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Product development of black glutinous rice cracker with Panang flavor and its quality changes

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Abstract

The aim of this research is to develop a nutritious snack that is suitable for health and acceptable for adolescents and adults. This product consists of 26% black glutinous rice flour, 13% white glutinous rice flour, 50% coconut milk, 4.5% shallots, 2% garlic, 1.5% shrimp paste, 0.75% salt, 0.25% pepper and 0.5% of each galangal, bergamot peel, coriander roots and lemon grass. The black glutinous rice crackers were produced by grounding all spices together and then mixing with flours and coconut milk. This mixed is poured into trays and steamed for 20 min after that flattened to thin sheet and reduced temperature to 4-6°C. Cut the sheet with mold and put into an oven at 150-155°C for 16 min. The mean score of overall liking and consumer acceptability were 7.2±1.2 and 84.5%, respectively. The physical quality of the product was found that lightness was 34.1±2.6, redness was 7.3±1.0, yellowness was 5.3±1.0, hardness was 301.24±40.77 g.force and water activity was 0.41±0.01. The moisture, carbohydrates, fat, protein, and ash were 3.83±0.04%, 61.62±0.94%, 14.98±0.37%, 16.51±0.44% and 3.07±0.10%, respectively. Anthocyanin content and energy were 28.24±0.08 mg/kg and 4.69±0.45 kcal/g, respectively. The microbiological quality of the product was found that total plate count was <10 cfu/g, yeast and mold was <10 cfu/g, coliform bacteria was <3 MPN/g and *E. coli* was <3 MPN/g. The shelf life of the black glutinous rice cracker with Panang flavor was at least 3 months.

Introduction

Generally, wheat flour is a major ingredient of almost all snacks. Many people are suffering from gluten intolerance, and so the development of gluten-free snacks that exploit the anti-allergenic and health-enhancing properties is interesting (Han *et al*., 2010). Thai commercial snacks, such as puffed snacks, potato chips, dried squid, popcorn, fish snacks, nuts and prawn crackers are gluten-free and commonly consumed. Some of these snacks contain elements, such as certain nutrients or vitamins, that are beneficial for health. However, several of them are harmful to health, as they have high fat, oil, salt or sugar content, which can cause dental caries, obesity or diabetes. Moreover, several consumers tend to have snacks as main dishes which could cause malnutrition or obesity. Wangcharoen *et al.* (2005) surveyed consumer behavior with regard to the seven kinds of snacks mentioned above. They found that a large amount of consumers purchased snacks because of their taste and factors influent by advertising. Therefore, it can be showed that purchasing of snacks in Thailand does not consider to nutrient.

Generally, the main ingredient of Thai snacks is flour, such as white rice flour, white glutinous rice flour and black glutinous rice flour. Black glutinous rice flour, which largely used as an ingredient in desserts and snacks, is produced with black glutinous rice (*Oryza sativa* L.) (Tananuwong and Tewaruth, 2010). The color of black glutinous rice is caused by anthocyanins, which are a group of reddish purple water soluble flavonoids (Shen *et al.*, 2009) and located on pericarp, seed coat and aleurone layer (Sompong *et al.*, 2011). Anthocyanins are the main antioxidants in black glutinous rice, and they are composed of anthocyanidin and sugar. Four main anthocyanidins in black rice are malvidin, pelargonidin-3,5 glucoside, cyaniding-3- gluconside and cyaniding-3,5-diglucoside (Zhang *et al.*, 2006). Cyaniding-3-glucoside and pelargonidin-3- glucoside showed aldose reductase inhibitory activities, and therefore, they would be beneficial for the prevention of diabetes (Yodmanee, 2011). Moreover, antioxidants in pigmented rice are able to reduce atherosclerotic plague formation, and some metabolic abnormalities associated with high fructose (Tananuwong and Tewaruth, 2010).

Due to the large consumption of snacks in Thailand as mentioned by Wangcharoen (2005), the production of nutritious and tasty snacks could be beneficial for several wellbeing of Thai people. The objectives of this work, therefore, are to develop nutritious and delicious snack by adding a favorite

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Thai flavor, Panang, and investigate the quality changes.

Materials and Methods

Preparation of rice cracker with Panang flavor

Prototype: Preparation of rice cracker followed the method of Guraya and Toledo (1994) with some modifications. A 34 g amount of black glutinous rice flour (13.25%) and 66 g of white glutinous rice flour (25.73%) were poured into 125 g of coconut milk (48.73%). Panang paste was prepared by mincing (Model MX-795N, National, Malaysia) 4.59 g of chili powder (1.79%), 11.23 g of shallots (4.38%), 5.02 g of garlic (1.96%), 1.09 g of galangal (0.42%), 1.30 g of bergamot peel (0.51%), 1.28 g of coriander root (0.50%), 1.3 g of lemon glass (0.51%), 0.56 g of black pepper (0.22%), 1.88 g of salt (0.73%) and 3.26 g of shrimp paste (1.27%), and then mixed with the rice flour and coconut milk paste. The mixture was poured into a 20x28 cm^2 tray and steamed for 20 min. The dough was kneaded by hand for 10 min, then flattened into a 2 mm thick sheet. The sheet was kept in the refrigerator until its temperature was 6-10^oC. Next, the sheet was cut with the diameter of a 2.8 cm cylinder mold and heated at 150-155^oC. The investigation of moisture and water activity (aw) was conducted in two-minute intervals in order to determine the optimum time to produce rice cracker.

Product development

Completely randomized design (CRD) was used to find the optimum amount of chili powder in Panang paste. The factor was varied at 3 levels as 0, 1 and 2 g. The process of preparing rice cracker was the same as that for the prototype with a heating time of 16 min.

Physical analysis

Hardness analysis was performed by the Texture Analyzer, TA-XT2i model (Stable Micro Systems, UK). This analytical method was adapted from that of Keeratipibul *et al*. (2008). An aluminium cylinder 2 mm in diameter probe (P/2) was used. Pre-test, test and post-test speeds were set at 1, 1 and 10 m/s, respectively. The hardness was determined by the maximum force in grams force. Each sample was analyzed in five replicates. The color of the product was determined using a colorimeter (Minolta, CR-10, Japan). Each sample was measured in five replicates. Water activity was measured using awQuick (Rotronic Instrument, Switzerland).

Sensory evaluation

For prototype product, sensory evaluation was determined using a 9-point hedonic scale together with a 5-point 'just about right' scale. The hedonic scale ranged from 1, representing 'extremely dislike', to 9, representing 'extremely like'. The 'just about right' scale ranged from 'decrease very much' to 'increase very much'. Product was evaluated by 30 panelists in the characteristics of color, size, crispiness, Panang-flavor, saltiness, spiciness and overall liking. For product development, the 9-point hedonic scale was used with 30 panelists for the same sensory characteristics mentioned above. Samples were served in randomized order in a zip pack and coded with three random digits.

Chemical analysis

AOAC (2010) was used to determine moisture (950.46), ash (923.03), protein (991.20) fat (948.15) and carbohydrate (by difference). Anthocyanin content was determined using pH differential method (AOAC, 2006; 2005.02).

Microbiological study

Total plate count and yeast and mold count were determined using FDA BAM online 2001. Coliform bacteria and *Escherichia coli* were determined using FDA BAM online 2002.

Storage study

Rice cracker was kept in plastic laminated with foil bag at ambient temperature. Water activity, hardness, color, and sensory evaluation were investigated every 2 weeks for 3 months.

Statistical analysis

Means and standard deviations of experiment were calculated. ANOVA and LSD were performed at < 0.05.

Result and Discussion

Optimum heating time for rice cracker

The study of optimum heating time was carried out at 150-155^oC and sampling was conducted every 2 min. It was found that moisture content and water activity decreased with time (Figure 1). Generally, if water activity is less than 0.6, microorganisms cannot grow and some chemical reactions will be reduced. At 14 min, the moisture content was 5.07% and water activity was 0.59. However, this water activity was near the border line, hence heating time was set at 16 min resulting in water activity of 0.31 ± 0.01.

Sensory evaluation

The sensory evaluation of the prototype by 30 panelists is shown in Table 1. The preference of color,

Table 1. Sensory evaluation of black glutinous rice cracker as prototype using 9-point hedonic scale and 5-point just about right scale (n=30)

Attribute	Mean±SD	Very much decrease	Slightly decrease	Just about right	Slightly increase	Very much increase	Net effect*
Color	5.5 ± 1.9	12.5	30.0	50.0	7.5	0.0	-35.0
Size	6.2 ± 1.4	0.0	0.0	45.0	42.5	12.5	55.0
Crispiness	6.5 ± 1.9	2.5	15.0	72.5	10.0	0.0	7.5
Panang flavor	5.1 ± 2.3	15.0	25.0	45.0	12.5	2.5	-25.0
Saltiness	5.2 ± 2.2	2.6	15.4	48.7	25.6	7.7	15.3
Spiciness	3.5 ± 2.4	37.5	37.5	22.5	2.5	0.0	-72.5
Overall liking	5.0 ± 1.8	-	-	-	-	-	-

Net-effect: (Slightly increase + Very much increase) - (Slightly decrease + Very much decrease)

Table 2. Sensory evaluation of black glutinous rice cracker varying amount of chili by 9-point hedonic scale (n=30)

Attribute	Amount of chili (g)		
	0	1	2
Color ^{ns}	5.6 ± 2.0	5.7 ± 1.9	5.7 ± 1.9
Size ^{ns}	6.2 ± 1.5	6.0 ± 1.4	6.1 ± 1.5
Crispiness ^{ns}	6.9 ± 1.6	6.9 ± 1.5	6.8 ± 1.5
Panang flavor ^{ns}	6.0 ± 1.5	5.6 ± 1.7	5.5 ± 2.0
Saltiness ^{ns}	6.2 ± 1.5	6.0 ± 1.6	6.2 ± 1.7
Spiciness	6.0 ± 1.5^{a}	4.9 ± 2.2^{b}	4.5 ± 2.5^{b}
Overall liking	6.4 ± 1.2^{a}	5.8 ± 1.5^{ab}	5.6 ± 1.6^{b}

Value are mean ± SD

Mean value in the same row with different letter are significantly different ($p < 0.05$)

ns in the same row represents no significantly different ($p > 0.05$)

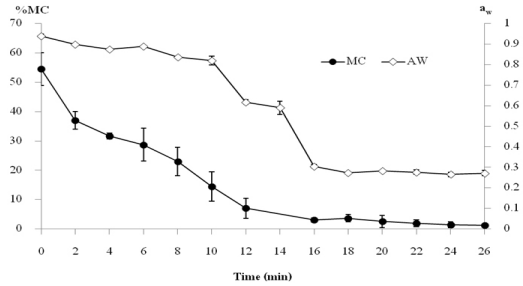

Figure 1. Relationship of moisture content, water activity and drying time (150-155°C)

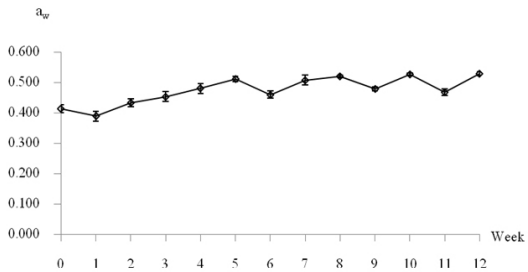

Figure 2. Water activity of black glutinous rice cracker during storage

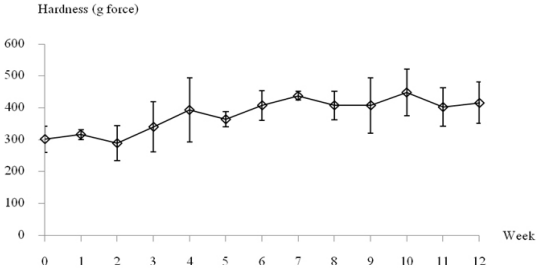

Figure 3. Hardness of black glutinous rice cracker during storage

size, crispiness and Panang flavor were in range of 'neither like nor dislike' to 'slightly like' (5.0-6.5), while spiciness ranged from 'slightly dislike' 'to moderately dislike' (3.5). This information can be combined with the results of the 'Just about right' scale to determine the direction of improvement. The

Table 3. Chemical composition, anthocyanin content and energy of black glutinous rice cracker

Composition	Mean ± SD
Carbohydrate (%wb)	61.62 ± 0.94
Protein (%wb)	16.51 ± 0.44
Fat (%wb)	14.98 ± 0.37
Moisture (%wb)	3.83 ± 0.04
Ash (%wb)	3.07 ± 0.10
Anthocyanin (mg/kg)	28.24 ± 0.08
Energy (kcal/g)	4.69 ± 0.45

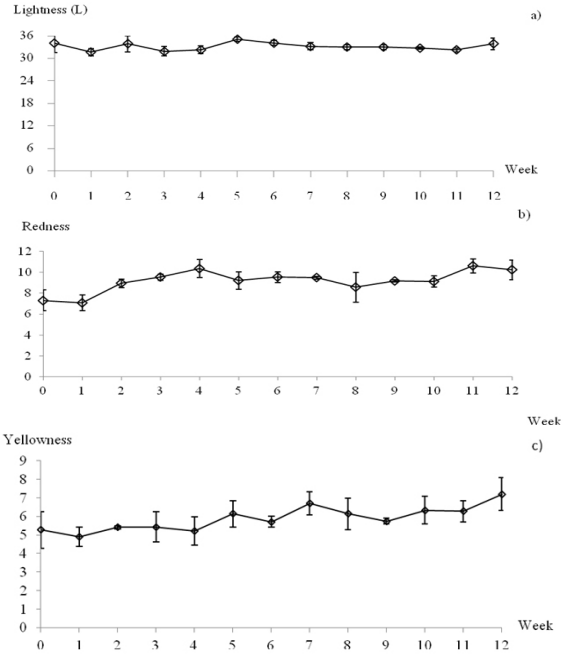

Figure 4. Color of black glutinous rice cracker during storage; a) lightness, b) redness and c) yellowness

criteria of 'just about right' was set at 70%, therefore, crispiness of rice cracker was just about right (72%). However; the optimum score of the other sensory attributes was less than 70%, hence net-effect should be considerable in the next order where net-effect represents direction of improvement. A negative value of net-effect should lead to a reduction in the intensity of the specific attribute, while a positive value should lead to increasing the intensity of that attribute (Prinyawiwatkut, 2010). Generally, the criterion of net-effect is set at less than -20 or higher than 20. Thus, size should be larger and color should be less intense. However; most panelists agreed that the rice cracker was too spicy. Consequently, the amount of chili was varied and the result is shown in Table 2. No significant difference in color, size, crispiness, Panang flavor and saltiness were found among each other ($p > 0.05$). On the other hand, spiciness and overall liking were significantly different with a lesser amount of chili corresponding to a higher preference score. Hence, the finished product of black glutinous rice cracker had no chili powder added to it. The confirmation of this formula with 50 panelists was showed that the mean score of overall liking and consumer acceptability were 7.2±1.2 and 84.5%, respectively.

Table 4. Sensory changing and acceptability during storage

Attribute	0	1	2	3	4	5	6	7	8	9	10	11	12
Color	7.7± 1.0	7.7± 1.0	7.9± 0.9	7.4± 0.8	7.9± 0.8	7.5± 0.7	7.5± 0.7	7.2± 1.2	8.0± 0.0	7.5± 0.7	7.3± 0.5	7.5± 0.8	7.5± 0.8
Size	7.5± 1.1	7.4± 1.2	7.9± 0.9	8.1± 0.6	7.3± 1.3	7.7± 0.7	7.5± 0.7	7.9± 0.8	7.5± 0.7	7.0± 0.0	7.3± 0.5	7.8± 0.9	7.3± 0.8
Crispiness	7.9± 1.0	7.9± 0.9	7.7± 1.0	7.3± 1.1	7.0± 0.7	7.2± 0.9	7.3± 0.8	7.2± 0.8	7.0± 0.0	7.0± 0.0	6.9± 0.9	6.9± 1.2	6.9± 0.9
Panang flavor	7.8± 0.9	7.9± 0.7	8.2± 0.7	7.8± 0.9	7.4± 1.1	7.1± 1.2	7.0± 0.9	7.1± 0.7	7.5± 0.7	6.5± 0.7	6.8± 0.7	6.8± 0.9	6.9± 1.2
Taste	7.7± 0.8	7.8± 0.7	7.9± 0.69	7.9± 0.9	7.5± 0.9	7.1± 1.2	7.1± 0.6	7.4± 0.5	7.0± 0.0	6.5± 0.7	6.6± 1.0	6.9± 1.1	6.8± 1.0
Overall liking	7.9± 0.7	7.6± 0.5	7.99± 0.7	7.9± 0.8	7.5± 0.9	7.3± 0.8	7.2± 0.7	7.4± 0.5	7.0± 0.0	6.5± 0.7	6.7± 1.1	7.0± 0.9	7.0± 1.0
%Acceptable	100	100	100	100	100	100	100	100	100	93.33	93.33	93.33	93.33

Physical analysis of black glutinous rice cracker

Black glutinous rice cracker was made from its flour which was ground without remove outer layer (pericarp) of grain. Hence, the color of product was dark purple-red color represented of anthocyanin located in pericarp. The parameter of lightness, redness and yellowness were 34.13 ± 1.23, 9.00 ± 0.98 and 5.43 ± 0.82, respectively. Hardness was determined by measure force in compression and the result showed not much value (301.24 g.force). This result accorded to crispy of product by sensory evaluation. Panelists preferred product because it is brittle represented by hedonic score. Water activity was 0.41 and it was not higher than criteria (0.6).

Chemical composition and anthocyanin content

The major component of black glutinous rice cracker was carbohydrate (Table 3) since the main ingredient was flour. Protein content of cracker was appreciably high (16.51%wb). According to the study of Sompong *et al.* (2011), black rice varieties from Thailand had higher protein content than those from China and Sri Lanka. Lipid content was mostly from coconut milk. Ash content of product was higher than black glutinous rice flour studied by Sompong *et al.* (2011) resulted by Panang paste component such as galangal, bergamot peel, coriander root and lemon glass added. Anthocyanin content in cracker (28.24 mg/kg) was less than black glutinous rice reported by Satharut and Sudarat (2012) as 103.45 mg/100 g since white glutinous rice flour was added as ingredient. Moreover, Kong and Lee (2010) who studied milling fraction of black rice found that whole grain, endosperm and rice bran had different amount of anthocyanin. Therefore, commercial black glutinous rice flour used in this experiment might be having less anthocyanin content.

Microorganism analysis

The total plate count and yeast and mold count of this product were less than 10 CFU/g. The MPN of coliform bacteria was less than 3 per gram as same as *E. coli.* Thus, it could be implied that the product was safe to consume.

Qualities changing during storage

The qualities changing of cracker were investigated of aw, hardness, color and sensory evaluation for twelve weeks. At first date of storage, aw was 0.41 and trended to increase slightly (Figure 2) until three months. Water activity range was 0.39-0.53 and it was in scope which was set as 0.55. Hardness of cracker at initial week was 301.24 and increased to 416.24 g force at twelfth week (Figure 3). The changing of lightness was nearly constant with range of 31.70-35.13. Redness increased from 7.06 to 10.70 alike the yellowness, it increased from 4.90 to 7.20 within three months (Figure 4).

The sensory evaluation (Table 4) was found that hedonic score of color, size crispy, Panang flavor, taste and overall liking were in range of 6.5-8.0. It could be explained that panelist like cracker slightly to like very much. During twelve weeks of storage, all attributes had higher score than borderline as 6.5 and acceptance of product was 93.33%. Hence, it could be say that shelf life of black glutinous rice crackers was twelve weeks at least.

Conclusion

Black glutinous rice cracker is gluten-free snack which has higher nutrient compare to other rice snack such as Arare. Shelf life of this snack is at least three months.

Acknowledgement

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