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Effects of using green banana flour as a substitute for wheat flour on the production of chiffon cakes

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Abstract - The flour made from green bananas contains a lot of resistant starch and can be used in the baking and confectionery sectors as a fiber source to create functional foods like functional cakes. The purpose of this study was to develop a formal chiffon cake. Green banana flour (GBF) was substituted for wheat flour in various proportions (0, 20%, 50%, and 100%) to make unique chiffon cakes. The results showed that the L* values decreased with an increasing percentage of GBF substitution in wheat flour, indicating that higher substitution for green banana flour gave progressively darker chiffon cake. The a* value increased with an increasing percentage of GBF in the chiffon cake, whi. suggests that the cake became more reddish The b* values decreased with an increasing percentage of GBF substitution in wheat flour, which indicates that the cake became less yellow The color change had the lowest value at 20% of GBF and the highest value at 100% of whole wheat flour. The chiffon cakes with 20% GBF had the lowest fracturability value of 3.20±0.21 N, whereas the control chiffon cakes had the highest value of 4.89±0.17 N. The hardness decreased as the GBF substitution increased from 8.88±0.14 to 6.06±0.26 N. The lowest hardness value of 6.06±0.26 N was observed in chiffon cakes

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with 100% GBF. The highest hardness value was 8.88±0.14 N in control chiffon cakes. There was no significant difference in hardness at 20, 50, and 100% GBF. Springiness at 100% GBF were significantly different fromat 20% and 50% GBF. The addition of GBF had no influence on stickiness or cohesivenes.

Keywords: Green banana flour, chiffon cake, color, texture

1. Introduction

Banana cultivar *Musa sapientum* (ABB group) or Kluai Namwa, a genus and family of hybrids and species in the Musaceae family that are primarily grown in subtropical and tropical climates (Mau *et al.*, 2017; Zozimo *et al*., 2018). Kluai Namwa can grow in many parts of Thailand and have become an important fruit crop that impacts Thailand's economy. Kluai Namwa bananas generate substantial employment opportunities for Thai farmers and agricultural laborers. In regions where banana cultivation is prevalent, the banana industry provides income and a means of support for numerous rural communities. Thailand is one of the leading exporters of bananas globally, and Kluai Namwa is among the most popular export varieties. The demand for Kluai Namwa in international markets, including neighboring countries and overseas, helps strengthen the country's trade balance and support its overall economy (Suvittawatt, 2014). For human nutrition, bananas are regarded as a healthy source of energy. The banana fruit, as well as Kluai Namwa, can be consumed either ripe or unripe. The fruits of bananas can also be turned into a variety of products such as desserts, candy, chips, powder, and flour. Unripe banana flour can be utilized as food additives o medicines with therapeutic effects such as those used to treat peptic ulcers (Agama-acevedo *et al.*, 2012; Giraldo Toro *et al.*, 2015. Pereira *et al.*, 2020).

Unripe bananas are a great source of carbohydrates, bioactive compounds including phenols, flavonoids, and carotenoids, as well as minerals like potassium and magnesium (Chaguri *et al.*, 2017; Kumar *et al.*, 2019). They also contain a high level of dietary fiber (Rodríguez-Ambriz *et al.*, 2008), with a sizeable portion of resistant starch (RS), which is the starch that makes it to the large intestine (Segundz, *et al.*, 2017; Pico *et al.*, 2019). On a dry basis, green banana flour (GBF) has a starch content of 61.3-76.5 g/100 g. GBF consisted of dietary fiber without RS or fructans (6.28-15.54 g/100 g) (de la Torre-Gutiérrez *et al.*, 2008; Izidoro *et al.*, 2011; Menezes *et al.*, 2011;Wang *et al.*, 2012; Kamali *et al.*, 2021), less than 4% of the total protein, less than 1% of the total fat (Menezes *et al.*, 2011), and only 1.81% of the total soluble carbohydrates are present (Segubo, *et al.*, 2017a). Meanwhile, the ripening of bananas increases protein, decreases starch, and increases sugar. (Segubo, *et al.*, 2017b). The fructooligosaccharides, potassium, catechin, and tannin content of ripe bananas are also high (Der Agopian *et al.*, 20 A. Pereira *et al.*, 2018). Moreover, it possesses strong antioxidant action (Borges *et al.*, 2020).

However, bananas are climacteric fruits and people typically eat ripe fruit, significant amounts of this product are lost during marketing and processing carried out after harvest. Banana flour production is low-cost and reduces losses due to ripe banana spoilage. One technique to preserve bananas acquired using processing methods focused on drying is to produce green banana flour. Numerous food products, such as biscuits, bread, low-calorie spaghetti, and meat products, have benefited from thusage of green banana flour (J. Pereira *et al.*, 2020). Banana flour has a lot of resistant starch and can be used in the baking and candy making industries as a source of fiber and prebiotics to make functional foods like functional cakes (Tribess *et al.*, 2009).

The most tasty and rich foam cake is the chiffon cake. In comparison to sponge cakes and angel food, the texture is firmer but lighter and airier (Miller, 2015). One of the main components required to make cakes is wheat flour, along with eggs, sugar, oil, coconut milk, seasoning, etc. The nutritional value and functionality of baked goods are supposed to be enhanced by substituting other types of flour for wheat flour, and in relation to wellness and health concerns by consumers (Coelho & Salas-Mellado, 2015; Tasnim *et al.*, 2020; Mau *et al.*, 2017), it has have suggested that up to 60 percent of black rice powder coulewas utilized to partially substitute wheat flour. Very few research reports are available on replacing wheat flour with banana flour in food items. De Souza Viana *et al.* (2018) assessed the effects of adding 15% and 20% of green banana floslicedsliced bread, which produced a product with a high level of sensory accept Amini Khoozani *et al.* (2020) substituted nearly 30 percent of wheat flour with green banana flour, which significantly boosted the bread's total fiber, ash, and mineral content. Mabogo *et al.* (2021) reported on the characteristics of biscuits made with under-ripe muomva red banana flour (0, 10, 15, 20, and 25%) in place of wheat flour. It is not unusual for other important quality features to be compromised when a food item is included in a food production to enhance specific characteristics of the food. Banana flour is known for its high dietary fiber content and contains various essential nutrients such as potassium, magnesium, and vitamin C. The incorporation of green banana flour into a chiffon cake can increase its fiber content, introduce additional nutrients, and possibly modify its texture and flavor. It can be a suitable option for those looking to enhance the nutritional profile of their cake or explore gluten-free alternatives. Based on the above report, it would be beneficial to create a unique chiffon cake recipe using green banana flour. Therefore, the purpose of this study was to find out what would happen if green banana flour were used in place of wheat flour in chiffon cakes. The final products' feature and the substitution percentages for wheat flour were 0%, 20%, 50%, and 100% green banana flour.

2. Materials and methods

2.1 Preparation of green banana flour (GBF)

Kluai Namwa were obtained at a local market in Mahasarakham province, Thailand. The bananas utilized in this investigation were in stage two of ripening, which is green with a hint of yellow. The bananas were cleaned before being peeled with a stainless-steel knife and chopped into 3 mm-thick pieces. The slices were then soaked in lemon water for 5 minutes to prevent enzymatic browning. Then, slices were spread out on filter paper to dry the surface of the water. After this step, the slices were weighed, placed on trays, and dried in a 3000 watt far-infrared dryer. The temperature for drying was set to 60 °C. The drying process reduced the moisture cnt d to a 10% dry basis. Aferwards, the banana slices were crushed in a mill, and the flour obtained from the green bananas was placed in polyethylene plastic bags and stored at ambient temperature while waiting for additional analysis.

2.2 Chiffon cake preparation

The formulation for the chiffon cake used in this investigation was modified from Moreno *et al.* (2020. The Chiffon cakes' ingredients were wheat flour, fresh eggs, coconut milk, sugar, rice bran oil, salt, vanilla, and cream of tartar, and they were purchased from the local market. Chiffon cake formulations were investigated and replaced with green banana flour concentrations of 0% (control), 20%, 50%, and 100%. The ratio of ingredients is detailed in Table 1.

Table 1. Percentage of ingredients in chiffon cake formulations.

Ingredients	Content of green banana substitution wheat flour (%)			
	0	20	50	100
Wheat flour (g)	100	80	50	0
Green banana flour (g)	0	20	50	100
Baking powder (teaspoon)	1/2	1/2	1/2	1/2
Egg yolk (piece)	4	4	4	4
Rice bean oil (ml)	40	40	40	40
Coconut milk (ml)	40	40	40	40
sugar (g)	50	50	50	50
Vanilla (teaspoon)	1	1	1	1
Egg white (piece)	4	4	4	4
Cream of tartar (teaspoon)	1/4	1/4	1/4	1/4
Sugar (g)	30	30	30	30

The preparation of the chiffon cake was divided into three steps: First, sift the flour, salt, and baking powder into a separate medium bowl. In a medium bowl, the egg yolks, water, rice bran oil, vanilla, and coconut milk were combined. Second, whisk the cream of tartar and egg whites in a sizable mixing container. They were blended at speed 3 for one minute and then at speed 6 for nine minutes in a KitchenAid mixer (which has speeds ranging from 1 to 10). The remaining sugar was gradually added and mixed until soft peaks were formed, and the egg whites were glossy. Finally, the egg white batter was put into the egg yolk, and 1/3 of it was folded in with a spatula to lighten; the rest of the egg whites were gently folded in two equal parts until no white streaks remained. Then, the cake dough was placed in a cake mold with a diameter of 30 centimeters and baked in a laboratory oven at 160 °C for 30 minutes (Electric deck oven TNP SO 863 B, Zhongshan, China) After baked, the cakes were removed from the mold and chilled at room temperature for an hour. Then, the cakes were wrapped in plastic bags and kept at room temperature for evaluation. The baking conditions for chiffon cakes might vary depending on the recipe and the individual ingredients utilized. While 160 °C is the normal temperature for baking chiffon cakes (Sirisoontaralak *et al.*,2017), this study used a baking time of 30 minutes, which was appropriate for all formulas because when a toothpick or cake tester was inserted into the middle of the cake, it came out clean or with a few moist crumbs sticking to it. It's important to take into account that baking times can vary depending on components such as the size and shape of the cake pan, the thickness of the batter, and the particulars of the individual oven to determine the optimum baking time for a certain chiffon cake recipe.

2.3 Characterizations of Chiffon Cake

The color values (L*, a*, and b*) of chiffon cakes were determined using a colorimeter. (Hunter Lab, Model MiniScan Ez, Japan). Chiffon cake's brightness is indicated by the symbol L* (0 represents a dark color and 100 a white color). The colors red and green are represented by positive and negative a* values, respectively. Positive and negative values for b* correspond to the colors yellow and blue, respectively. Three mean color values were calculated for each color using three replicates and three repeated measurements. The formula $[(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2}$ was used to calculate the total color difference (ΔE*). The parameter h° defines the proportions in which redness and yellowness are presented relative to each other, with 0°/360° being regarded as red/magenta. In the case when $a^* > 0$ and $b^* > 0$ and $h°=\tan^{-1}(b^*/a^*)$, an angle of 90° denotes yellow, 180° green, 270° blue, 0° and 360° red (Kamali *et al.*, 2021). The water activity (a_w) of each cake was determined in triplicate at 25 °C using a Vapor Sorption Analyzer (DECAGON, model Aqualab-VSA, USA). Texture features of chiffon cakes in triplicate were evaluated using a 36-mm compression probe (P/36) on a texture analyzer (Model TA. XT Plus, Stable Microsystem, Surrey, UK). Texture Profile Analysis (TPA) devised a double compression technique to assess the texture of crumbs. Before measuring the cake samples, 25 x 25 x 25 cm cubes were cut from each sample. Cake slices were crushed to half their original height using a 50-mm-diameter cylindrical aluminum probe at pre-test, test, and post-test speeds of 2.0 mm/s, 2.0 mm/s, and 10 s, respectively, and time intervals of 10 s. The computer that regulates the instruments and analyzes the data was interfaced with the texture analyzer. Fracturability, hardness, stickiness, springiness, and cohesiveness of chiffon cakes included the variables determined from the force-time diagram. Hardness was defined as the product's initial compression's maximum force at the point of 50% compressed of the original sample height. The distance required to fracture the sample was used to characterize its fracturability (Paula & Conti-Silva, 2014). Stickiness describes the effort needed to overcome the forces holding the sample to the probe. The sample's springiness is defined as the level of height recovery it received between the first compression cycle and the second (Di Cairano *et al.*, 2021). However, cohesiveness is determined by comparing the area under compression twice and dividing by the area under compression once (Trinh & Glasgow, 2012).

2.4 Statistical analysis

The statistical investigations employed one-way analysis of variance (ANOVA) and Duncan's multiple range test (DMRT). The data was analyzed using SPSS Statistics, Version 20.0 software. The results provided a confidence interval of 95% for statistically significant differences ($p < 0.05$). All information was expressed using the mean and standard deviation (SD) values.

3. Results and discussion

3.1 Color measurement of chiffon cakes

All chiffon cake formulations were different in terms of appearance (Figure 1). The preferred color of chiffon cake is commonly baked to have a golden or light brown color on the exterior. This is achieved by properly baking the cake to ensure a nicely browned crust without it becoming too dark or burnt (Mua *et al.*, 2017). Chiffon cakes were color-measured using the parameters L*, a*, and b* (Table 2). The varying ratios of GBF to wheat flour resulted in significantly different ($p< 0.05$) hues for chiffon cakes. The values for lightness (L*rewere found be decreaed with an increasing percentage of GBF from replacing wheat flour from 70.462±0.40 to 61.35±0.67. This indicated that higher substitution for GBF gave progressively darker chiffon cake. This result corresponds to the experiment reported by Mabogo *et al*. (2021), who found that the L* valas decreased with increased banana flour in biscuit. The a* value increased with an increasing percentage of GBF from 3.40±0.20 to 4.33±0.24 in chiffon cake. The a* value obtained from the percentage of GBF at 0-50% was not statistically different, while the a* value obtained from the percentage of GBF at 100% in the chiffon cake was. The b* value decreased with an increasing percentage of GBF, from 21.83±0.24 to 16.78±0.12 in chiffon cake. This suggests less yellowness in chiffon cakes. This could be due to the presence of certain compounds or pigments in GBF that interact with the natural yellow color of the cake, resulting in a decrease in perceived yellowness. These results agree with Mashau *et al.* (2022), who reported banana flour on biscuits. The total color change (ΔE*) was used to characterize the total color difference between a chiffon cake made from whole wheat flour and a chiffon cake mixed with GBF and wheat flour. The color change parameter had the lowest value of 13.97±0.18 at 20% of GBF and the highest value of 24.20±0.60 at 100% lourgreen banana flour. Thus, the content of GBF had a great effect on the total color change of the chiffon cake. The hue angle values decreased with the increasing percentage of GBF, from about 83.01±0.21 to 75.51±0.85 in chiffon cake. The lowest* L and hue values showed that the color of the chiffon cake supplied a browner product color compared with the other percentages of GBF. Color measurements for food products are critical because they have a direct impact on consumers' perceptions and initial acceptance a new food products.

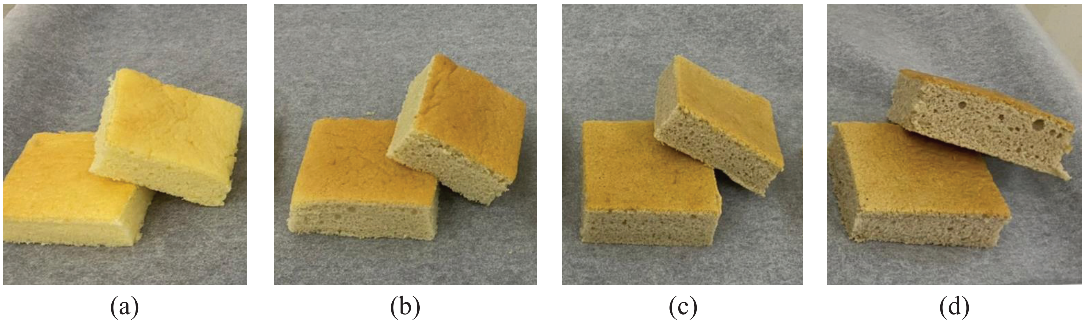

Figure 1. Appearance of chiffon cake containing different portion of green banana and wheat flour: a) 0% GBl b) 20% GBF c) 50% GBF and d) 100% GBF.

Table 2. The effect of replacing wheat flour with green banana flour in chiffon cakes on color and water activity.

Content of green banana flour (%)	Color			Total color change (ΔE*)	Hue angle (°h)	Water activity (a_w)
	L*	a*	b*			
Control (0)	80.62±0.88^a	3.28±0.46^b	31.39±0.33^a	-	84.02±0.90^a	0.91±0.01^a
20	70.46±0.40^b	3.40±0.20^b	21.83±0.24^b	13.97±0.18^a	83.01±0.21^a	0.92±0.01^a
50	62.58±0.23^c	3.58±0.14^b	20.00±0.70^c	21.34±0.36^b	79.84±0.14^b	0.91±0.00^a
100	61.35±0.67^d	4.33±0.24^a	16.78±0.12^d	24.20±0.60^c	75.51±0.85^c	0.88±0.00^c

Note: Mean ± SD. Means with distinct superscript letters within a row differ considerably ($p<0.05$).

3.2 Texture measurement of chiffon cakes

The textural characteristics of chiffon cake were described as fracturability, hardness, stickiness, springiness, and cohesiveness (Table 3). Chiffon cakes are recognized for their light and airy texture. They feature a soft, moist, and slightly spongy crumb. The chiffon cakes with 20% GBF had the lowest fracturability value of 3.20±0.21 N, whereas the control chiffon cakes had the highest value of 4.89±0.17 N. The fracturability decreased when substituting wheat flour with GBFed, possibly due to the dietary fiber intake; nonetheless, the GBF ratios showed no statistically significant variation. In general, the reduced gluten protein concentrations in the composite of the products result in looser matrix formation. Mabogo *et al.* (2021) reported that fracturability increased with the increase in banana flour concentration in biscuits. However, this was not the case in this study, possibly due to the contribution of other influencing factors such as the cultivar of banana, the state of ripening, and the ingredients in different products The hardness decreased as the GBF substitution increased from 8.88±0.63 to 6.06±0.26 N. The lowest hardness value of 6.06±0.26 N was observed in chiffon cakes with 100% GBF. The highest hardness value was 8.88±0.14 N in control chiffon cakes. These findings imply that using GBF increases softening texture. However, there was no significant difference in hardness at 20, 50, and 100% GF. Possibly by adding green banana flour, dietary fiber assists in moisture retention and provides tenderness to baked products (Bharathi *et al.*, 2021). Banana flour contains more dietary fiber, which can also contribute to a softer texture. Generally, banana flour is gluten-free. When banana flour is used as a substitute, it can result in a cake with a denser texture and an increase in the cake's firmnesy, GomB. et lal., 2016) discovered that wheat flour with a 20% banana flour substitution was harder than wheat flour with a 10% banana flour replarness. On the other hand, other researchers suggested that the resistant starch type 2 in GBF could have decreased hardness due to the matrix's discontinuous and irregular structure, which may reflect the product's reduced hardness (Sanz *et al.*, 2009). Therefore, this study may have the effect of dietary fiber resulting in chiffon cake softening. However, the result depends on the recipe, quantities, and other facture. The springiness decreased with the increase in the percentage of GBF. The highest springiness value of 0.50±0.01 was observed in control, and the lowest value was 0.30±0.0h with 100% GBF. Between 20 and 50% GBF, there was no significant change in the amount of springiness, but both of those ratios were significantly different at 100% GBF. The loss of springiness was directly affected by the chiffon cake formulations with different GBF, which had varying gluten concentrations in their components. Chiffon cakes made with mixed green banana flour have a lower gluten level, which can affect their softness. It could be explained that gluten makes the dough elastic enough that the bubble walls can expand and capture air bubbles during mixing and CO_2 produced from baking (Hedayati *et al.*, 2018). This agrees with the results of Bharathi *et al.* (2021), which showed a decrease in the cake's springiness with an increase in banana flour. Furthermore, Segundo *et al.* (2017b) observed that replacing wheat flour with ripe banana flour had no effect on the springiness of sponge duction. Öksüz and Karakaş, 2016) reported similar results on gluten-free biscuits made with buckwheat flour. Greater global gluten protein content improves dough gas retention. The gluten network established during ingredient mixing and hydration should moreover allow the dough to be extensible enough not to result in cell wall breakage (Zandonadi *et al.*, 2012; Ávila *et al.*, 2017; Hosokawa *et al.*, 2020).

Table 3. Texture properties of substituting green banana flour for wheat flour in a chiffon cake at various ratios.

Content of green banana flour (%)	Texture of chiffon cake				
	Fracturability (N)	**Hardness (N)**	**Stickiness (N.s)**	**Springiness (-)**	**Cohesiveness (-)**
Control	4.89±0.1^{7}a	8.88±0.1^{4}a	-0.06±0.05^{a}	0.50±0.0^{1}a	0.74±0.00^{a}
20	3.20±0.21^{b}	6.43±0.63^{b}	-0.05±0.05^{a}	0.37±0.01^{b}	0.78±0.01^{a}
50	3.23±0.12^{b}	6.42±0.28^{b}	-0.05±0.06^{a}	0.39±0.03^{b}	0.77±0.09^{a}
100	3.26±0.2^{0}b	6.06±0.2^{b}b	-0.05±0.04^{a}	0.30±0.0^{4}c	0.75±0.00^{a}

Note: Mean ± SD. Means with distinct superscript letters within a row differ considerably ($p<0.05$).

4. Conclusion

In the present study, unripe banana flour was used up to 100% as a substitution for wheat flour in chiffon cakes, which is expected to benefit consumers due to the nutrition of banana. However, the lightness and yellowness values declined as the percentage of GBF substitute wheat flour increased, showing that a greater proportion of green banana flour produced a darker chiffon cake In terms of the sample's texture, the fracturability, hardness, and springiness decreased compared to the control. The hardness decreased when wheat flour was substituted with GBF; however, at 20, 50, and 100% GBF, there was no difference in hardness. Springiness at 100% GBF were significantly different from 20% and 50% GBF, with the effect of dietary fiber resulting in chiffon cake softening. The addition of GBF had no influence on stickiness or cohesiveness. Future studies will be undertaken to determine the nutritional analysis, physical characteristics of cake batters, and sensory evaluation level of chiffon cake with different levels of green banana flour for improving their final products and having them accepted by consumerss.

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