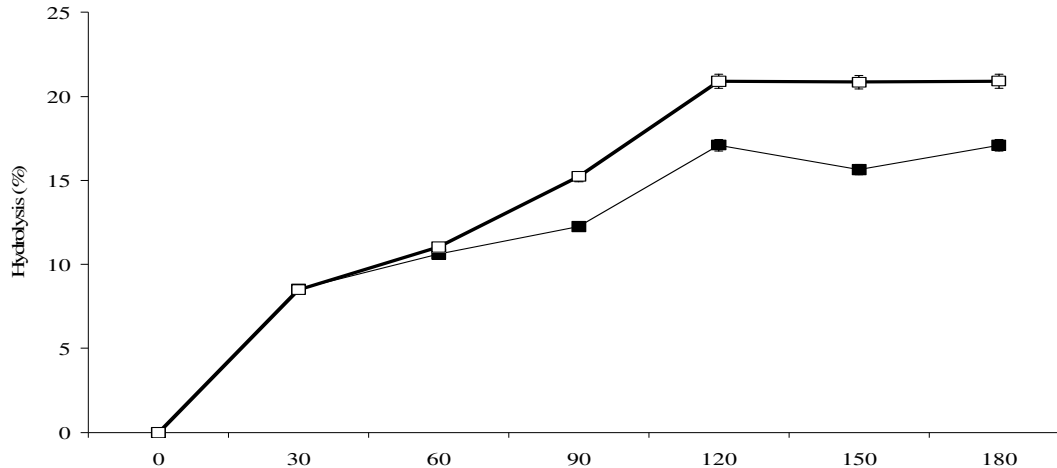


Figure 2. Rate of starch hydrolysis of control (□) and BP noodles (■) following chewing, incubation with pepsin, and subsequent incubation with pancreatic α -amylase in noodles: Values are means \pm standard deviations of three chewing and digestion experiments (n=3). Areas under curves were used for calculation of HI.

of wheat flour partial substitution with banana flour.

The overall network that holds noodles' structure may consist primarily of protein and starch matrices. These matrices gradually disintegrate during a long period of extensive cooking (Cleary and Brennan, 2005) that result in the absorption of water followed by swelling up of starch granules (Ahmed *et al.*, 2008) and softening of texture. The results of tensile strength (TS) and elasticity of noodles are shown in Figure 1 (b). It is evident that BP noodles had higher values of TS and elasticity modulus than the control noodles. This suggests that the texture of the modified noodles was altered by incorporating BP.

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 Figure 2. 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. At 10 % partial substitution of wheat flour with BP flour, HI's calculated from the hydrolysis curves were 23.3 ± 0.0 and 20.1 ± 0.3 and corresponding GI's were 53.0 ± 0.0 and 50.0 ± 0.1 for control and BP noodles respectively. Thus, BP noodles exhibited lower GI than the control noodles and this could be attributed to the presence of resistant starch and dietary fiber in the green banana flour (Juarez-Garcia *et al.* 2006). 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 (Granfeldt *et al.*, 1992). Studies in other starch-based foods such as bread with added banana flour, revealed a low hydrolysis percentage that was in agreement with high resistant starch and dietary fibers of banana flour (Juarez-Garcia *et al.*, 2006). Therefore partial substitution of wheat flour with banana pulp flour may exert similar effect by means of dietary fiber and resistant starch content in the flour.

Conclusion

BP noodles had a lower estimated glycemic indices, higher tensile strength and elasticity values as compared to control noodles. The modified noodle product described in this study may broaden the range of low glycemic index foods and increase innovation of products from banana flour.

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