The objectives of this research were to examine the physicochemical properties of modified rice flour including dry milled (DM) rice flour, pre-germinated brown (PGB) rice flour, and heat moisture treatment (HMT) rice flour and investigate the effect of three modified rice flours for banana rice cake production by using wheat flour as a control. The physicochemical properties including swelling power, solubility, and pasting properties of samples were analyzed. It was found that the physicochemical properties were significantly different (p≤0.05). The swelling power value of PGB rice flour (13.56 g/g) and HMT rice flour (12.38 g/g), the breakdown value of PGB rice flour (138.75 RVU) and HMT rice flour (107.38 RVU) were lower than DM rice flour. The appropriated banana rice cake formula was adapted according to modified rice flours. The results showed that the banana rice cake from PGB rice flour (4.29 cm) and HMT rice flour (4.29 cm) had higher height than others. Furthermore, the sensory evaluation with 9 point hedonic scale of banana rice cake from PGB and HMT rice flours showed the appearance, color, taste, flavor, texture, and overall preference scores to be slightly like to moderately like.

**Keywords:** Banana rice cake, Dry milled rice flour, Pre-germinated brown rice flour, Heat moisture treatment rice flour
INTRODUCTION

Thai Jasmine rice varieties, such as Khao Dawk Mali 105 (KDML 105), are very popular and widely gained acceptance in Thailand due to their specific characteristics, particularly flavor and unique aroma. Rice flour has many unique attributes and non allergenic properties. It is cholesterol and gluten free (Shih and Daigle, 2002). Several studies have been attempted to improve quality of baked products, such as breads, cakes, and cookies, which were formulated with KDML 105 rice flour alone or combination with other flours substitutes or novel ingredients. Rice flour preparation is one of the important physical characteristics that affect to quality of rice cake. The rice flour with varying preparation has different physicochemical properties, which cause differences in functional properties of the end products. Many researchers reported that the HMT process can decrease peak viscosity and breakdown but increase gelatinization temperature. The low breakdown value indicated that the starch granule in the rice flour was more durable to heating and shearing (Horndok and Noomhorm, 2007; Shih et al., 2007; Khunae et al., 2007). From this reason, the HMT can be use in the baked goods.

The aim of this research was to evaluate the physicochemical profile of rice flours which was differently modified processes and wheat flour. The panel evaluation of banana cake, which made from each modified rice flours, was done by comparing to banana cake from wheat flour.

MATERIALS AND METHODS

Materials

1) Low protein wheat flour (Royal fan cake flour, UFM)
2) Thai Khao Dawk Mali 105 (KDML 105)
3) Commercial pre-germinated brown rice (Thai Khao Dawk Mali 105, KDML 105 variety) (Nutra GABA Rice, Mah Boonkrong Plus)

The preparation of modified rice flours samples

1) Dry milled (DM) rice flour: Thai Khao Dawk Mali 105 (KDML 105) was dry-milled by hammer mill (model ZM 1, Retsch, Germany), and then sieved through a 100 mesh.

2) Commercial pre-germinated brown (PGB): rice flour Thai Khao Dawk Mali 105 (KDML 105) was obtained from Mah Boonkrong Plus Co. Ltd, Thailand. Next, it was dry-milled by hammer mill (model ZM 1, Retsch, Germany), and then sieved through a 100 mesh.

3) Heat moisture treatment (HMT) rice flour: HMT of rice flour sample was carried out by using the method of Chaichaw and Naivikul (2009). An exactly known moisture content of rice flour sample was weighed into polyethylene (PE) bag. Adjusted moisture content of sample to 25% (by calculated), and then
mixed together. The sample bag was tightly closed and left in refrigerator at 4°C for 24 hours. The sample bag was stood at 30°C for 1 hour and then packed into tightly sealed aluminum foil. The sample was kept in the hot air oven at 120°C for 5 hours and then heated in the tray dryer at 45±50°C for 6 hours.

This modified rice flour sample was milled and sieved through a 100 mesh.

All of the rice flours samples were kept in the PE bag at 4 °C until they were analyzed.

The determination of swelling power and solubility (Modified from Schoch, 1964)

Each flour sample (1 gram) was mixed with 15 ml distilled water and then heated at 95°C in water bath for 30 minutes. The sample was centrifuged at 2,200×g for 15 minutes. The supernatant was carefully poured in weighed aluminum can and then weighed the precipitated. The supernatant in aluminum can was dried at 100°C for 3 hours in hot air oven and then cooled in desiccators for 30 minutes. The dried solid in aluminum can was weighed and then calculated for solubility and swelling power by following equations:

\[
\text{Solubility (\% flour dry base)} = \frac{\text{weight of dried solids from supernatant} \times 100}{\text{weight of dried flour}}
\]

\[
\text{Swelling power (g/g flour dry base)} = \frac{\text{weight of precipitated}}{\text{weight of dried flour} \times (100-\text{solubility})} \times 100
\]

The determination of pasting properties (The AACC method 61-02.01 (AACC, 2000))

A Rapid Visco Analyser (RVA, Series 4V, Newport Scientific Pty. Ltd., Warriewood, Australia) was employed to investigate the pasting properties of the flour. In this assay, 3 grams (at 12% moisture content) rice flour sample was dispersed in 25 ml distilled water. The heating and cooling cycle were programmed in the following manners. The sample was held at 50°C for 1 minute, heat to 90°C within 3 minutes and then held at 90°C for 2 minutes. It was subsequently cooled to 50°C within 3 minutes and then held at 50°C for 2 minutes.

The banana cake production

Banana cakes were produced from wheat flour and three rice flour samples. The formula to produce the cakes were calculated using bakery percentage (100% flour). All dried ingredients, composed of rice flour (100%), fine sugar (90%), leavening agent (2%), baking soda (1.67%), and salt (0.83%) were sieved and then mixed with eggs (195%). Continue mixing with vegetable oil (100%) and Cavendish banana (100%), added banana flavor and lime juice. The 250 grams of well prepared batters were weighed into aluminum mold (7.5×16.5 cm), and then baked in oven at 170°C for 45
minutes. The ratio between solid and liquid phases of batter was adapted for banana rice cake production.

**Banana cake qualities evaluation**

1. **The determination of cake height**
   The height of banana cake was determined by scientific ruler (2 decimals) in the middle piece of cake.

2. **Sensory evaluation**
   The banana cakes were made from wheat flour, DM rice flour, PGB rice flour, and HMT rice flour which was sensory evaluated for the appearance, color, flavor, taste, texture and overall characteristics. The samples were presented in an identical container. Thirty untrained panels were selected from students of the department of food science and technology, faculty of agro-industry to perform the evaluation using 9 point hedonic scale. The banana cakes were submitted to a satisfactory test using proper questionnaire.

**Experimental designs and statistical analysis**

A completely randomized design (CRD) was used for evaluating the pasting properties, swelling power, and solubility property of flours and a randomized complete block design (RCBD) was used for evaluating the sensory properties of banana cakes. The difference between means was determined using the Duncan news multiple range test (DMRT) at the confidence level as 95 percentages. The data in the table and figure were reported as the averages of triplicate observations.

**RESULTS AND DISCUSSIONS**

1. **Swelling power and solubility of wheat flour and modified rice flours**
   The swelling power and solubility of flours were shown in Table 1. It was found that the swelling power value of modified rice flours were significantly different \((p \leq 0.05)\). When compared among rice flours with different modification methods, the swelling power could be sorted as in the following order, DM rice flour \((14.54 \text{ g/g})\) > PGB rice flour \((13.56 \text{ g/g})\) > HMT rice flour \((12.38 \text{ g/g})\). The differences of these values were related to the modification methods. The DM and PGB rice flours had the higher swelling power than HMT rice flour. Because the heat moisture treatment process might rearrange the double helical amylopectin side chain clusters in starch molecule causing limited the hydration starch and swelling capacity (Zavareze et al., 2010). Furthermore, the swelling power of PGB rice flour was not significantly different \((p > 0.05)\) when compared to wheat flour.
Another property related to swelling power is solubility (Table 1). The solubility of modified rice flours and wheat flour were in the following order, DM rice flour (2.80 %) < PGB rice flour (5.08 %) < HMT rice flour (7.12 %) < wheat flour (8.77 %). After modification, the solubility had lower than wheat flour due to a strengthening of the bonds, with an increase in the interactions among amylose and amylopectin molecules, restricting them from leaching out of the granules (Zavareze et al., 2010).

Table 1 The swelling power and solubility of modified rice flours and wheat flour.

<table>
<thead>
<tr>
<th>Flour types</th>
<th>Swelling power (g/g)</th>
<th>Solubility (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>13.48 ±0.36</td>
<td>8.77 ±0.96</td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) DM</td>
<td>14.54 ±0.20</td>
<td>2.80 ±1.49</td>
</tr>
<tr>
<td>2) PGB</td>
<td>13.56 ±0.14</td>
<td>5.08 ±0.19</td>
</tr>
<tr>
<td>3) HMT</td>
<td>12.38 ±0.14</td>
<td>7.12 ±0.33</td>
</tr>
</tbody>
</table>

Means within the same column with different letters are significantly different (p ≤ 0.05).

2. Pasting properties of wheat flour and modified rice flours

The pasting characteristics of wheat flour and modified rice flours samples were shown in Table 2 and Figure 1. Pasting temperature of different flours ranged from 86.55-92.35°C, the HMT rice flour had the highest pasting temperature (92.35°C) and followed by wheat flour (88.43°C), PGB rice flour (87.18°C), and DM rice flour (86.55°C). When compared wheat flour and modified rice flours, it was shown that pasting temperature of wheat flour was not significantly different (p>0.05) from DM and PGB rice flours.

Peak viscosity of DM rice flour (243.55 RVU) was found to be the highest and followed by PGB rice flour (205.46 RVU), wheat flour (164.71 RVU), and HMT rice flour (130.09 RVU). Breakdown values of all flours as in the following order, DM rice flour (174.00 RVU) > PGB rice flour (138.75 RVU) > wheat flour (128.84 RVU) > HMT rice flour (107.38 RVU). It was shown that the final viscosity of DM rice flour (288.42 RVU) is higher than PGB rice flour (271.21 RVU), HMT rice flour (199.38 RVU), and wheat flour (197.71 RVU). Set back was calculated and appeared as in the following order, PGB rice flour (132.46 RVU) > DM rice flour (114.42 RVU) > HMT rice flour (92.00 RVU) > wheat flour (68.88 RVU). As the results, the pasting properties of modified rice flours were shown dependent on process or modification methods such as dry milling, pre-germination, and heat-moisture treatment. In case of HMT rice flour, it exhibited a significantly low breakdown which was clearly attributed to the starch granule in the rice flour was more durable to heating and shearing. For PGB rice flour, during germination amylolytic enzymes activate to break down
starch producing more sugars and oligosaccharides, resulting in loss of viscosity (Panchan and Naivikul, 2009).

Figure 1 Pasting properties of wheat flour and modified rice flours.

Table 2 Pasting characteristics of wheat flour and modified rice flours.

<table>
<thead>
<tr>
<th>Flour types</th>
<th>Peak time (min)</th>
<th>Pasting temperature (ºC)</th>
<th>Pasting properties (RVU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>6.44 ± 0.05</td>
<td>88.43 ± 0.67</td>
<td>164.71 ±3.48, 35.88 ± 3.60, 128.84 ± 0.12, 197.71 ± 6.19, 68.88 ± 6.30</td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1) DM</td>
<td>5.94 ± 0.09</td>
<td>86.55 ± 1.13</td>
<td>243.55 ± 0.18, 69.55 ± 1.59, 174.00 ± 1.77, 288.42 ± 1.77, 114.42 ± 0.00</td>
</tr>
<tr>
<td>2) PGB</td>
<td>5.84 ± 0.05</td>
<td>87.18 ± 1.17</td>
<td>205.46 ± 1.59, 66.71 ± 1.36, 138.75 ± 0.24, 271.21 ± 0.76, 132.46 ± 0.53</td>
</tr>
<tr>
<td>3) HMT</td>
<td>6.20 ± 0.18</td>
<td>92.35 ± 0.57</td>
<td>130.09 ± 1.65, 22.71 ± 0.76, 107.38 ± 2.41, 199.38 ± 1.70, 92.00 ± 4.13</td>
</tr>
</tbody>
</table>

a-d Means within the same column with different letters are significantly different (p<0.05).

3. The height of banana cakes

The heights of banana cakes were shown in Figure 2. It was found that the banana cake from modified rice flours and the banana cake from wheat flour were significantly different (p<0.05). The banana cake from wheat flour (3.80 cm) had lower height than the PGB (4.29 cm) and HMT (4.29 cm) rice flours except the banana cake from DM rice flour (3.41 cm). The appropriated banana cake formula was adapted according to modified rice flours. From this reason, this formula was not suitable for banana cake from wheat flour production by increasing the liquid phase of batter, oil and egg, and caused the collapsed structure. The banana cakes from PGB and HMT rice flours were not significantly different (p>0.05), and were the highest height of banana cake which indicated the stability of cake structure during forming and setting, while the banana cake from DM flour was the lowest height. Consequently,
the PGB and HMT rice flours could have more stable starch granules and lower swelling power than DM rice flour. So that, the banana cakes from PGB and HMT rice flours could maintain the structure more than DM rice flour.

![Figure 2](image.png)

**Figure 2** The banana cake heights from wheat flour (a), DM rice flour (b), PGB rice flour (c), and HMT rice flour (d).

*a-c* Means with different superscript letters are significantly different (p≤0.05).

### 4. Sensory evaluation of banana cakes

The results of the sensory evaluation of banana cakes samples were presented in Table 3.

**Table 3** Sensory evaluation† of banana cakes from modified rice flours and wheat flour.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Wheat flour</th>
<th>DM rice flour</th>
<th>PGB rice flour</th>
<th>HMT rice flour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>5.13±1.61</td>
<td>4.40±1.54</td>
<td>6.37bc±1.75</td>
<td>7.23a±1.07</td>
</tr>
<tr>
<td>Color</td>
<td>5.07±1.86</td>
<td>4.63c±1.87</td>
<td>6.50b±1.59</td>
<td>7.27a±1.08</td>
</tr>
<tr>
<td>Flavor</td>
<td>6.20±1.35</td>
<td>5.47±1.81</td>
<td>6.23±1.69</td>
<td>6.40±1.59</td>
</tr>
<tr>
<td>Taste</td>
<td>6.10±1.81</td>
<td>5.63±2.01</td>
<td>5.80±1.69</td>
<td>6.00±1.68</td>
</tr>
<tr>
<td>Texture</td>
<td>5.77±2.03</td>
<td>5.30±2.12</td>
<td>5.50±1.78</td>
<td>6.27±1.70</td>
</tr>
<tr>
<td>Overall</td>
<td>5.77bc±1.68</td>
<td>5.50c±1.78</td>
<td>6.20bc±1.35</td>
<td>6.60a±1.30</td>
</tr>
</tbody>
</table>

*a-c* Means within the same row with different letters are significantly different (p ≤0.05).

Ns Means within the same row are not significantly different (p>0.05).

†Hedonic sensory evaluation performed by 30 persons with 9 scales scoring.

The banana HMT rice cake showed the highest score for all attributes due to the modification of the formula. This formula is somewhat higher moisture content than the normal banana cake made from wheat flour. The color (5.07) and overall (5.77) scores from banana wheat cake were similar to banana
DM rice cake. The banana PGB rice cake showed the overall (6.20) not significantly different (p>0.05) to the banana HMT rice cake (6.60).

CONCLUSION
As the results, the heat moisture treatment modification and pre-germination process for rice flours are beneficial for banana rice cake production in this appropriate banana rice cake formula. While the dry milled rice flour processing was not suitable for the banana rice cake production.

ACKNOWLEDGEMENT
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