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Development of Local Halal Food Product: Budu Tumih Noni Leaf Rice Crisp

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Abstract

This research was conducted to figure out the proper concentration of noni leaf juice to produce noni rice crisp and the appropriate budu-tumih content for topping the crisp in order to be one of local halal food products. The study focuses on the product's chemical composition, physical properties, sensory properties, consumers' acceptance and shelf life. The results reveal that the proportion of noni leaf and water at 120:500 g/ml used in the extraction process and 5 g/piece of budu-tumih content by weight are appropriate in budu-tumih noni leaf rice crisp production. The L*, a* and b* values of the product were 14.27, 4.04 and 2.36, respectively. The a_w was 0.34. For chemical composition, it found that 10.17, 25.97, 61.20, 3.62, 1.90 and 4.14% of protein, fat, carbohydrate, fiber, ash, and moisture, respectively, with a pH of 4.25. The texture property in terms of hardness and crispness was 5.61 and 4.52. The consumer acceptance test shows that the mean of "overall preference" score for the product was at the like to mostly like level (4.99±0.53). It also found that 89% of consumers accept the product and 90% of consumers would purchase the product if it is available in the market. The microbiological quality of the product found the total plate count of $<1x10^6$ cfu/g whereas yeast and mold were <100 cfu/g. The results indicate that the shelf life of the product was at least 10 weeks.

Introduction

The word 'Halal' is an Arabic term referring to what is permissible or lawful in the Islamic law. Halal food is not only concerned about the slaughter of animals, the use of alcohol, the sources of food and beverages, but it is also about standard and process in ensuring the safety and cleanliness of food products (Teng et al., 2013). For many practicing Muslims, keeping a halal diet is an important part of daily life. Halal food has come to represent high quality safety and cleanliness (Ambali & Bakar, 2014).

Rice crisp is a traditional crispy rice snack of Thailand. It is made from rice and has a unique taste and texture. Rice crisp is a snack that has been found since ancient times as one of Thai culture heritage. Up to now, rice crisp is still popular and can be adapted to a variety of taste. (Songpranam, 2013). Many attempts are being

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made to improve the snacks' nutritive value and functionality by modifying its nutritive composition with many kinds of vegetables and herbs. The herbs have medicinal and chemical properties for maintaining health or reducing the risk of disease such as high blood cholesterol, cardiovascular disease and high blood pressure disease (Walden & Tomlinson, 2011).

In the south of Thailand, Khao Yum (Rice salad) is a classic traditional Thai dish, It mostly consists of cooked rice, assorted fresh vegetables as well as herbs especially noni leaf. The noni leaf is an example of a plant used as a functional food and has been widely studied due to its apparent beneficial effects on human health. It has been investigated as an alternative in anticancer, antibacterial, and antimicrobial therapies, and in the treatment of esophageal reflux and ulcers in animals (Mahattanadul et al., 2017; Zhang et al., 2016).

Budu-Tumih is a semi-solid fish dish that is popularly eaten as a side dish or as a seasoning in mixed rice, popularly among Muslims in the south of Thailand. Nowadays, the budu-tumih can be found only in the southernmost provinces of Yala, Pattani and Narathiwat. Budu-tumih comprises of many ingredients such as budu, fresh coconut milk, tamarind, sugar, dried chili, garlic, etc. It is commonly used as a dip or flavoring in the Muslim household of Thailand and other countries.

Therefore, the objectives of this research are to bring budu-tumih and noni leaf which is a side dish that is eaten together and to combine them with rice crisps in order to produce a new food product that will increase the value of local halal food as well as to study the product properties.

Materials and methods

1. Study on the appropriate concentration of noni leaf extract to produce noni rice crisps

Noni leaf was collected from 7.5 GY 4/4 color using munsell color book. The juice extract was prepared from 3 proportions of noni leaf and water at 70:500, 90:500 and 120:500 g/ml. Rice crisp was produced by adapting the method from Tachasiriwichai et al. (2015) (Fig. 1). The rice crisp was tested in accordance with the Thai Community Product Standard TCPS: ICS; 119/2011, 2011). (A score must be equal to or greater than 2 and the moisture level of not more that 6%.)

The 3 standard samples of noni rice crisps were tested for sensory quality assessment using 9 point hedonic scale. There were 40 untrained panelists in the study. The sensory quality assessment included appearance, color, odor, taste, crispness and overall preference; the experiment design was Randomized Complete Block Design (RCBD), Analysis of variance (ANOVA) and Duncan's New Multiple Range Test at 95% confidence level.

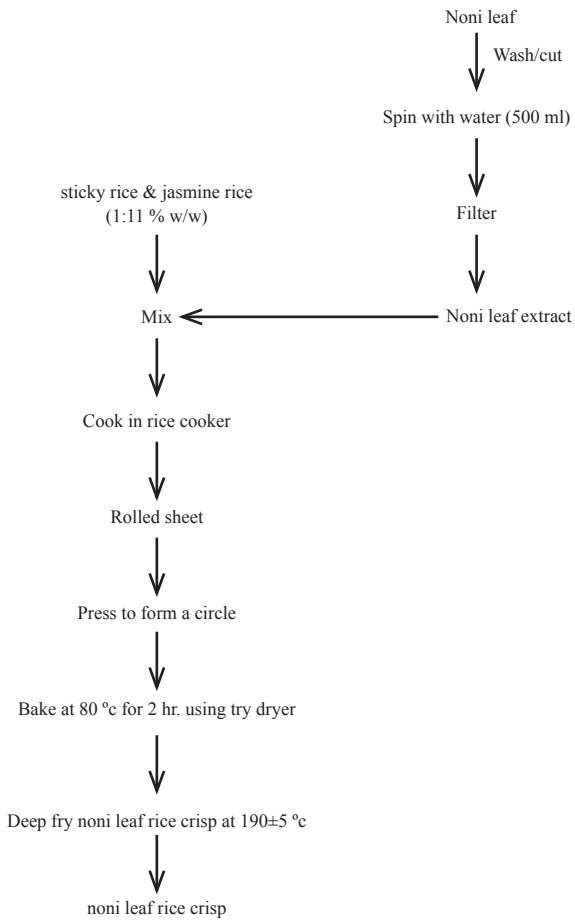

Fig.1 The production process of noni leaf rice crisp (modified from Tachasiriwichai et al., 2015)

2. Study on the appropriate quality of budu-tumih content on the top of the rice crisp

The rice crisp from no. 1 above was topped with budu-tumih. The production process of budu-tumih was modified from the method of Srisuk et al. (2017) as shown in Fig. 2. The amount of budu-tumih per piece of noni leaf rice crisp was varied at 3, 5 and 7 grams and the rice crisp with topping was baked at 80ºC for 1 hour.

The 3 recipes of budu-tumih noni leaf rice crisp were tested for sensory quality assessment using the 9-point hedonic scale (Nicolus et al., 2010) in order to choose

the recipe that has the highest scores. The 40 untrained testers consumed rice crisp regularly. The experimental design used Randomize Complete Block Design (RCBD), analysis of variance (ANOVA) and Duncan's New Multiple Range Test at $p<0.05$.

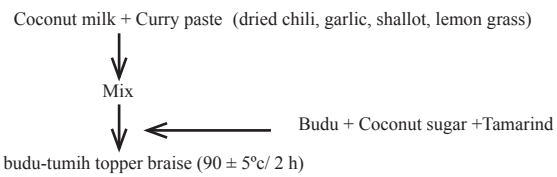

Fig. 2 The production process of budu-tumih (modified from Srisak et al., 2017)

3. Study on the physical properties and chemical compositions of budu-tumih noni leaf rice crisp

The recipe that received the highest scores according to no. 2 above was used in preparing the budu-tumih noni leaf rice crisp in order to test for properties and chemical compositions as follows:

3.1 Physical properties

3.1.1 Water activity (a_w) was measured using a water activity meter (Novasina AG, Neuheimstrasse 12, CH-8853, Lachen, Switzerland).

3.1.2 The rice crisp color was measured at a planar sample surface in which the light (L*), redness/ greenness (a*) and yellowness/blueness (b*) were determined using Hunter lab (Color Aqua Lab s3600090, Hunter Associate Laboratory, VA, USA).

3.1.3 Hardness and crispness were measured by a penetration test using a texture analyzer (TA-XT2 stable Micro System, England). The cracker samples were placed on a fabricated hollow cylindrical base (25 mm inner diameter, 1.5 mm thickness, stainless steel). Force was applied using a 5 mm spherical compression probe (TA7) at the test speed of 0.5 mm/s until the sample cracked. Hardness and crispness were recorded.

3.2 Chemical compositions

3.2.1 The moisture content of the rice crisp was determined by drying a 3 g sample in an oven of 105ºC for 3 hours until a constant weight was obtained (AOAC, 1999).

3.2.2 Crude protein content (g water/100 g sample) was analyzed according to the Kjeldahl method using a factor of 6.25 for the conversion of the nitrogen to crude protein.

3.2.3 Ash content was performed on a 2-3 g sample after combustion in a muffle furnace at 550ºC for 8 h. Calculate the percentage of total ash in the weight of g sample (g ash/100 g sample).

3.2.4 Fat was calculated for weight loss by extraction for 8 h with petroleum ether in a soxhlet apparatus.

3.2.5 Total dietary fiber (TPF) was determined by the method of AOAC (AOAC, 1990).

3.2.6 pH value was determined by dipping the pH electrode into the homogenates of the rice crisp in distilled water (1/1). All measurements were performed at room temperature using pH-meter (WTW Inolab, Weinheim, Germany).

4. Study on the level of consumers' acceptance of budu-tumih noni leaf rice crisp

The rice crisp sample that has been accepted in no.2 was prepared for the consumer test and was kept in polyethylene plastic container at ambient temperature before usage. A survey for acceptance of target consumers that consume rice crisp product at least once per week using questionnaire. Data gained includes demographic data, consumers' liking scores toward the product (using the 5-point hedonic scale), and data of 100 panelist' acceptance (using the binomial (yes/no) scale). The sensory test was used to determine consumer preference of color, odor, taste, crispness and overall acceptance.

5. Study on the shelf life of budu-tumih noni leaf rice crisp

The rice crisp was kept as described in no.4 was tested for the value of a_w, color, and microbial content every 2 weeks for 10 weeks.

6. Statistical analysis

Three replications of the experiment were conducted at separate times and all analyzes were performed in triplicates. Mean and standard errors were calculated. Data gained were analyzed with ANOVA. The results of acceptance test comprised the frequency (percentage) and the average liking score of consumers toward the developed budu-tumih noni leaf rice crisp. Statistically difference was established at $p< 0.05$.

Results and discussion

1. The appropriate concentration of noni leaf extract for the production of noni leaf rice crisp.

The results of the sensory score assessment of 40 untrained panelists' reports in Table 1. From the results obtained, there was no statistically significant difference ($p\geq 0.05$) in the appearance, odor, crispness and overall preference of each recipe. It was found that only the

characteristic of taste in the 3rd recipe was more preferable than the 1st recipe but not different from the 2nd recipe significantly ($p<0.05$). The result indicated that the rice crisp has the taste of noni leaf more pronounced since a higher proportion of noni leaf was used. Thus, the appropriate concentration of noni leaf extract to produce noni rice crisp is the 3rd recipe, which consists of 120 grams of noni leaf and 500 ml of water.

Table 1 Sensory evaluation results for the three noni leaf rice crisp recipes

Sensory characteristic	Sample of noni leaf rice crisp recipes		
	Recipe 1 (70 g noni leaf)	Recipe 2 (90 g noni leaf)	Recipe 3 (120 g noni leaf)
Appearance^{ns}	7.17±0.78	7.47±0.68	7.17±0.83
Color^{ns}	7.13±0.93	7.30±0.65	7.20±0.69
Odor^{ns}	6.97±0.96	7.20±0.84	7.47±0.73
Taste	7.07±0.94^{b}	7.40±0.93^{ab}	7.60±0.77^{a}
Crispness^{ns}	7.23±0.69	7.20±0.08	7.26±0.75
Overall preference^{ns}	7.43±0.72	7.66±0.88	7.70±0.95

Remark: Each value is presented as mean ± standard deviation (n=3)
Different superscripts in the same row indicate significant differences ($p<0.05$)
ns shows that there was no statistically significant difference at ($p\geq0.05$)

2. The appropriate quantity of budu-tumih content of noni leaf rice crisp topper

The sensory quality assessment of 30 untrained panelists' performing with 9-point hedonic scale is shown in Table 2. The results reveal that, the 1st recipe characteristics were significantly different from the 2rd and the 3rd recipe whereas the 2nd and the 3rd characteristics were not significantly different in all characteristics ($p<0.05$) except for the crispness.

Therefore, the selected recipe of budu-tumih at the level of 5 g/piece was used in the product development of the rice crisp due to the use of less budu-tumih. The picture of the 3 rice crisps are displayed in Fig 3.

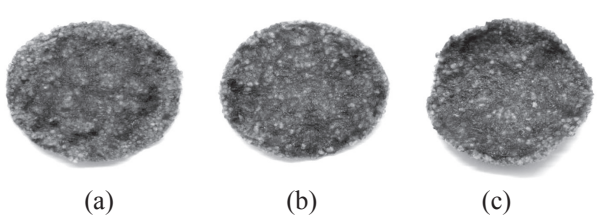

Fig 3. The rice crisp products with difference of budu-tumih topper paste (a) 3 g per piece, (b) 5 g per piece and (c) 7 g per piece

Table 2 sensory evaluation results for the three noni leaf topping with different three budu-tumih contents

Sensory characteristic	Recipe		
	1 (3 g/ piece)	2 (5 g/ piece)	3 (7 g/ piece)
Appearance	7.07±0.98^{b}	7.78±0.73^{a}	7.70±0.98^{a}
Color	7.17±0.69^{b}	7.80±0.66^{a}	7.60±0.89^{a}
Odor	6.90±0.86^{b}	7.73±0.94^{a}	7.43±0.74^{a}
Taste	7.06±0.90^{b}	7.86±0.97^{a}	7.80±0.84^{a}
Crispness^{ns}	7.60±0.81	7.93±0.69	7.66±0.75
Overall preference	7.26±0.73^{b}	8.03±0.71^{a}	7.80±0.88^{a}

Remark: Each value is presented as mean standard deviation (n=3)
Different superscripts in the same row indicate significant differences ($p < 0.05$)
ns shows that there was no statistically significant difference ($p \geq 0.05$)

3. Physical properties and chemical compositions of budu-tumih noni leaf rice crisp.

3.1 Physical properties

The physical properties of the final product are shown in Table 3. The low a_w and pH of the budu-tumih noni leaf rice crisp in which both parameters are highly related to product deterioration. This indicates that the risk of deterioration (by microorganisms, enzymes or none enzymatic reactions) is minimal. The product's a_w values (0.39±0.01) is similar to the study of Sangkabhan (1998) who reported that Khao Tang Na Tang from rice (rice crisp), groundnut and sesame tempeh had the a_w of 0.39. The aw still remains lower than 0.6 in which the level of bacteria are unable to grow (Seman et al., 1980).

The results on the color measurement of the final product in term of Hunter L*, a*, b* color coordinate values were lightness (L*) 14.27±1.27, redness (a*) 4.04 ±0.46 and yellowness (b*) 2.36 ± 0.25. The Hunter Lab a* value represents red color. The red color is derived from the mixture of curry dried chili in which the dried chili has a colorant or pigment called carotene.

The b* value represents a yellow color of paste. In the manufacturing of the budu-tumih, coconut milk is the main ingredient. When coconut milk is heated it changes the color to brown and/or darker. Therefore, budu-tumih shows an attractive color.

Table 3 Physical properties of budu-tumih noni leaf rice crisp

Physical characteristic		Values
Color		
	L*	14.27 ± 1.27
	a*	4.04 ± 0.46
	b*	2.36 ± 0.25
	a_w	0.39 ± 0.01
Texture		
	Hardness	5.61±0.12
	Crispness	4.52±0.09

Remark: Each value is presented as mean ± standard deviation (n=3)

The texture property in terms of hardness and crispness were 5.61 and 4.52. This is similar to the value 4.4 and 4.0 black sesame crispy cracker made from broken Sinlek rice that is reported by Ladnoi & Wongtong (2017). Crispness can be affected by the nature of the material and the structure that the material forms (Zzaman et al., 2017).

3.2 Chemical compositions.

The chemical composition analysis of budu-tumih noni leaf rice crisp has mostly been accepted (2nd recipe), the results reveal that protein, fat, carbohydrate, fiber, ash and moisture content were 10.17%, 18.97%, 61.20%. 3.62%, 1.90% and 4.14%, respectively (Table 4). From Table 4, the moisture content of the rice crisp product was somewhat equal to the 4.08 of Khao-Tang supplemented with calcium from gray feather back fish bone reported by Iamkampeng & Inget (2015). According to the Thai Community Product Standard (TCPS:ICS; 119/2011, 2011), the moisture content in rice cracker products (Khaotang) must contain a maximum of 6 %. The protein content in 10.17% is most probably due to the production process of budu-tumih, which has a fish content in budu of 7.17% - 12.08%. The fat content of the rice crisp was 18.97 because the process of budu-tumih production consist of coconut milk and vegetable oil.

Table 4 Chemical compositions of budu-tumih noni leaf rice crisp

Chemical composition	Noni leaf budu-tumih rice crisp
Protein	10.17±0.20
Fat	18.97±0.28
Carbohydrate	61.20±0.03
Fiber	3.62±0.01
Ash	1.90±0.25
Moisture	4.14±0.38

4. Consumers' acceptance of the budu-tumih noni leaf rice crisp

The results of consumers' acceptance on the finished product which covers the demographic data and the consumers' linking and preference test, using 100 respondents in Yala province are shown in Table 5 and Table 6.

Table 5 Demographic data

Demographic attribute	Frequency (percent)
1. Gender	
- Male	30
- Female	70

Table 5 Demographic data (continued)

Demographic attribute	Frequency (percent)
2. Age	
- Less than 20	-
- 21-25	57
- 26-30	15
- 31-35	15
- 36-40	13
- More than 40 years old	-
3. Occuoation	
- Student	30
- Contractors	13
- Housewife/Steward	10
- Government Official	12
- Personal Businness	15
- Farmer/Gardener	20
4. Education Level	
- High School	3
- Vocational Certificate	17
- High Vocational Certificate	21
- Bachelor's degree	57
- Master's degree	2
- Higher than Master's degree	-
5. Average monthly income	
- Less than 5,000	25
- 5,001-10,000	47
- 10,001-15,000	23
- 15,001-20,000	5
- 20,001-25,000	-
- More than 25,000	-

Table 6 Mean liking scores of the budu-tumih noni leaf rice crisp

Sensory attribute	Mean±SD
Apperance	4.30 ± 1.68
Color	4.62 ± 1.58
Odor	4.08 ± 0.10
Tested	4.53 ± 1.02
Crispness	4.40 ± 0.38
Overall preference	4.99 ± 0.53

Remark: Each value is presented as mean ± standard deviation (n=3)

The results from testing of consumers liking on the 5-point hedonic scale (1-dislike very much and 5-like very much) of the finished product was conducted using 100 respondents. 70% of consumers were females and 30% were males (21-40 age range). The testers mostly rated the highest score of overall preference at 4.99±0.53 point. The characteristic of appearance, color, odor, taste and crispness were 4.30±1.68, 4.62±1.58, 4.08±0.10, 4.53±1.02 and 4.40±0.38, respectively (Table 6). This indicates that the finished rice crisp sensory attributes have a mean of like to like very much.

The results of consumers' acceptance and purchasing decision of the budu-tumih noni leaf rice crisp are shown in Table 7.

Table 7 Consumers' acceptance and purchasing decision of the budu-tumih noni leaf rice crisp

Data	Frequency (percent)
Consumers' acceptance of the budu-tumih noni leaf rice crisp	
- Accept	89
- Decline	11
Purchasing decision of the budu-tumih noni leaf rice crisp	
- Purchase	90
- Not purchase	10

The results from the survey of the consumers' acceptance and decisions on purchasing the budu-tumih noni leaf rice crisp indicates that 89% of the consumers accept the product. 90% of the consumers decided to purchase the product. Therefore, budu-tumih noni leaf rice crisp from this research has a high chance to be produced commercially.

5. Study on the shelf life of the budu-tumih noni leaf rice crisp

The qualities of change in rice crisp were investigated in terms of aw, color and microbial content up to 10 weeks. At first date of storage, a_w was 0.36 and tended to increase slightly until ten weeks as shown in Fig. 4. Water activity range changed to 0.36-0.48 and it was in the scope which was set as 0.60 (Pornchaloempong & Ratanapanon, 2002). The result coincides with the study of Sangkapan (1998) who reported that Khao Tang Na Tang (rice crisp) from rice, groundnut and sesame tempeh has a_w equal to 0.34. The a* values correspond to red-green profile increasing from 1.76 to 2.62 as shown in Fig.5 (b). This change shows that the obvious redness in the color profile. The b* values which represents yellowness increased from 20.32 to 31.02 within 10 weeks as shown in Fig. 5 (c). From the results obtained, the redness of the crisps increased with an increase of a_w. There was higher water absorption and oxygen permeability during storage in accelerated mallard reaction resulting in the red color change (Rattanapanone, 2002). The total plate count of the product was less than $1x10^6$ CFU/g and yeast as well as mold count was less than 100 CFU/g. Thus, it could be implied that the product was safe to consume (Table 8).

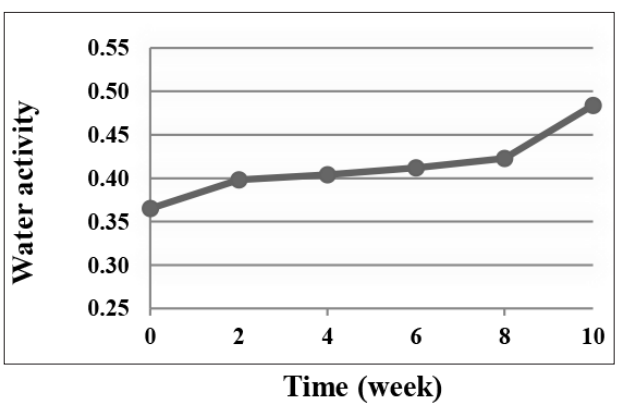

Fig. 4 Water activity change of budu-tumih noni leaf rice crisp during storage period up to 10 weeks

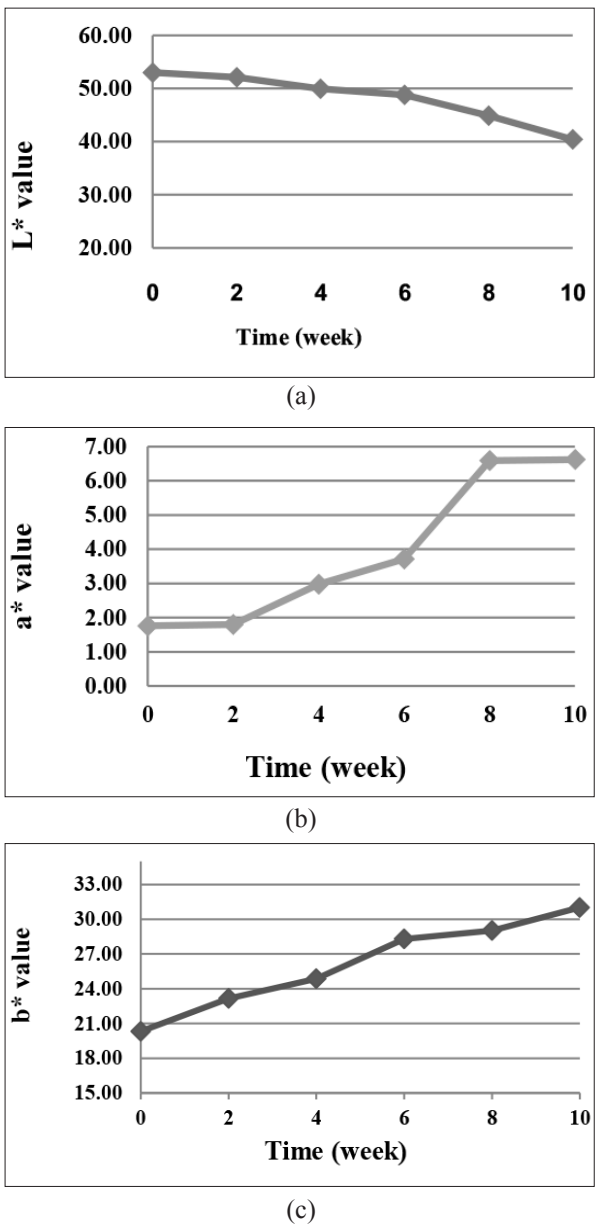

Fig. 5 Color change of budu-tumih noni leaf rice crisp during storage up to 10 weeks: (a) lightness, (b) redness and (c) yellowness

Table 8 Microbial analysis results of budu-tumih noni leaf rice crisp during storage up to 10 weeks in polyethylene plastic container at ambient temperature.

Storage period (week)	Microbial analysis	
	Total plate Count ($x10^6$ CFU/g)	Yeast and Mold (CFU/g)
0	ND	≤100
2	ND	≤100
4	ND	≤100
6	ND	≤100
8	0.05±0.02	≤100
10	0.12±0.01	≤100

Remark: ND = not detect, Each value is presented as mean±standard deviation (n=3)

Conclusion

The purpose of this research was to develop a new rice crisp by adding noni leaf extract and topping with budu-tumih paste as one of local halal food products. The noni leaf rice crisp were dark-green. The results indicate that the proper concentration of noni leaf extract was the ratio of noni and water at 120:500 g/ml and the amount of budu-tumih suitable for the topping of the rice crisp was 5 g/piece (w/w). The product shows an attractive color and odor in which the consumers are satisfied with a high protein content of 10.17%. The product has low moisture content at 4.14%. The product was judged by the average consumers' liking scores in the "like to mostly like" range (4.99±0.53). 89% of consumers accept the product and 90% of the consumers decided to purchase the product if available in the market. From the results of the shelf life study, it was shown that the total plate count was less than $1x10^6$ CFU/g while the yeast and mold count was less than 100 CFU/g at 10 weeks storage period which complies with the Thai Community Product Standard. Hence, the shelf life of the product was at least 10 weeks at room temperature storage. This implies that it is feasible to produce budu-tumih noni leaf rice crisp to commercial scale.

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