# Effect of Substitution of Wheat Flour with Germinated Brown Rice Flour on Physicochemical and Sensory Qualities in Cracker Products

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## Abstract

This research focused on the cracker produced from germinated brown rice flour by studying the volume of germinated brown rice flour applied in the formula at the level of 0%, 20%, 25%, and 30% of the weight of wheat flour. It was found that the formula suitable for the production of cracker from germinated brown rice flour consists of germinated brown rice flour (12.76%), wheat flour (38.27%), salt (0.61%), sugar (5.10%), shortening (10.20%), butter (10.20%), water (22.45%), and baking powder (0.41%). The germinated brown rice grains soaked in the water for 72 hours could yield the GABA at 1.89 mg/100 g, the highest volume of reducing sugar of 505.0 mg of glucose per 100 g of sample, and the lowest viscosity. The most suitable formula accepted by the panelist was the mixture between the germinated brown rice flour and wheat flour at the ratio of 25:75 which yielded the highest score. The sensory evaluation revealed that the cracker produced from germinated brown rice yielded a moderate liking score. The physicochemical characteristic of such cracker indicated the L*, a*, and b* of 62.62, 8.57, and 30.16 respectively where the $a_w$ value of 0.142, moisture of 7.95%, fat of 26.48%, protein of 1.07%, ash of 1.09%, reducing sugar of 287.2 mg/100 g, and GABA of 1.04 mg/100 g were obtained.

**Keyword:** Germinated brown rice, Wheat flour, Cracker-Type Snack

## 1. Introduction

Rice is the main food of most peoples, particularly, in China, India, Japan, Indonesia, Bangladesh, and Thailand as well as the peoples in other Asian countries. Currently, brown rice is more preferred than white rice because it is preliminarily milled, its husk is peeled off for 2-3 times, and its germ and bran, the sources of Vitamin E and B, remain. They consist of the fibers helping the excretion system to avoid constipation, fat, and sugar combustion. The vitamins are

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Received: 11 พ.ค. 64; Revised: 10 ก.ค. 64; Accepted: 14 ก.ย. 64

capable of resisting oxidation which is the cause of cancer (Vipa, 2007). The brown rice has more strength than white rice causing the consumption issue, that is why the brown rice is often soaked in water for 2-3 days to cause the softness and the root of rice will begin germinating, the product obtained called germinated brown rice (Jeon et. al, 2003).

Germinated brown rice is derived from soaking the brown rice in water at the proper temperature to gain nutritional value. The brown rice grain consists of Gamma-Aminobutyric Acid (GABA) beneficial for health, namely, it acts as a neurotransmitter preventing headache, controlling the functions of kidneys and brain, and reducing blood pressure (Zeng et. al, 2002; Okada et.al., 2000). Additionally, brown rice consists of nutrients, e.g., Vitamin B1, phosphorus, niacin. Brown rice has been applied as the raw materials for several products, i.e., tea, ready-to-consume rice, soup, and bread made from germinated brown rice (Ohtsubo et. al, 2005). One way of value-added concept for germinated brown rice is production of snacks from germinated brown rice flour to increase nutritional quality before selling.

Nowadays, Thais are alert to seek the correct knowledge and practices concerning foods and nutrition more. A course capable of gaining the economic value of rice and satisfying the nutritional market is the production of snacks from germinated brown rice flour, e.g., cracker. This type of snack is greatly popular in the present time mainly consisting of wheat flour. Therefore, the concept of substituting the wheat flour with germinated brown rice flour for cracker production to increase the value and nutrition emerged.

## 2. Method

### 2.1 Preparation of raw materials and germinated brown rice flour

3 durations of rice grain soaking were studies by using dry white jasmine 105 brown rice grains as a control. The preparation was performed by the quality check of 1000 grams White Jasmine 105 brown rice grains in the areas of purity (%) and germination (%). The White Jasmine 105 brown rice grains were cultivated under the CRD trial. The factors studied were 3 durations of rice grain soaking, i.e., 24, 48, and 72 hours at the control temperature of 35°C, and the control sample was dry White Jasmine 105 brown rice grains, a total of 4 samples.

### 2.2 Study the effect of duration on quality of germinated brown rice and its flour product

The cultivation method was modified from the method of Liu et. al (2005). All the White Jasmine 105 brown rice grains were cleaned and soaked in Peroxy Acetic Acid at the concentration of 1000 ppm for 15 minutes to reduce the microbes which may contaminate the

grains. Then, the grains were soaked in clean water at the ratio of 1:5 (w/v) and stored in the incubator at 35°C for 24, 48, and 72 hours, respectively where the water was replaced every 6 hours. achieving the duration defined, the grains were filtered, drained, and dehydrated at 55°C in the incubator for 10 hours. The grains were packed in the nylon bag using a vacuum sealing machine. The germinated grains were sampled for physical analysis: the length of sprout and germination, chemical quality and moisture. The processed grains were milled by centrifugal miller through mesh no. 100, kept in the vacuum-sealed nylon bag. White Jasmine 105 germinated brown rice flour was introduced to quality check.

**2.2.1 Physical analysis**

The study in the viscosity of germinated brown rice flour was conducted through the Rapid Visco Analyzer (RVA) using the germinated brown rice solution at the concentration of 10% (w/v). The RVA software was employed to assess the samples at the different temperatures for 13 minutes with the variance not exceeding 1°C and the initial heat of 50°C which were increased to 95°C at the rate of 12°C/min. The sample was stored at 95°C for 2.5 minutes and such temperature was reduced to 50°C at the rate of 13°C/min to store the samples for 2 minutes. The operation was ceased at 13 minutes, the speed of the motor of 960 rpm for the first 10 seconds, which was reduced and remained at 160 rpm. The result was analyzed by the software Thermocline for Windows.

**2.2.2 Chemical qualities**

The analyses were done as follows:

(1) Chemical compositions, i.e., moisture and protein according to the A.O.A.C (2000) method

(2) Reducing sugar by using Somogyi (1944) and Nelson method (1952)

(3) Gamma-Aminobutyric Acid (GABA)

**2.3 Study in the germinated brown rice flour suitable for cracker production**

The cracker production was performed by using the flour produced above where the processes were modified from the cracker production processes of Sinsalee Snack and Biscuit Limited Partnership. The suitable amount of germinated brown rice flour for cracker production was studied by applying in stead of wheat flour with different ratio in the formula as indicated in Table 1.

**Table 1** Comparison between the amount of wheat flour and germinated brown rice flour for the substitution in cracker production

| Ingredients | Standard formula (0 %) | Formula 1 (20%) | Formula 2 (25 %) | Formula 3 (30 %) |
|---|---|---|---|---|
| germinated brown rice flour | 00.00 | 10.20 | 12.76 | 15.31 |
| wheat flour | 51.02 | 40.83 | 38.27 | 35.72 |
| salt | 0.61 | 0.61 | 0.61 | 0.61 |
| sugar | 5.10 | 5.10 | 5.10 | 5.10 |
| shortening | 10.20 | 10.20 | 10.20 | 10.20 |
| butter | 10.20 | 10.20 | 10.20 | 10.20 |
| water | 22.45 | 22.45 | 22.45 | 22.45 |
| baking powder | 0.41 | 0.41 | 0.41 | 0.41 |

The sensory quality of the cracker using germinated brown rice flour instead of wheat flour was tested by 10 untrained panelist. The qualities of color, smell, the layer of flour, texture, and collective preference were tested through the 9-Point Hedonic Scale to select the best formula for cracker production. The test was conducted within the area of the Rajamangala University of Technology Tawan-ok by employing 100 panelist to complete a questionnaire. Upon such achievement, the physicochemical qualities of the cracker produced from germinated brown rice flour were physically analyzed in the areas of color, crispness, and $a_w$ values, where the chemical qualities were analyzed as moisture, fat, protein, ash, and GABA volumes.

The consumer product acceptance towards the cracker production using from germinated brown rice flour was studied through 25 trained consumers where the scoring was done through 9-Point Hedonic Scale focusing on the level of such acceptance in the areas of appearance, color, smell, flavor, sweetness, texture (Crispness), and collective preference.

## 3. Results and Discussion

### 3.1 Raw material quality

#### 3.1.1 brown rice grain quality check

The qualities of white jasmine 105 brown rice grain are indicated in table 2. The grains' purity and moisture were in line with the standard and similarly ranked. The brown rice grain standard (National Bureau of Agricultural Commodity and Food Standards, 2003) indicates that the least purity and germination of rice grain are 98 and 80 respectively where the moisture is not above 14% which depend on the loss of rice due to harvest and post-harvest treatment as well as the environment, e.g., air temperature and relative moisture. The rice quality will be deteriorated by high temperature and moisture and the day-to-day temperature changes also affect the deterioration of rice grains (Juangjun, 1986).

### 3.2 Effect of duration on quality of germinated brown rice and its flour

#### 3.2.1 Physical quality of germinated brown rice flour

According to the study in the viscosity of germinated brown rice flour by RVA appearing in Table 2, it was found that the said changes of viscosity depended on the duration of water soaking where the peak viscosity and setback were from trough values reduced by such duration. The maximum viscosity and minimum setback from trough values 23.21 RVU, and 17.08 RVU, respectively, when soaked in the water for 72 hours. after comparing with the flour made from the dry germinated brown rice and the flour made from the germinated brown rice grains soaked in the water for 24 and 48 hours. The reduction of viscosity may result from the great increase of amylase, particularly on alpha-amylase enzyme which would digest amylose and amylopectin into dextrin and monosaccharide for the growth of the embryo and this leads to the lower viscosity of germinated paddy flour than the non-germinated paddy flour (Pathirana et.al, 1983). Therefore, increasing soaking led to reduction in viscosity of flour.

In consideration of setback from trough value relating to product texture (Newport Scientific, 1995), the more or positive setback from trough value the better retrogradation and it tends to yield the flour with great strength (Beta and Corke, 2001). The results indicated that the maximum setback from trough value of flour, 73.42 RVU, was found in the 24-hour cultivated rice flour and the minimum value, 17.08 RVU, was found in the 72-hour cultivated rice flour. The setback from trough values of the normal germinated brown rice flour was 100.42 RVU but the flour from the cultivated germinated brown rice grains for 24, 48, and 72 hours yielded the value of 73.42, 66.50, and 17.08 RVU respectively. As the setback from trough relates to the

retrogradation, the process of re-organization of the molecule, such value thereby relates to the final texture of products (Halick et. al, 1959). For the gelation of cooked flour, if the temperature is reduced and the duration is prolonged, such structure will be formed and the free molecule of water will be pushed out of the gel (syneresis) which will be turbid and white. The cooked flour fails to preserve the viscosity us such conditions and this refers to low retrogradation (Rahman, 2006). The results indicated that the minimum setback from trough value was yielded from the flour made from 72-hour soaked grains, this meant the long duration of soaking led to the reduced retrogradation rate of the cooked flour which may be consistent with the principle that the flour digested by alpha-amylase enzyme results in its shorter molecule then the retrogradation rate is also reduced.

For the final viscosity, the parameter indicating the quality and the characteristics of flour and products whether mucilage or gel after passing heat and cooling (Newport Scientific, 1995). The final viscosity will emerge upon cooling the gelatinized. Amylose will form its new 3D structure with higher viscosity or gelation (Rahman, 2006) because the heated and cooled flour gel causes the re-organization of the adjacent amylose with hydrogen bond resulting in the higher viscosity the low-amylose rice becomes the soft gel and the high-amylose rice forms the strong gel having harder texture (Hamad and Field, 1979). The final viscosities of the cooled flours made from the brown rice grains soaked in the water for 24, 48, and 72 were 236.72, 154.38, and 28.63 RVU respectively. Since the final viscosity of such flours was higher than the minimum viscosity, the flour made from germinated rice, after being heated and cooled, would be gelatinized (Beta et.al, 2001).The duration of soaking of brown rice affected the characteristics of flour gel where the hardest gel was yielded from the flour made from the brown rice grain soaked for 24 hours (236.72 RVU) and the softest gel was yielded from the flour made from the brown rice grain soaked for 72 hours (28.63 RVU).

In term of pasting temperature, or the temperature at which the heated flour granules will swell rapidly and its viscosity is increased, it was found that the flour made from dry brown rice grains yielded the pasting temperature of 74°C but after considering the grains soaked in the water for 24, 48, and 72 hours, it was revealed that the duration of soaking yielded no statistically significant effect on the change of pasting temperature ($p>0.05$) and the flour made therefrom yielded the pasting temperatures ranging from 73.18 °C.

**Table 2** Quality of the change of viscosity of the flours made from germinated brown rice grains soaked in the water in various durations.

| Duration of Soaking (Hours) | Pasting Temperature ($^{o}$C) | Result of Viscosity Analysis (RVA) | | | | |
|---|---|---|---|---|---|---|
| | | Max. Viscosity | Min. Viscosity | Difference between Max. and Min. Viscosity | Final Viscosity | Setback from Trough Value |
| 0 | 74.00 | 255.46 | 157.09 | 98.35 | 257.50 | 100.4 |
| 24 | 73.36 | 207.22 | 138.83 | 69.36 | 236.72 | 73.42 |
| 48 | 73.18 | 130.00 | 87.88 | 42.13 | 154.38 | 66.50 |
| 72 | 74.05 | 23.21 | 11.55 | 11.67 | 28.63 | 17.08 |

**3.2.2 Chemical qualities of germinated brown rice flour**

Upon the chemical quality analysis was accomplished, it was found that the reducing sugar of the non-germinated brown rice was 264.5 mg of glucose per 100 g of sample. After soaking the brown rice grains in the water until they germinated, the increasing of reducing sugar was varied according to the duration of soaking. The flour made from 72-hour water-soaked brown rice grains yielded reducing sugar of 505.0 mg of glucose per 100 g of sample which was significantly higher than the same yielded from 24-hour and 48-hour water-soaked brown rice grains (31.8 and 354.7 mg of glucose per 100 g of sample, respectively) and from the control sample ($p<0.05$) as indicated in Table 3, where the volume of reducing sugar was increased for 1.9-fold compared with the control sample and this was consistent with the research of Thongplio (1989) who found that the germinated rice yielded lower starch bur higher reducing sugar. Additionally, Nirmala et.al (2000) discovered that the volume of reducing sugar in the germinated rice was increased from 1.44% to 8.36% of non-germinated rices. This is because while the rice is germinating, the grain synthesizes the above mentioned alpha-amylase which increases the volume of sugar. Moreover, the results were also consistent with the reduction of viscosity upon the increase of duration of soaking.

Upon considering the moisture and volume of protein of the germinated brown rice soaked in the water for 0-72 hours as exhibited in Table 3, the moisture of the germinated rice flour ranged from 9.42 -10.45% where the standard dry weight thereof should not exceed 14%.

The water-soaked germinated brown rice grains yielded statistically indifferent volumes of protein ($p<0.05$) with an average of 8.01% where their dry weights were significantly higher than the dry brown rice grains' (7.81%) ($p<0.05$). Such increase resulted from the degradation of protein accumulated in the seeds' structures and the new syntheses of protein in other parts of the seeds occur for growing to be the root and trunk. Such protein degradation arises from protease enzyme generated during the germination which degrades protein to be amino acid adopted in protein re-synthesis (Wanchai, 2010). This was consistent with the works of Hamad and Field (1979) who studied the volume of lysine in the germinated rice and reported that the lysine in the germinated rice significantly increased compared with ordinary rice.

The results indicated that the longer duration of water soaking, the significantly higher volume of GABA ($p<0.05$) as exhibited in Table 3 because the Glutamic Acid Decarboxylase (GAD), the enzyme controlling the GABA synthesis. The volumes of GABA obtained from the flours made from water-soaked brown rice grains for 24, 48, and 72 hours were 0.92, 1.15, and 1.82 mg of glucose per 100 g of sample, respectively which were similar to the volumes obtained from H. Scabra rice (Morakot et. al, 2017) and increased for 3, 6, and 8 folds respectively compared with the GABA of the flour made from non-germinated brown rice grains (0.21 mg of glucose per 100 g of sample) which was consistent with the report of Oh et. al. (2003) who studied the changes of GABA volumes in the germinated brown rice grains and found that the accumulated GABA increased by the duration of water soaking where the volume of GABA from the water-soaked germinated brown rice was 5-fold higher than the dry ones (150 mg of glucose per 100 g of sample).

**Table 3** Volume (dry weight) of moisture, reducing sugar, protein, and GABA of the germinated brown rice flour made from the grains soaked in water in different durations

| Duration of Water Soaking (Hours) | Moisture (%) | Reducing Sugar (mg of glucose per 100 g of sample) | Protein (%) | GABA (mg per 100 g of sample) |
|---|---|---|---|---|
| 0 | $12.09^{a}$ (0.25) | $264.5^{d}$ (0.43) | $7.81^{b}$ (0.01) | $0.21^{c}$ (0.01) |
| 24 | $9.49^{c}$ (0.13) | $311.8^{c}$ (0.51) | $8.01^{a}$ (0.01) | $0.92^{b}$ (0.01) |
| 48 | $9.42^{c}$ (0.26) | $354.7^{b}$ (0.36) | $8.02^{a}$ (0.05) | $1.15^{a}$ (0.03) |
| 72 | $10.45^{b}$ (0.35) | $505.0^{a}$ (0.48) | $8.01^{a}$ (0.01) | $1.82^{a}$ (0.03) |

Note: (a-d) The average values of each set of column data marked with different letters refer to the statistical difference ($p<0.05$) and the quoted number refers to the respective standard deviation of the data.

**3.3 Results of study in the volume of germinated brown rice flour suitable for cracker production**

To obtain the results of the consumer acceptance towards the cracker produced from germinated brown rice flour, the panelist tasted the product and provided their liking score under the 9-Point Hedonic Scale type and the data was analyzed by SPSS. It was discovered that the maximum score of preference was placed at the cracker produced from substituting the wheat flour with the germinated brown rice flour at the rate of 25%.

According to the results of physicochemical quality analysis of the cracker produced from the germinated brown rice flour indicated in Table 4, the L*, a*, and b* of the cracker indicating its luminance, redness, and yellowness were 62.62, 8.57, and 30.16, respectively, which meant the cracker yielded high luminance, low redness, and quite high yellowness where its crispness was 17.34 N and $a_w$ was 0.41.

**Table 4** The qualities of physicochemical compositions of the cracker produced

| L* | a* | b* | Crispness (N) | $a_w$ | Moisture content (%) | Fat (%) | Protein (%) | Ash (%) | GABA (mg) |
|---|---|---|---|---|---|---|---|---|---|
| 62.62 (2.48) | 8.57 (1.11) | 30.16 (0.53) | 17.34 | 0.41 | 7.95 | 26.48 | 1.07 | 1.09 | 1.04 |

The qualities of chemical compositions of the cracker produced from germinated brown rice flour were as follows: moisture of 7.95%, fat of 26.48%, protein of 1.07%, ash of 1.09%, and GABA of 1.04 mg of glucose per 100 g of cracker. The formula for cracker production employed the germinated brown rice flour of 25% yielded a higher volume of GABA than the bread made from the germinated brown rice flour having the GABA volume of 0.92 but lower than the extruded germinated brown rice flour of 25% having the GABA volume of 1.89 mg of glucose per 100 g of the bread (Ohtsubo et. al, 2005). The volumes of GABA in the germinated

brown rice flour of 25% was not significantly different from the same found in the bread made from the germinated brown rice flour and extruded germinated brown rice flour of 25%.

The consumer acceptance test was conducted by performing the test to study the consumer acceptance in the product developed. The cracker produced from the germinated brown rice flour was tested with 25 trained consumers who scored their preference using the 9-Point Hedonic Scaling method to study the level of acceptance in the areas of appearance, color, smell, flavor, sweetness, texture (crispness), and collective preference. The results were exhibited in Table 5 where the qualities were ranged from less to moderate preference.

**Table 5** Consumers' average sensory liking score towards the cracker

| Qualities | Liking score |
|---|---|
| appearance | 6.3 (0.9) |
| color | 6.6 (1.1) |
| smell | 7.1 (1.1) |
| flavor | 7.4 (0.9) |
| sweetness | 6.8 (1.2) |
| texture (crispness) | 6.5 (1.0) |
| collective preference | 7.4 (1.2) |

Note: The quoted numbers are the respective standard deviations of the data.

## 4. Conclusion

According to the results of the effect of the germination period of the germinated brown rice grains in the water for 24, 48, and 72 hours on the quality of germinated brown rice, it was discovered that increasing soaking duration resulted in water absorption of the grains to extent of their larger size and more sprout germinated including the increased volume of GABA and reducing sugar but lower maximum viscosity. The germinated brown rice grain soaked in water for 72 hours obtained the GABA content of 1.89 mg per 100 g and the maximum reducing sugar of 505.0 mg of glucose per 100 g of sample where the water soaking duration of 72 hours led to the minimum viscosity.

The most suitable formula accepted by the panelist was the mixture between germinated brown rice flour and wheat flour at the ratio of 25:75 because this formula obtained the maximum liking score. The results of the sensory quality assessment indicated that the

cracker produced from the germinated brown rice flour obtained moderate scores of collective preferences (7.4) and texture (crispness) (6.5). The panelist accepted the cracker produced from the germinated brown rice flour. The physicochemical characteristic of the cracker indicated the L*, a*, and b* of 62.62, 8.57, and 30.16, respectively where the $a_w$ value of 0.142, moisture of 7.95%, fat of 26.48%, protein of 1.07%, ash of 1.09%, reducing sugar of 287.2 mg/100 g, and GABA of 1.04 mg/100 g were obtained.

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