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# Effect of Addition of Sourdough on Physicochemical Characteristics of Wheat and Rice Flour Bread

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## ABSTRACT

Gluten-free bread has been developed for people suffering from celiac disease. Nonetheless, the lack of gluten can change the quality of the bread. This study investigated the effect of the addition of sourdough on the physicochemical characteristics of wheat bread and gluten-free bread. In wheat bread, the addition of sourdough (0–15 g per 100 g dough) had no significant effect on the moisture content of the bread. However, the moisture content increased when the sourdough content increased to 22.5–30.0 g per 100 g dough. The addition of sourdough (up to 30 g per 100 g dough) decreased the hardness of the gluten-free bread from 28.94 to 14.95 N. The springiness of the gluten-free bread significantly ($P \leq 0.05$) increased from 0.54 to 0.81 with the addition of 22.5–30.0 g per 100g dough sourdough. Likewise, the springiness of the wheat bread significantly increased ($P \leq 0.05$) from 0.91 to 0.99. However, with the addition of 30 g sourdough per 100g dough, the hardness of the wheat bread increased significantly ($P \leq 0.05$). The cohesiveness of both breads significantly ($P \leq 0.05$) increased with an increase in the sourdough content. The addition of sourdough had no significant effect ($P > 0.05$) on the crust color, but affected the crumb color significantly ($P \leq 0.05$). Therefore, the addition of sourdough could change the characteristics of both wheat and gluten-free breads.


**Keywords:** sourdough, gluten-free, bread, wheat, Jasmine rice

## INTRODUCTION

Bread is a staple food consumed worldwide and its consumption is continually increasing (Novotni *et al*., 2012). It normally contains gluten from wheat flour because gluten is responsible for the elastic and extensible properties which are required to produce good quality bread (Gallagher *et al.,* 2003). However, the gluten can be harmful to consumers who suffer from celiac disease and for this reason, gluten-free bread has been developed for those people (Arendt *et al*., 2008). The lack of gluten can deteriorate bread quality (Sivaramakrishnan *et al*., 2004) and consequently, it is necessary to add some ingredients or apply other methods to improve the quality of gluten bread to be comparable to that of wheat bread.

Sourdough is a mixture of flour and water fermented with lactic acid bacteria (LAB) and can be used for sourdough bread production (Diowksz and Ambroziak, 2006). Sourdough contains lactic acid and acetic acid resulting in a sour taste of the end product. The action of sourdough could be responsible for the characteristics of sourdough bread in terms of acid production, aroma and leavening, resulting in an improvement in the volume, texture, flavor and

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nutritional value (Espinosa *et al.,* 2011). In wheat bread, the addition of 20% sourdough increased $CO_2$ production and thereby decreased the crumb hardness (Sandra *et al.,* 2012). Higher addition of sourdough (30 g per 100 g dough) provided a protective effect with regard to bread staling and extended the shelf life of the bread (Torrieri *et al.,* 2014). In gluten-free bread, Novotni *et al.,* (2012) reported that the addition of 15.0–22.5 g sourdough per 100 g batter could improve the volume and texture significantly. The glycemic index of bread was also decreased to a low level.

In the current research, sourdough was added to both wheat flour and rice flour dough. Its effect on the quality of the developed regular and gluten-free bread was investigated.

## MATERIALS AND METHODS

### Materials

Wheat flour (12–14% protein) (Hong Kaw, Bangkok, Thailand), jasmine rice flour (Kwao Dawk Mali 105; Pechpanthong; Roi Et, Thailand), soy protein (Pro 500A; Vicchi Enterprises; Bangkok, Thailand), dry yeast (Bruggeman; Ghent, Belgium), sugar (Mitr Phol; Suphanburi, Thailand), salt (PrungThip; Nakornratchasima, Thailand), butter (Allowrie; Bangkok, Thailand), hydroxypropyl methylcellulose (Methocel K4M; Vicchi Enterprises; Bangkok, Thailand), milk (Dutch Mill; Nakhon Pathom, Thailand), egg (CP Ltd; Chonburi, Thailand) and sourdough starter (King Arthur Flour; Norwich, VT, USA) were used to make the wheat bread and gluten-free bread.

### Sourdough preparation

Wheat flour or jasmine rice flour (200 g) and water (100 g) were mixed with the sourdough starter (28 g) and fermented at 30 °C and 95% relative humidity (RH) until the pH reached 4.00 ± 0.05 (Novotni *et al*., 2012).

### Bread making

#### Wheat flour bread making

All ingredients (Table 1) and sourdough were mixed in a blender (Kenwood Electronics, Havant, England) at speed 2 for 2 min. Then, butter was added and continuously mixed at speed 2 for 15 min. The dough was kneaded and placed in a mold and allowed to prove at 35 °C and 95% RH (modified from Therdthai *et al*., 2007) using a prover for 60 min. Finally, the dough was baked in a conventional oven at 195 °C for 30 min and cooled at room temperature (25 °C) for 60 min.

#### Rice flour bread making

All dry ingredients (Table 1) and

**Table 1** Ingredients used in bread formulas.

| Ingredient (g) | Bread type | |
|---|---|---|
| | Wheat flour | Rice flour |
| Wheat flour | 100.0 | - |
| Jasmine rice flour | - | 100.0 |
| Soy protein | - | 4.0 |
| Baker's yeast | 1.8 | 1.6 |
| Sugar | 4.0 | 18.0 |
| Salt | 1.0 | 1.0 |
| Water | - | 75.0 |
| Butter | 5.0 | 20.0 |
| HPMC | - | 4.0 |
| Milk | 65.0 | - |
| Egg | 6.5 | - |

Source: Adapted from Nishita *et al.* (1976)

sourdough were mixed in the blender at speed 2 for 2 min. Then, butter was added and continuously mixed at speed 2 for 3 min. The batter was kneaded and placed in a mold and allowed to prove at 35 °C and 95% RH (modified from Therdthai *et al.,* 2007) using a prover for 120 min. Finally, the batter was baked in a conventional oven at 195 °C for 30 min and cooled at room temperature (25 °C) for 60 min.

A completely randomized design was used to determine the effect of the sourdough content (0, 7.5, 15.0, 22.5 and 30.0 g per 100 g dough) on the quality of wheat flour bread and rice flour bread.

**Determination of bread quality**

**Moisture content**

Bread crumbs (20 mm diameter) were sampled from the center of the loaf to measure the moisture content using an oven method (Association of Official Analytical Chemists, 1990).

**Texture profile analysis**

The bread was cut into 15 × 15 × 15 mm cubes to measure the texture profile (15 cubes per measurement). The texture profile was analyzed using a texture analyzer (TA-XT plus; Charpatech Center; Bangkok, Thailand) and a P50 cylinder probe. The testing speed was set to 20 $mm.s^{-1}$ at 60% deformation.

**Crust and crumb color**

Color was measured for samples of the bread crust and crumbs based on the CIE L*, a* and b* system (Furlan *et al.,* 2015) using a spectrophotometer (Model CM - 3500d; Minolta; Ramsey, NJ, USA). The values for L*, a* and b* represent lightness, greenness-redness and blueness-yellowness, respectively.

**Statistical analysis**

Analysis of variance was carried out using the SPSS software package (version 12.0; SPSS Inc, Chicago, IL, USA) with significance tested at the 95% confidence level and differences among means were determined using the least significant difference and Duncan's test.

## RESULTS AND DISCUSSION

**Effect of flour type and sourdough content on moisture content of wheat flour and rice flour bread**

Table 2 shows the moisture content of the wheat flour bread and the rice flour bread with and without the addition of sourdough. The addition of sourdough (0–15.0 g per 100 g dough) had no significant effect on the moisture content of the wheat flour bread. However, increasing the sourdough content to 22.5–30.0 g per 100g dough increased the moisture content of the wheat flour bread. The final moisture content of the rice flour bread significantly increased from 37.97 to 44.20% (wet basis; wb) with an increase in the sourdough content from 0 to 30 g per 100 g dough because the addition of sourdough increased the amount of water in the wheat dough and rice batter. (Torrieri *et al.* (2014) reported that an increase in the sourdough content from 20 to 30 g per 100 g dough increased the water content by 2–25%, depending on the type of starter used.

**Table 2** Moisture content of wheat flour and rice flour bread.

| Bread type | Moisture (%) | | | | |
|---|---|---|---|---|---|
| | Sourdough (g per 100g dough) | | | | |
| | 0.0 | 7.5 | 15.0 | 22.5 | 30.0 |
| Wheat flour | $40.01 \pm 0.06^{c}$ | $40.40 \pm 0.03^{bc}$ | $41.20 \pm 0.01^{abc}$ | $41.96 \pm 0.16^{ab}$ | $43.60 \pm 0.01^{a}$ |
| Rice flour | $37.97 \pm 0.01^{e}$ | $38.54 \pm 0.03^{d}$ | $39.81 \pm 0.04^{c}$ | $43.71 \pm 0.01^{b}$ | $44.20 \pm 0.08^{a}$ |

a-e = Means ± SD within the same row with different lowercase superscript letters are significantly different ($P \leq 0.05$).

**Effect of flour type and sourdough content on the texture of wheat flour and rice flour bread**

The analysis of the texture profile of the wheat flour bread showed that the hardness decreased significantly with an increase in the sourdough content because the sourdough improved gas retention in the bread dough. Moreover, acidification caused by the sourdough impacted on the solubility of the structure-forming components such as gluten, starch and protein (Gobbetti *et al.,* 2008). However, the addition of sourdough at 30 g per 100 g dough increased the hardness of the wheat flour bread significantly because the addition of too much sourdough affected the growth of yeast and thereby the bread volume expansion and density. In addition, the springiness and cohesiveness of the wheat flour bread increased significantly with the increased sourdough content (Table 3) because sourdough created a spongy structure in the bread which was reflected in the increased springiness and cohesiveness.

Similarly, in the rice bread, the addition of sourdough (up to 30 g per 100 g dough) decreased hardness significantly from 28.94 to 14.95 N due to the increased gas retention in the dough (Gobbetti *et al.,* 2008). Furthermore, the springiness of the rice flour bread increased significantly from 0.54 to 0.81 with the addition of 22.5 and 30.0 sourdough g per 100 g dough. Likewise, the cohesiveness of the rice flour bread increased significantly with the increased sourdough content (Table 4). This coincided with the report of Diowksz and Ambroziak, (2006) that sourdough strongly influenced the crumb structure.

**Effect of flour type and sourdough content on color of wheat flour and rice flour bread**

The L*, a* and b* values of the wheat flour bread crust were in the ranges 38.95–52.69, 11.48–14.89, and 22.62–29.82, respectively. There was no significant difference among the wheat flour bread crusts. However, the L* values of the wheat flour bread crumb decreased with

**Table 3** Texture of wheat flour bread.

| Bread type | Sourdough (g per 100 g dough) | Hardness (N) | Springiness | Cohesiveness | Gumminess | Chewiness (N) | Resilience |
|---|---|---|---|---|---|---|---|
| Wheat flour | 0.0 | $4.43 \pm 0.10^{a}$ | $0.91 \pm 0.09^{c}$ | $0.67 \pm 0.02^{e}$ | $3.65 \pm 0.16^{a}$ | $3.45 \pm 0.21^{a}$ | $0.31 \pm 0.01^{e}$ |
| | 7.5 | $3.77 \pm 0.19^{b}$ | $0.95 \pm 0.07^{b}$ | $0.76 \pm 0.03^{d}$ | $2.94 \pm 0.08^{b}$ | $2.79 \pm 0.26^{b}$ | $0.39 \pm 0.02^{d}$ |
| | 15.0 | $1.12 \pm 0.05^{d}$ | $0.98 \pm 0.10^{a}$ | $0.83 \pm 0.04^{b}$ | $1.25 \pm 0.42^{d}$ | $1.24 \pm 0.43^{d}$ | $0.46 \pm 0.05^{b}$ |
| | 22.5 | $0.86 \pm 0.14^{e}$ | $0.99 \pm 0.06^{a}$ | $0.89 \pm 0.18^{a}$ | $1.01 \pm 0.09^{e}$ | $0.94 \pm 0.06^{e}$ | $0.48 \pm 0.04^{a}$ |
| | 30.0 | $1.80 \pm 0.04^{c}$ | $0.99 \pm 0.07^{a}$ | $0.82 \pm 0.01^{c}$ | $1.35 \pm 0.35^{c}$ | $1.34 \pm 0.36^{c}$ | $0.44 \pm 0.02^{c}$ |

a-e = Means ± SD within the same column with different lowercase superscript letters are significantly different ($P \leq 0.05$).

**Table 4** Texture of rice flour bread.

| Bread type | Sourdough (g per 100 g dough) | Hardness (N) | Springiness | Cohesiveness | Gumminess | Chewiness (N) | Resilience |
|---|---|---|---|---|---|---|---|
| Rice flour | 0 | $28.94 \pm 0.92^{a}$ | $0.54 \pm 0.10^{c}$ | $0.31 \pm 0.03^{e}$ | $7.23 \pm 1.00^{e}$ | $3.92 \pm 1.19^{e}$ | $0.17 \pm 0.01^{d}$ |
| | 7.5 | $26.18 \pm 1.35^{b}$ | $0.50 \pm 0.10^{d}$ | $0.38 \pm 0.03^{d}$ | $9.98 \pm 1.09^{b}$ | $5.08 \pm 1.42^{c}$ | $0.19 \pm 0.01^{c}$ |
| | 15 | $23.92 \pm 0.37^{c}$ | $0.46 \pm 0.07^{e}$ | $0.39 \pm 0.06^{c}$ | $9.33 \pm 1.42^{c}$ | $4.38 \pm 1.28^{d}$ | $0.20 \pm 0.04^{b}$ |
| | 22.5 | $19.35 \pm 0.30^{d}$ | $0.81 \pm 0.01^{a}$ | $0.58 \pm 0.01^{a}$ | $11.52 \pm 0.30^{a}$ | $9.39 \pm 0.28^{a}$ | $0.31 \pm 0.01^{a}$ |
| | 30 | $14.95 \pm 0.60^{e}$ | $0.79 \pm 0.04^{b}$ | $0.57 \pm 0.03^{b}$ | $8.82 \pm 0.39^{d}$ | $7.01 \pm 0.51^{b}$ | $0.31 \pm 0.02^{a}$ |

a-e = Means ± SD within the same column with different lowercase superscript letters are significantly different ($P \leq 0.05$).

the addition of sourdough (Table 5). This was influenced by the color of the sourdough starter.

Similar to the wheat flour bread, the rice flour bread crust color (L*, a* and b*) was not significantly different among the various levels of sourdough content. However, increased sourdough content caused a significant reduction in the L* values of the rice flour bread crumb (Table 6). Compared to the wheat flour bread crumb, the rice flour bread crumb had higher L* values due to the light color of the rice flour.

## CONCLUSION

Wheat flour and rice flour were used to develop regular and gluten-free bread with various levels of sourdough content. An increase in the sourdough content increased the moisture content of the rice flour bread but not of the wheat flour bread. Regardless of the flour type, the increased sourdough content increased the cohesiveness and decreased the hardness of the bread crumb significantly. In addition, the L* values of both the wheat flour and rice flour bread crumb decreased with increased sourdough content. However, the effect of the addition of the sourdough content on all types of bread crust was not significant.

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**Table 5** Crust and crumb color of wheat flour bread.

| Bread type | Sourdough (g per 100 g dough) | Crust | | | Crumb | | |
|---|---|---|---|---|---|---|---|
| | | L* | a* | b* | L* | a* | b* |
| Wheat flour | 0.0 | $47.90 \pm 15.70^{a}$ | $13.47 \pm 2.35^{a}$ | $24.45 \pm 9.67^{a}$ | $58.12 \pm 0.02^{b}$ | $0.19 \pm 0.05^{c}$ | $12.21 \pm 0.23^{b}$ |
| | 7.5 | $45.61 \pm 20.13^{a}$ | $11.48 \pm 3.38^{a}$ | $24.66 \pm 12.52^{a}$ | $57.13 \pm 0.01^{c}$ | $0.83 \pm 0.01^{a}$ | $16.54 \pm 0.01^{a}$ |
| | 15.0 | $41.49 \pm 12.98^{a}$ | $13.39 \pm 2.75^{a}$ | $22.62 \pm 9.41^{a}$ | $46.31 \pm 1.14^{e}$ | $0.20 \pm 0.00^{b}$ | $11.21 \pm 0.77^{d}$ |
| | 22.5 | $38.95 \pm 12.15^{a}$ | $14.89 \pm 0.66^{a}$ | $22.86 \pm 9.26^{a}$ | $60.84 \pm 1.67^{a}$ | $0.11 \pm 0.06^{d}$ | $12.11 \pm 0.50^{c}$ |
| | 30.0 | $52.69 \pm 18.13^{a}$ | $11.63 \pm 2.41^{a}$ | $29.82 \pm 10.56^{a}$ | $50.90 \pm 0.07^{d}$ | $0.03 \pm 0.00^{e}$ | $10.66 \pm 0.08^{e}$ |

a-e = Means ± SD within the same column with different lowercase superscript letters are significantly different ($P \leq 0.05$).

**Table 6** Crust and crumb color of rice flour bread.

| Bread type | Sourdough (g per 100 g dough) | Crust | | | Crumb | | |
|---|---|---|---|---|---|---|---|
| | | L* | a* | b* | L* | a* | b* |
| Rice flour | 0.0 | $53.00 \pm 23.71^{a}$ | $9.74 \pm 5.31^{a}$ | $27.48 \pm 13.46^{a}$ | $71.54 \pm 0.05^{a}$ | $0.08 \pm 0.01^{e}$ | $16.38 \pm 0.16^{a}$ |
| | 7.5 | $53.54 \pm 21.70^{a}$ | $10.94 \pm 8.39^{a}$ | $26.27 \pm 9.09^{a}$ | $68.77 \pm 0.09^{c}$ | $0.76 \pm 0.06^{a}$ | $18.19 \pm 0.43^{a}$ |
| | 15.0 | $51.07 \pm 19.78^{a}$ | $11.14 \pm 7.75^{a}$ | $26.58 \pm 10.01^{a}$ | $67.60 \pm 0.33^{d}$ | $0.75 \pm 0.11^{b}$ | $17.93 \pm 0.51^{b}$ |
| | 22.5 | $51.09 \pm 13.70^{a}$ | $13.17 \pm 5.61^{a}$ | $29.80 \pm 2.38^{a}$ | $67.12 \pm 0.16^{e}$ | $0.57 \pm 0.03^{d}$ | $16.72 \pm 0.19^{d}$ |
| | 30.0 | $57.36 \pm 14.07^{a}$ | $11.64 \pm 5.83^{a}$ | $30.91 \pm 2.91^{a}$ | $69.11 \pm 0.11^{b}$ | $0.58 \pm 0.05^{c}$ | $17.04 \pm 0.26^{c}$ |

a-e = Means ± SD within the same column with different lowercase superscript letters are significantly different ($P \leq 0.05$).

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