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Improvement the texture and prebiotic properties of steam bun quality using cultivated banana (Musa ABB cv. Kluai 'Namwa') flour

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Abstract

This research aimed to improve the properties of steam buns using banana flour supplements with wheat flour and evaluate their quality. The factor studied was the amount of banana flour substituted with wheat flour into 3 levels: 30, 40 and 50%. The optimum formula is used banana flour instead of 40% wheat flour. The nutritional value per 100 g gave 6.17 g of dietary fibre, and 0.251, 0.428, 54.63 and 0.42 mg of vitamin B1, B2, calcium, and iron respectively. The results obtained in the present study demonstrated that the steam bun using banana flour was increased in order to improve the prebiotic properties. The overall preference score of very like and consumers are interested in buying accounted for 81.0% because it was a fibre-enriched product and prebiotic which gives certain health benefits and it has a novelty in texture.

1. Introduction

Bananas are one of the most produced and consumed fruits worldwide. Green banana (Musa ABB cv. Kluai 'Namwa') is highly nutritious that contains flavonoids, dietary fibre (DF) and resistant starch (RS) that are more at the beginning of ripening than at maturity (Vu *et al*., 2018). One of the important features of RS is that of not digested within 2 hrs in the intestine and it enhances the growth of probiotics in the large intestine, which may have a positive indirect effect on colorectal cancer (Amini *et al*., 2016). Prebiotics are substrates selectively utilized by host microorganisms, providing health benefits. Among them are fermentable dietary fibres, such as inulin, fructooligosaccharides (FOS), galactooligosaccharides (GOS), and resistant starch (RS). When these undigested carbohydrates reach the colon, they are fermented by specific colon bacteria, which leads to changes in the composition and metabolic activity of the gut microbiota, benefiting the health of the host. Banana flour made from green banana is now often used as a gluten-free replacement for wheat flour or as a source of resistant starch, which has been promoted by certain dieting trends. Unripe banana is rich in starch and its flour contains 61.3-76.5 g/100 g of starch (dry weight) and has high fibre content (6.3-15.5 g/100 g) (dry weight) (Mota *et al*., 2000). A high dietary fibre intake has a beneficial effect on human health. Much research has been recently carried out to improve the nutrition properties of food products by adding to its supplements from unripe banana flour. Earlier, the attention of researchers was focused on banana flour incorporated with bread and pasta (Juarez-Garcia *et al*., 2006; Ovando-Martinez *et al*., 2009). Amini Khoozani *et al.* (2020) reported that green banana flour has the potential as a source of nutrition and in-vitro digestibility in bread. In addition, to date, there are no reports on the utilization of banana flour in making steamed buns. Banana flour does not contain gluten different, unlike wheat flour. Wheat flour has a high gluten content of wheat flour is an essential property of most baked foods

Nowadays, steamed bread is well known, and popular breakfast item consumed in China, Japan, Korea and Southeast Asian countries (Lin *et al*., 2012). Over 1.3 billion people in Asia consume steam bun regularly. The steam bun is formulated with wheat flour, water and commercial yeast. Their unique characteristics, which are distinctly different from baked bread, are their white

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colour and round shape with very thin and soft skin, and they are made by steaming instead of baking. For every 51 g of a steam bun, there are 123 calories which come from 1.5 g of fat, and 21 g of carbohydrate. It is a lot of calories for carbohydrates and fat, which are not essential for a healthy diet. This means that it lacks another nutrition or interesting bioactive compound which can be supplemented by a healthy ingredient such as banana flour. Therefore, this research was aimed to improve the properties of steam bun products using Banana Flour by studying the optimum amount of green banana flour substituted for wheat flour and evaluating their nutrition, physical, microbial and sensory contents.

2. Materials and methods

2.1 Materials

Green banana, Cultivated Banana (Musa ABB cv. Kluai 'Namwa') at stage 1 ripeness according to banana ripeness chart (Dadzie and Orchard, 1997). were purchased from One Banana Co., Ltd. and food-grade citric acid was purchased from Krungthepchemi Co., Ltd.

2.2 Preparation of banana flour

Green banana (Musa ABB cv. Kluai 'Namwa') each 3 kg of bananas steamed for 15 mins and then peeled and thinly sliced pieces (1.5 mm) of banana slices soaked in 0.5% w/v citric acid solution for 10 mins to prevent enzymatic browning (Saifullah et al., 2009), then drained. The banana slices were dried in an oven at a temperature of 60°C for 12 hrs. Dried banana chips were milled and sieved through an 80-mesh size sieve. The banana flour was analyzed for appearance, percentage of yield, colour measurement (HunterLab Lovibond SP60) and moisture content AOAC (2020). BF was packed in a polypropylene plastic bag with a vacuum packager. The packed flours were then stored in a chiller at 6±2°C until further usage.

2.3 Study the optimum formula steam bun

The basic formula of the steam bun was 50% wheat flour, 8% sugar, 0.5% salt, 25% yeast, 4.5% soybean oil, 4.5% milk powder and 30% warm water. In this study, the steam bun formula used in production was using banana flour instead of wheat flour, 30, 40 and 50%. The experimental design was a Completely Randomized Design (CRD). The process to produce steam bun, firstly by making the water-sugar suspension. Then, flour, yeast and salt were mixed with the sugar solution in a mixing bowl. The dough was optimally mixed using the mixer (Kitchen Aid-KSM 900, USA) for about 60 mins until the dough became soft and elastic. After mixing, 60 g of the samples were weighed individually and moulded into a shape manually. The moulded dough was placed on a tray for further incubation at 30±1°C. After 20 mins, the dough was placed on a tray and steamed for 20 mins in a steamer. The cooked steamed bun was cooled before further testing the quality as follow:

2.3.1 Colour measurement

Three samples of steam bun (carried out within 1 hr after steaming) were measured using a colourimeter (HunterLab Lovibond SP60) for Lightness (L* 0 black, 100 white), a* (+red, - green) and b* (+yellow, - blue) values which were calibrated using a white reference plate under standard daylight settings.

2.3.2 The specific volume of steam bun

Specific volume by Rapeseed Displacement is measured by replacing it with sesame seeds according to the method of Keeratipibul *et al.* (2008).

2.3.3 Scanning Electron Microscopy

The steam bun was examined following the methods of Kim *et al.* (2003). Steam bun samples were freeze-vacuum-dried at -50°C for 24 hrs. The freeze-dried steam bun was cut with a razor blade into 0.8 × 0.8 × 0.3 cm crumbs that were mounted onto brass stubs using silver glue. Then the samples were freeze-vacuum-dried at -50°C once more for 48 hrs. A gold coating was applied using a sputter coater (LADD No. 30800, Sputter Coater, Burlington, Vermont, USA). Samples were examined at 20 KV using a JSM-6510 Scanning Electron Microscope (Tokyo, Japan).

2.3.4 Texture properties of steam bun

The texture of the steam bun was measured by using TA (Texture Analyser-XT2; version 1.05 Table Microsystem Ltd, UK) with a measured force in the compression test selected. The instruments included P1.51 1.5 inches DIA aluminium cylinder probe and grain gauge sensitive plat. These instruments were connected to the Texture Expert computer program to analyze the data. The parameters determined were hardness, cohesiveness, elasticity, chewiness, and adhesiveness. The texture profile analysis was done according to the method of AACC 74-09 (2000).

2.3.5 Sensory evaluation

Steam bun samples were served to 50 panellists to evaluate aroma, mouthfeel, and overall acceptability. Panellists were instructed to evaluate each attribute using a nine-point hedonic scale ranging from "dislike extremely = 1" to "like extremely = 9". Steam bun samples coded with three digits were supplied to them. Each data point from the sensory analysis represents an

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average of 50 panellists.

2.4 Studying the quality of steam bun supplement with banana flour

The steam bun supplement with banana flour produced from the appropriate formula in 3 was analyzed the following quality: Physical quality by measuring values of colour using (HunterLab Lovibond SP60), measuring water activity (aw) using Water Activity Nobasina, the texture profile analysis was done according to the method of AACC 74-09 (2000). Nutritional values (AOAC, 2020) such as protein, fat, and fibre. Microorganisms' quality i.e., analysis of total microorganisms, yeast and mould, and coliforms (AOAC, 2020). The prebiotic index (PI) adapted from the method of Palframan *et al*. (2002). The Consumer preference test, a panel of 100 consumers, both male and female in Pathum Thani provinces. For each coded sample, consumers had to score their level of liking towards the sample on a 9-point hedonic scale. Sensory attributes which consumers evaluated included colour, aroma, texture, flavour, and overall liking before testing the product, they must fill out a consent form first. The samples were presented to the consumers in a randomized complete block design where all the samples were assessed by consumers.

2.5 Statistical analysis

Data were analysed by analysis of variance programs using the SPSS statistics program for Windows Version 21 (SPSS Inc., Chicago, IL, USA). Duncan's new multiple range tests were used to identify differences between treatments at a 5% significance level ($p<0.05$).

3. Results and discussion

3.1 The quality of banana flour

The appearance of banana flour was light brown as shown in Figure 1.

The drying procedure used in this study is aimed to produce banana flour with low moisture content. The moisture content of banana flour was 6.45. Moisture content influences shelf life because increased water in a product raises its susceptibility to microbes, which can rot and damage the food. Therefore, maintaining a known level of moisture in a product allows producers to accurately estimate the shelf life of a product, helping to keep consumers safe from consuming spoiled food. Flour specifications usually limit the flour moisture to 14% or less (Moorthy, 2002) because high water content will cause the flour to become moist and encourage the growth of food spoilage and pathogenic microorganisms. The L*a*b* was 70.19, 1.30 and 1.09 respectively. Siriwong *et al.* (2007) found L* values depending on the banana varieties and the process to inhibit the browning reaction. According to Raju and Bawa (2006), enzymatic browning is the discolouration that results from the oxidation of mono-phenolic compounds of plants in the presence of atmospheric oxygen and polyphenol oxidase (PPO). These compounds will be hydroxylated to o-diphenols and further oxidized to o-quinones. It is very common for fruits like bananas that contain various enzymes, especially polyphenol oxidase (PPO) to be oxidized through enzymatic reactions as it contains various polyphenols. The yield of the flour from unripe green bananas was only 36.24%.

Figure 1. Green cultivated banana flour

3.2 The optimum formula steam bun

The three formulations of steam bun supplemented with banana flour 30 40 and 50%. The appearance was shown in Figure 2

Figure 2 shows the brown colour of the steam bun would become darker with an increased amount of banana flour because the higher carbohydrate content in banana flour may have also resulted in an increase in the Maillard reaction. According to Chong and Noor Aziah (2008), the research showed that the higher banana flour incorporated doughnuts had an increase in brownness and roughness. The sponging of the steam bun is decreased when substituted for banana flour greater. It

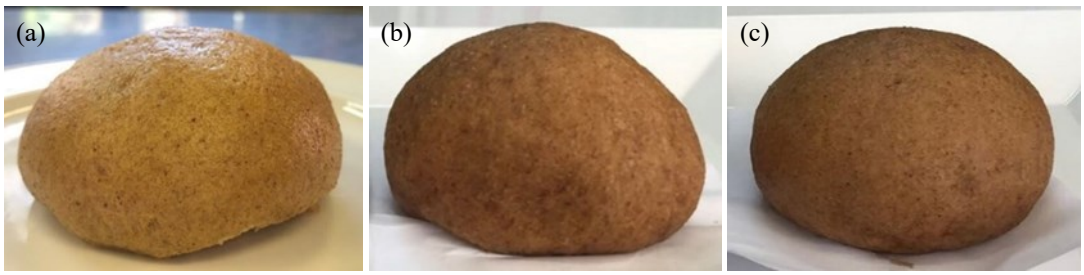

Figure 2. Steam bun supplemented with banana flour. (a) 30% banana flour, (b) 40% banana flour. and (c) 50% banana flour.

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could be seen that the major problem in bakeries produced using banana flour as a substitute for wheat flour. Gluten in wheat flour is the major contributing agent to the elasticity, adhesiveness and sponging of a batter (Guadarrama-Lezama *et al.,* 2016).

Three samples of steam buns were then analyzed by scanning electron microscopy (Figure 3) and their physical and sensory qualities were analyzed. The results were shown in Tables 1 and 2.

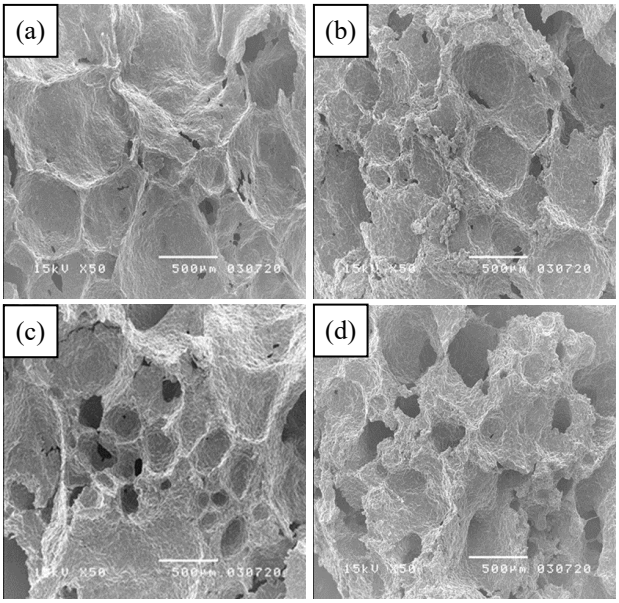

Figure 3. Steam bun supplemented Banana flour (BF) structures by scanning electron microscope. (a) Control (0% banana flour), (b) 30% banana flour, (c) 40% banana flour, (d) 50% banana flour.

3.2.1 Scanning Electron Microscopy

The structures of steam bun supplemented with Banana flour from the four formulas were studied by means of a scanning electron microscope at 15× magnification as shown in Figure 3 The gas cells of steam bun made with 30, 40 and 50% banana flour were irregularly larger than those of control (made from wheat flour). This characteristic of the structure will vary according to the increased amount of banana flour. If the number of banana flour increases, the cohesion of the dough was decreased. This is seen by more porous flour. The cohesion of the dough depends on the amount of protein, which means gluten in wheat flour, so when the amount of wheat flour is reduced by replacing it with banana flour, the dough was decreased in smoothness, cohesion or stickiness. The amount of banana flour incorporated into the dough can be expected more fibre and slightly less gluten. Banana flour contains high fibre and low protein which affects the rheological properties of the dough (Bakare *et al.,* 2017). Fibrous compounds have a negative effect on the detachment of the starch-protein matrix (Tudorică *et al.,* 2002) and hence the above observation was related to the high fibre content and its adverse effect on the integrity of the viscoelastic gluten network.

3.2.2 Physical and sensory qualities

The physical and sensory qualities of the three formulations of steam bun supplemented with banana flour 30 40 and 50% compare with control (0% banana flour) were shown in Table 1-2

Specific volume decreased with the proportion of banana flour increased (Table 1). There were significant differences ($p<0.05$) in specific volume control and steamed buns with 50% banana flour. A good choice for using banana flour in the steam bun was 40% banana flour.

In terms of the colour analysis (Table 1), the steam bun from wheat flour was lightest in colour (L*81.53, a* 0.41, b*15.21) whilst the steam bun with 30, 40 and 50% banana flour had a significantly darker colour (L*60.86-69.45, a*4.67-6.79 and b*11.14-13.74) ($p<0.05$). The browning of the steam bun during steaming occurs due to the Maillard reaction, which involves the interaction of free reducing sugars with free amino groups from protein (Pyler and Gorton, 2009)

Texture analysis results showed that the amount of

Table 1. Physical properties[1] of steam bun substituted with banana flour.

Quality	Control (0% BF)	30% BF	40% BF	50% BF
Specific Volume (mL/g)	5.86±0.63^{a}	5.72±0.71^{a}	5.51±0.83^{a}	4.57±1.04^{c}
Colour values				
L*	81.53±1.13^{a}	69.45±1.47^{b}	65.28±1.34^{c}	60.86±1.04^{d}
a*	0.41±0.54^{d}	4.67±0.63^{c}	5.13±0.38^{b}	6.79±0.23^{a}
b*	15.21±0.62^{a}	13.74±0.11^{b}	12.02±0.57^{b}	11.14±0.76^{c}
Texture analysis				
Hardness (g)	417.82±53.98^{b}	425.31±46.31^{b}	487.45±63.26^{b}	589.26±0.36^{a}
Cohesiveness	0.86±0.05^{a}	0.82±0.03^{a}	0.72±0.07^{b}	0.68±0.05^{c}
Springiness (mm)	1.05±0.08^{a}	0.98±0.04^{a}	0.92±0.07^{a}	0.76±0.01^{b}
Adhesiveness (mJ)	0.42±0.21^{a}	0.38±0.85^{a}	0.31±0.14^{a}	0.24±0.07^{b}

[1]Physical properties stated in table where value represented the mean±SD, where n = 10

Values with different superscript within the same row are significantly different ($P>0.05$) among samples.

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Table 2. Liking score of steam bun with different proportions of added banana flour (%)

Attribute	Formula 1 0%	Formula 2 (30%)	Formula 3 (40%)	Formula 4 (50%)
Colour	7.50±1.87[a]	7.30±1.10[a]	7.00±1.80[a]	6.07±2.10[b]
Softness	7.84±2.01[a]	7.53±1.25[a]	6.93±1.70[a]	4.90±2.01[b]
Sponginess	8.02±2.31[a]	7.67±1.35[a]	6.98±1.81[a]	4.77±2.06[b]
Natural Aroma[ns]	6.58±1.42	6.37±1.63	6.60±1.65	6.60±1.63
Natural Flavour[ns]	6.01±1.68	6.63±1.67	6.40±1.65	6.17±1.63
Overall Liking	7.26±1.32[a]	7.40±1.28[a]	6.96±1.73[a]	5.60±1.58[b]

Values are mean±standard deviation of the results from 50 panelists. Values with different superscript within the same row are significantly different (P<0.05) using Duncan Multiple Range Test. [ns]no significant difference within the same row using Duncan Multiple Range Test (P>0.05).

banana flour had a relative hardness, cohesiveness, springiness, and adhesiveness (p<0.05). The hardness springiness and adhesiveness of the steam bun containing banana flour at the 50% level was significantly different (p<0.05) from those of the controls and 30 and 40% banana flour substituted wheat flour. Hardness increased with banana flour increased, while cohesiveness springiness and adhesiveness decreased (Table 1). Ng *et al*. (2012) reported banana flour-incorporated muffins had reduced volume and increased hardness. This can be expected as wheat flour contains the highest proportion of gluten. The gluten provides elasticity and hence these characteristics in wheat flour make it more difficult to rupture when a force is applied to it (Brown, 2008). Therefore, when increased banana flour was incorporated into the dough, it can be expected that there was an increase in starch and a slight decrease in gluten since banana flour contains high carbohydrate and low protein which affects the texture properties of the steam bun. Texture properties were not significantly different (p>0.05) between the control and steam bun with 30 and 40% banana flour. The substitution of banana flour at the 40% level does not change the texture properties.

From Table 2, these significant differences (p<0.05) in colour, softness and sponginess may affect the overall acceptability. Colour had an important role in affecting expectations from consumers (Sung, 2014). For aroma and flavour, results show that consumers preferred the natural wheat aroma and flavour in wheat flour non-significant (p>0.05) the aroma and flavour of banana flour in the steam bun supplement with banana flour. Liking for steam bun supplement with banana flour was promising with a 50% increase in total dietary fibre but with drawbacks of poorer in all attributes.

From the scanning electron microscopy, physical properties and sensory analysis indicated that the optimal amount to substitute banana flour for wheat flour was 40%.

3.3 Study the physical, nutrition, microorganism, and sensory quality of steam bun supplement with 40% banana flour

The properties of the steam bun with 40% flour were presented in Table 3

From Table 3, the result indicated the colour (L*a*b*) were 65.18, 5.13 and 12.14 respectively. Water Activity (aW) was 0.91, which indicated most bacteria and fungi can grow. The consumer preference scores for a steam bun with 40% banana flour were very much liked. Steam bun supplement with 40%banana flour had a soft and cohesive texture because banana flour had good physical properties and could combine well with water. When heated, it swells clear and after cooling down, it resembles jelly because it was a dough that was high in amylose, which had a special characteristic, making it ideal to replace wheat flour in bakery products. Nutritional qualities (per 100 g) of steam bun with 40% banana flour, no cholesterol, 6.17 g of dietary fibre, 54.63 mg of calcium. Banana flour is produced from unripe bananas which contained high dietary fibre (Menezes *et al.,* 2011). The results obtained in the present study demonstrated that steam bun using banana flour reveals the promising beneficial effects of prebiotics on human health. A prebiotic is a substrate that is selectively utilized by host microorganisms conferring a health benefit (Gibson *et al.,* 2017). Consumers may have higher acceptability due to their knowledge that it is a fibre-enriched product that gives certain health benefits. The microbial quality was within the standard. Consumer preference score in overall liking from 100 consumers was 8.3±2.57 and most consumers are interested in buying a steam bun supplement with 40% banana flour, accounting for 81.0% because it is a fibre-enriched product which gives certain health benefits, and it has a novelty in texture.

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Table 3. Physical, nutrition, microorganism quality and prebiotic index of steam bun supplemented with 40% banana flour

Quality	Content		Unit
	Steam bun supplemented with 40% banana flour	Steam bun from wheat flour	(per 100 g sample)
Physical quality			
Colour			
L*	65.18±0.51	86.68±0.23	
a*	5.13±0.62	0.52±0.68	
b*	12.14±0.27	24.25±0.38	
Water activity value (a_w)	0.91±0.04	0.92±0.06	
Texture analysis			
Hardness (g)	487.45±63.26	463.45±70.26	
Cohesiveness	0.78±0.10	0.88±0.30	
Springiness (mm)	0.95±0.02	1.12±0.12	
Adhesiveness (mJ)	0.33 ±0.08	0.34 ±0.10	
Nutrition			
Moisture content	67.24	69.45	%
Total energy	276.65	247.14	kcal
Energy from fat	46.89	51.23	kcal
Total fat	5.21	3.59	g
Saturated fat	1.2	0.707	g
Cholesterol	ND	ND	mg
Protein	4.79	3.3	g
Carbohydrate	52.65	25.06	g
Dietary fibre	6.17	0.9	g
Total sugar	16.77	0.09	g
Sodium	274.02	549	mg
Vitamin A	ND	ND	µg
Vitamin B1	0.251	ND	mg
Vitamin B2	0.428	ND	mg
Calcium	54.63	2.6	mg
Iron	0.42	1.75	mg
Ash	1.55	1.45	g
Quality of microorganisms			
Total microorganisms	< 30	< 30	CFU
Yeast and Mould	< 30	< 30	CFU
Coliform	< 3	< 30	MPN
Staphylococcus aureus	ND	ND	
Prebiotic index (PI)	5.41	-	
Consumer Preference score			
Colour	6.8±1.54		
Softness	7.5±2.15		
Sponginess	8.2±1.87		
Banana Aroma	8.3±3.01		
Banana Flavour	8.0±2.36		
Over Liking	8.3±2.57		

ND, not detected

4. Conclusion

The amount of banana flour substituted for wheat flour in the production of steamed buns is 40%, and the quality of steamed bun products with banana flour 40% indicates the nutritional value (per 100 g). The total energy is 276.65 kcal, energy from fat is 46.89 kcal, total fat. 5.21 g, 1.20 g saturated fat, cholesterol-free, 4.79 g protein, 52.65 g carbohydrate, 6.17 g fibre, 16.77 g sugar, 274.02 mg sodium, vitamin B1 0.251 mg, vitamin B2 0.428 mg, calcium 54.63 mg and 0.42 mg. of iron. The steam bun using banana flour reveals the promising beneficial effects of prebiotics on human health. Overall preference is very like level, 8.3±2.57, and most consumers are interested in buying steam bun supplement with 40% banana flour, accounting for 81.0% because it is a fibre-enriched product which gives certain health benefits, and it has a novelty in texture.

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Conflict of interest

The authors declare no conflict of interest.

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