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Product development of fish tofu supplemented with Malva nut gum

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Abstract The development of fish tofu supplemented with malva nut gum is determined in term of improving the functional properties of the product. The result revealed that formulation contained 43%of fish fillet and 3% of malva nut gum that received the highest sensory scores of aroma, taste, and most acceptable with the scores of 7.00±1.16, 7.06±1.11, and 6.92±1.29, respectively. For the determination of some properties, the increasing of the amount of malva nut gum tended to decrease the lightness (L*), firmness, lipid and protein contents, whereas the redness (a*), yellowness, (b*), moisture content, water activity, and fiber were increased. The best formula was investigated for the effect of the shelf life in cold storage on the firmness and microbiology properties. The result showed that the firmness decreased, while the number of the viable cell count was increased at two weeks of cold storage. Finally, the developed fish tofu formula was tested by 100 consumers. It was found that most consumers accepted the new product in the level of moderately like with the average score of 7.09. The research highlighted that malva nut gum could be added to fish tofu in order to modify the dietary fiber content of a meat product.

Keywords: Product development, *Selaroides leptolepis*, Malva nut, Tofu

Introduction

Fish tofu is an emulsion type of meat product that uses fish meat as the main ingredient, which is finely chopped and mixed with soybean oil, soybean flour, salt, and sugar (Ketnawa *et al*., 2016). To improve the functional properties, dietary fiber is one of the ingredients that could be added to meat products for the development of low-fat and high-fiber functional meat products (Jayanthi *et al*., 2021). In addition, the dietary intake, particularly water soluble fiber, is strongly and associated with a lower risk of coronary heart disease, cardiovascular diseases, and cancer (Bazzano *et al.*, 2003).

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Prakongpan *et al*. (2002) reported that cellulose from pineapple cores had the potential to be a good source of dietary fiber and cellulose in bakery and meat products. The pineapple cores were more suitable for reducing shrinkage and improving the texture of beef burgers. Moreover, Kumar *et al.* (2010) studied the addition of green banana and soybean hull flour in chicken nuggets that exhibited adding dietary fiber could improve the nutritional quality. Interestingly, for meat products modified by adding fiber sources to decrease the possibility of chronic diseases and the guidance recommendation from the Food and Drug Administration (2014), the total dietary fiber intake should be 25 g per day out of which about 25% (about 6 g) should be soluble fiber (Bhat & Bhat, 2011; Jayanthi *et al.*, 2021).

Malva nut fruit (*Scaphium scaphigerum*) or the Thai local name of Samrong and Pungtalay has been identified in the Sterculiaceae family that is cultivated in Thailand, Vietnam, China, and Indonesia. In Thailand, it is cultivated in the Eastern part of the country especially Rayong, Chanthaburi, and Trat provinces (Petchlert *et al*., 2012). Malva nut has long been served in Chinese medicine, and many South East Asian countries have produced a functional beverage from malva nut seed (Srichamroen, 2018). For example, Chaiyasit and Wiwanitkit (2017) used a supplement of 250 $cm^3$of malva nut juice per day for a Thai HIV-infected male patient. The results revealed that the CD^{4+} count increased after the patient drank malva nut juice for one month.

Furthermore, Srichamroen (2018) reported that malva nut gum demonstrated effectiveness in lowering the glucose uptake in Caco-2 cells in both low and high carbohydrate concentrations. Pongthananikorn *et al.* (2007) also evaluated the clinical outcome of a malva nut drink in type 2 diabetic patients. The results showed that the malva nut beverage could help to reduce serum glucose and lipids in type 2 diabetic patients. From a nutrional point of view, Somboonpanyakul *et al.* (2011) developed a dietary fiber supplement tablet from malva nut powder and found that the optimum formula was 30% of malva nut powder, 45% of sorbitol, 0.3% of magnesium stearate, and the composition of microcrystalline cellulose: 24.7 % of croscarmellose sodium(80:20).

Additionally, Barbut and Somboonpanyakut (2007) demonstrated that modified crude malva nut gum and sodium triphosphate improved the yield, stability, and texture of emulsified meat batter. Frankfurters with 0.2g/100g of crude malva nut gum also showed low cooking loss and had better textural properties than frankfurters without malva nut gum. The sensory analysis revealed that frankfurters with 0.2 g/100g malva nut gum were firmer and more elastic (Somboonpanyakul *et al*., 2007).

From the interesting properties of malva nut as mentioned above and in terms of improving the nutritional value of fish tofu, the product development of fish tofu supplemented with malva nut gum was evaluated. The authors also found that no study of the development of fish tofu supplemented with malva nut gum had been previously undertaken. Therefore, the aim of research finding was to investigate fish tofu supplemented with malva nut gum and evaluate some properties, including the sensory evaluation, color parameters, and firmness. Then, the best formula was chosen to study the effect of cold storaged on the texture and microbiological properties. Finally, the developed fish tofu supplemented with malva nut gum was tested with 100 consumers for their opinions.

Materials and methods

Materials

Yellowstripe trevally (Selaroidesleptolepis) and malva nut seed were bought from a local market in Khao Khitchakut district, Chanthaburi province, Thailand and then stored in a refrigerater. For the other ingredients consisting ofone-day mushrooms, soybean oil, soy milk, sugar, egg white, wheat flour (Kite brand), tapioca starch, corn starch, and salt, these were also bought in the local market mentioned above and stored in room temperature for further study.Sodium triphosphate ($Na_5P_3O_{10}$) was purchased online from Chemipan.com.

Preparation of the fish fillet

The yellowstripe trevally was cleaned, and the innards were removed and the fish was cleaned again. Next, the fish fillets were cut into slices and the fish skin was removed. The obtained fish fillet was kept in plastic bags and placed in a freezer at a temperature of -15 ℃.

Preparation of the malva nut gum

The malva nut seed (50 g) was cleaned and then soaked in three liters of distilled water for 30 min. Then, the bark was removed and filtered by a net (2 mm). The obtained black malva nut gum was collected and kept in plastic bags and then refrigerated in the freezer at a temperature of -15 ℃.

Product development of fish tofu supplemented with malva nut gum

For developing the formulation of the fish tofu, six formulas of fish tofu supplemented with malva nut gumwere prepared by the various ratio of fish fillet:malva nut and mixed with soybean oil, soy milk, sugar, egg white, wheat flour,tapioca starch, corn starch, salt, sodium triphosphate, and ice (Table 1). A completely randomized design (CRD) was utilized as the experimental design in this study. The fish tofu was made by modifying the procedure of Bonin *et al.* (2013). Briefly, the fish fillet was chopped and mixed with salt and malva nut gum in various concentrations by using a mixer (Panasonic, MK-5086M, Thailand). Simultaneously, crushed ice was added until the ingredients were well-combined (the fish meat was viscous). Then, wheat flour, tapioca flour, corn starch, egg white, and sugar were added and chopped until the texture was smooth. Next, soy milk, soybean oil, and ice were slowly added and ground until the consistency was smooth and fine. The components were placed onto a greased baking tray and kept in the refrigerator for about 20 min. The obtained fish tofu was steamed at 100 ℃ for 15-20 min. The cooked fish tofu was soaked in cold water and then cut into 2x2x2 cm cubes. The obtained fish tofu was packed in plastic bags and kept in the freezer (-15 ℃). Before investigating the properties, the samples were fried at 180-190°C for 2 min. or when the color of the tofu samples was golden brown.

Table 1. The six formulas of fish tofu supplemented with malva nut gum

Formula No.	Ratio of fishfillet:malva nut gum (% w/w)	Soybean oil (%v/v)	Soy milk (%v/v)	Sugar (%w/v)	Egg white (%v/v)	Wheat flour (%w/v)	Tapioca starch (%w/v)	Corn starch (%w/v)	Salt (%w/v)	Sodium triphosphate (%w/v)	Ice (%w/v)
1(Control)	46:0	9	7	3	2	2	1	1	1	0.2	27.8
2	45:1	9	7	3	2	2	1	1	1	0.2	27.8
3	44:2	9	7	3	2	2	1	1	1	0.2	27.8
4	43:3	9	7	3	2	2	1	1	1	0.2	27.8
5	42:4	9	7	3	2	2	1	1	1	0.2	27.8
6	41:5	9	7	3	2	2	1	1	1	0.2	27.8

The suitability of the fish tofu supplemented with malva nut gum was selected by using the criteria as a sensory score.

Determinationof the sensory evaluation

Sensory quality was analyzed in terms of color, aroma, taste, texture, and overall liking by using 50sensory testers from the staff and students of the Department of Food Innovation and Business, Rajamangala University of

Technology Tawan-ok, Chanthaburi campus, Chanthaburi province. The experimental design was a randomized complete block design (RCBD) using a nine-point hedonic scale (1 most disliked – 9 liked the most). The design was statistically analyzed using an analysis of variance (ANOVA) and compared the differences by utilizing Duncan's new multiple range test (DMRT) at a 95%confidence level (Watts *et al*., 1989). Then, the fish tofu supplemented with malva nut gum from six formulas was evaluated for the color parameters and chemical composition, respectively.

Determination of some physical properties

The fish tofu supplemented with malva nut gum samples were evaluated for the color parameters by using a color meter (Nippon Denshoku, ZE-2000, Japan). The equipment was calibrated with a standard plate. The color measurements were expressed as follows: L* indicated the lightness on a 0 to 100 scale from black to white; a* (+; -) indicated the redness or greenness, respectively; b* (+; -) indicated the yellowness and blueness, respectively. The imageswere photographed with a camera from a smartphone (iPhone 7, America). For the investigation of the firmness, the properties were analyzed by using a texturometer (Lloyd Instruments TA500, England), which the measuring conditions were load cell 20N,pretest speed of 2mm/s, test speed of 2 mm/s, and post-test speed of 10 mm/s.

Determinationof the chemical composition

The analysis of the chemical quality of fish tofu supplemented with malva nut gum samples determined the activity content of the water (a_w), moisture content, lipid content, fiber content, ash content, protein content, and carbohydrate content calculator in accordance with the method established by AOAC International (2000).

Effect of cold storage on some properties of fish tofu supplemented with malva nut gum

The best formula was selected by the criteria of high consumer acceptability, firmness, and microbiological properties of fish tofu supplemented with malva nut gum, which was monitored at Weeks 0, 1, and 2 in cold storage (4℃) in a refrigerator. The firmness was analysed by using a texturometer (Lloyd Instruments TA500, England) as previously mentioned. For the microbiological properties, the standard plate count method and yeast

and mold counts were assessed with Plate Count Agar(PCA) and Potato Dextrose Agar (PDA) medium after 48 h of inoculation at a temperature of 37℃ for the total bacteria count and yeast and mold counts of the samples and then reported as CFU/g. (Yoon *et al.,* 2004).

Consumer testing

The highest overall acceptability of fish tofu supplemented with malva nut gum was prepared as described above; it was then determined for final consumer acceptability with 100 untrained panelists by using a central location test (CLT) using a nine-point hedonic scale as mentioned above (Boutrolle *et al*., 2007).

Data analysis

Property analysis was carried out in three replications. The data were subjected to ANOVA ($p \leq 0.05$) (Steel *et al.,* 1997). The mean with significant differences was separated by DMRT using computer software.

Results

Product development of fish tofu supplemented with malva nut gum

The six formulas of fish tofu supplemented with malva nut gum was investigated through sensory evaluation by using a nine-point hedonic scale (Table 2). The increasing of the concentration of malva nut gum tended to decrease the preference score in color and texture. Significantly ($p \leq 0.05$), the lowest scores of the color and texture were exhibited in formula No. 6 with the scores of 5.96 ± 1.16 and 5.90 ± 1.16, respectively. In contrast, the highest preference scores in aroma, taste, and overall acceptability were shown in formula No. 4., but the scores did not have any significant differences ($p \leq 0.05$) when compared with formulas nos.1-3. Therefore, fish tofu supplemented with malva nut gum formula No. 4 was the chosen formula in terms of the high acceptance score in aroma, taste, and overall acceptability.

For the color parameters, the increasing of the amount of malva nut gum tended to decrease the lightness (L*), whereas the redness (a*) and yellowness (b*) were increased (Table 3; Figure 1). The lowest score of lightness (L*) was significantly ($p \leq 0.05$) differed in the fish tofu formula No.6 with the score of 56.75 ± 0.87, while the highest score of redness (a*) and yellowness were significantly ($p \leq 0.05$) shown in fish tofu formula No.6 with the scores of

1.62 ±0.27 and 25.11 ±0.69, respectively. Overall, the color parameters and the images of the six formulas of fish tofu supplemented with malva nut gum were found with similar results.

Table 2. Sensory evaluation of the six formulas of fish tofu supplemented with malva nut (based on the nine-point hedonic scores)

Formula No.	Ratio of fish fillet:malva nut gum (%)	Preference Scores ±Standard deviation				
		Color	Aroma	Taste	Texture	Overall Acceptability
1(Control)	46 :0	6.96±1.07^{a}	6.70±0.93^{ab}	6.76±0.87^{a}	6.78±1.13^{a}	6.62±1.14^{ab}
2	45 :1	6.98±1.15^{a}	6.72±1.14^{ab}	6.86±1.13^{a}	6.86±1.14^{a}	6.78±0.89^{a}
3	44 :2	6.84±0.89^{a}	6.82±1.20^{ab}	6.94±1.27^{a}	6.76±1.41^{a}	6.86±1.11^{a}
4	43 :3	6.72±1.18^{a}	7.00±1.16^{a}	7.06±1.11^{a}	6.64±1.35^{a}	6.92±1.29^{a}
5	42 :4	6.34±1.08^{b}	6.38±1.01^{b}	6.30±1.07^{b}	6.24±1.22^{b}	6.38±0.99^{bc}
6	41 :5	5.96±1.16^{c}	6.02±1.06^{c}	6.16±1.02^{b}	5.90±1.16^{b}	6.12±0.92^{c}

The mean with different letters was statistically different ($p \leq 0.05$) according to Duncan's multiple range test.

Table 3. The color parameters of the six formulas of fish tofu supplemented with malva nut gum

Formula No.	Ratio of fish fillet:malva nut gum (%)	Color parameters		
		L*	a*	b*
1(Control)	46 :0	69.510±.61 ^{a}	-1.25±0.21 ^{a}	20.28±0.27 ^{a}
2	45 :1	68.14±0.37 ^{b}	-0.77±0.34 ^{a}	20.60±0.43 ^{a}
3	44 :2	67.13±0.33 ^{b}	0.080±.40 ^{b}	21.990±.48 ^{b}
4	43 :3	64.53±0.77 ^{c}	0.410±.18 ^{b}	23.39±0.53 ^{c}
5	42 :4	62.76±0.62 ^{d}	1.530±.11 ^{c}	23.860±.35 ^{c}
6	41 :5	56.75±0.87 ^{e}	1.620±.27 ^{c}	25.11±0.69 ^{d}

L* (lightness) 0 = black; 100 = white, a*(redness/greenness) + = redness; - = greenness, b*(yellowness/blueness) + = yellowness; - = blueness, Data represented the mean of the three replications, Mean with different letters was statistically different ($p \leq 0.05$) according to Duncan's multiple range test.

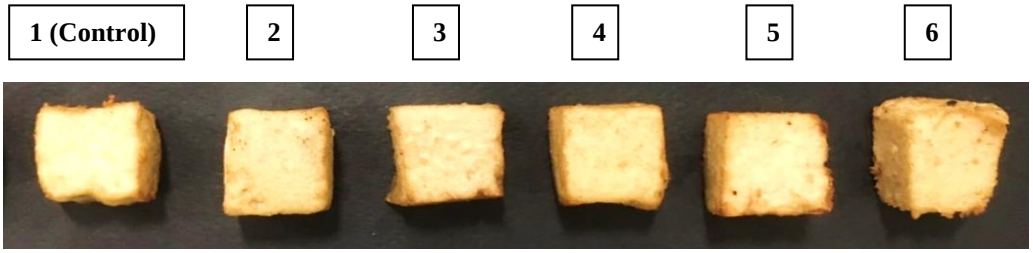

Figure 1. Images of the fish tofu supplemented with malva nut gum as various concentrations

For the investigation of the firmness, the increasing of malva nut gum tended to decrease the firmness of the fish tofu supplemented with malva nut gum. The lowest firmness was significantly ($\rho \leq 0.05$) exhibited in fish tofu formula No. 6 (ratio of fish fillet: malva nut gum; 41:5) with a level of 741 g, while the highest firmness was significantly ($\rho \leq 0.05$) shown in fish tofu control formula No. 1 (ratio of fish fillet: malva nut gum; 46:0) with a value of 1016 g (Figure 2).

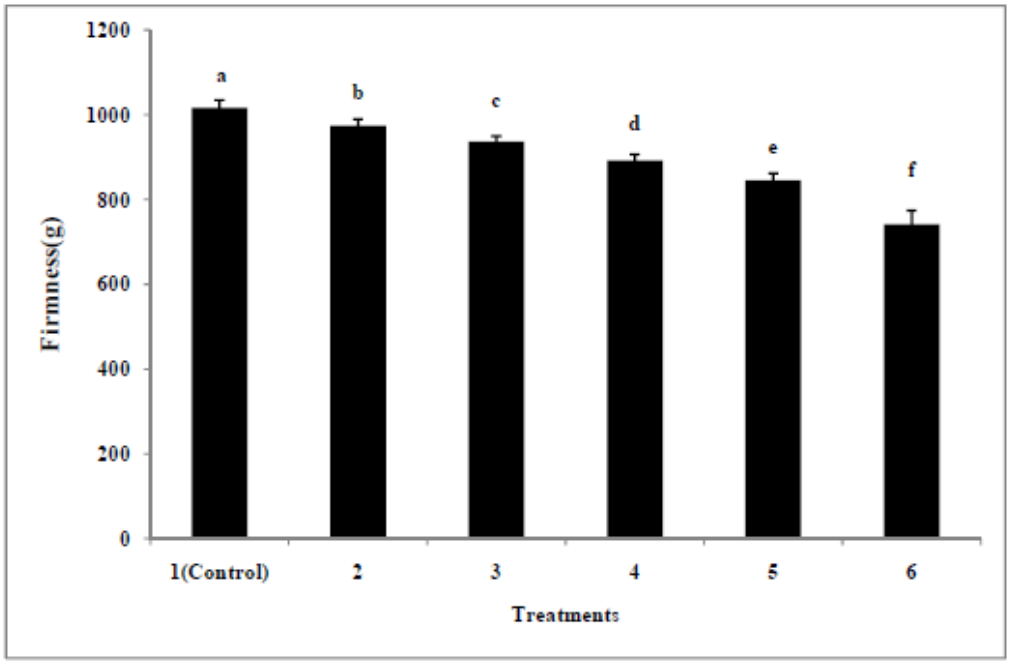

Figure 2. Firmness of the fish tofu supplemented with malva nut gum as various concentrations

For the chemical composition, the increasing of malva nut gum increased the moisture content and fiber of the fish tofu supplemented with malva nut gum. The lowest moisture content and fiber were significantly ($\rho \leq 0.05$) revealed in fish tofu control formula No. 1 (ratio of fish fillet: malva nut gum; 46:0) with the values of 65.98 ±0.66 and 1.17 ±0.33%, respectively, while the highest was significantly($\rho \leq 0.05$) shown in fish tofu control formula No. 6 (ratio of fish fillet: malva nut gum; 41:5) with the values of 68.13 ±0.08 and 2.45 ±0.21%, respectively. However, the increasing of malva nut gum decreased the lipid and protein contents of the fish tofu supplemented with malva nut gum. The lowest lipid and protein contents were significantly ($\rho \leq 0.05$) found in fish tofu formula No. 6 (ratio of fish fillet: malva nut gum; 41:5) with the values of 8.14 ±0.19 and 16.71 ±0.35%, respectively, whereas the highest was significantly ($\rho \leq 0.05$) shown in fish tofu control formula No. 1 (ratio of fish fillet: malva nut gum; 46:0) with the values of 9.61 ±0.51 and 18.37 ±0.54%, respectively. On the other hand, the increasing of malva nut gum did not significantly affect the ash and carbohydrate contents of the fish tofu supplemented with malva nut gum (Table 4).

The water activity of the six formulas of the fish tofu supplemented with malva nut gum as the ratio of fish fillet: malva nut gum, e.g.,46:0, 45:1, 44:2, 43:3, 42:4, and 41:5 were 80.23 ±0.57, 80.77 ±0.24, 82.18 ±0.27, 82.39 ±0.14, 84.20 ±0.32 and 85.63 ±0.27, respectively. The highest water activity was significantly indicated in fish tofu formula No.6 with the level of 85.63 ±0.27. Water activity and moisture content of fish tofu supplemented with malva nut gum were revealed as the same, which depended on the amount of malva nut gum.

Table 4. Chemical composition of the six formulas of fish tofu supplemented with malva nut gum as various concentrations

Formula N	Ratio of fishfillet:malva nut gum (%)	Chemical composition(%)					
		Moister content	Lipid	Protein	Fiber	Ash^{ns}	Carbohydrate^{ns}
1(Control)	46 : 0	65.98±0.66^{d}	9.61±0.51^{a}	18.37±0.54^{a}	1.17±0.33^{c}	1.45±0.24	3.42±0.15
2	45 : 1	66.88±0.26^{c}	9.18±0.43^{ab}	18.12±0.29^{ab}	1.36±0.19^{bc}	1.42±0.24	3.04±0.21
3	44 : 2	67.3±0.40^{bc}	8.78±0.41^{bc}	17.33±0.34^{bc}	1.67±0.20^{b}	1.58±0.32	3.01±0.23
4	43 : 3	67.64±0.25^{ab}	8.39±0.11^{c}	17.48±0.41^{bc}	2.06±0.13^{a}	1.30±0.21	3.13±0.47
5	42 : 4	67.87±0.30^{ab}	8.19±0.14^{c}	17.07±0.29^{c}	2.31±0.17^{a}	1.28±0.11	3.28±0.54
6	41 : 5	68.13±0.08^{a}	8.14±0.19^{c}	16.71±0.35^{d}	2.45±0.21^{a}	1.32±0.12	3.25±0.50

Mean with different letters was statistically different ($p \leq 0.05$) according to Duncan's multiple range test.

Based on the sensory evaluation criteria, formula No. 4 (Figure 3) was selected to investigate the effect of cold storage on the firmness and microbiological properties (Figure 4; Table 5). The firmness of the developed fish tofu supplemented with malva nut gum was decreased when it was kept for a longer time in cold storage. The lowest score of the firmness of developed fish tofu supplemented with malva nut gum was significantly ($p \leq 0.05$), revealed in two weeks of storage with a level of 869 g.

Figure 3. The image of developed fish tofu supplemented with malva nut gum

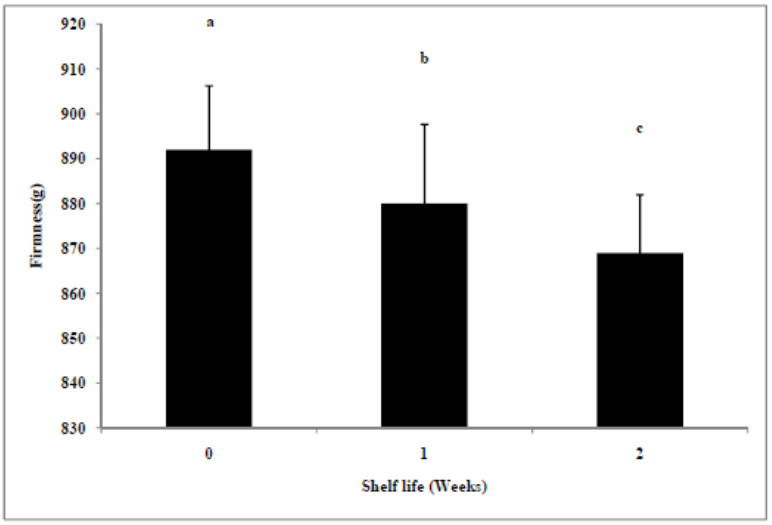

Figure 4. Effect of the shelf life of cold storage on the firmness of the developed fish tofu supplemented with malva nut gum

For the microbiological properties, the high concentration of the total viable count in two weeks of cold storage had shown the value of<$1x10^3$CFU/g (Table 5). However, the number of yeast and mold counts was stable with the level of <10 CFU/g until two weeks of cold storage. Finally, the developed fish tofu supplemented with malva nut gum was tested for its acceptance by 100 consumers by using a CLT. The results are shown in Figure 5. From the consumer testing by utilizing a CLT, the results found that most consumers (46%) rated "moderately like" (7.09), followed by 20% rated extremely like, 19% rated slightly like, 10% rated mostly like, 3% rated indifferent, and 2% rated slightly dislike, respectively.

Table 5. Effect of the cold storage time on the microbiological properties of developed fish tofu supplemented with malva nut gum

Storage time(weeks)	Total viable count(CFU/g)	Yeast and mold count (CFU/g)
0	Not detected	Not detected
1	<10	<10
2	$<1x10^3$	<10

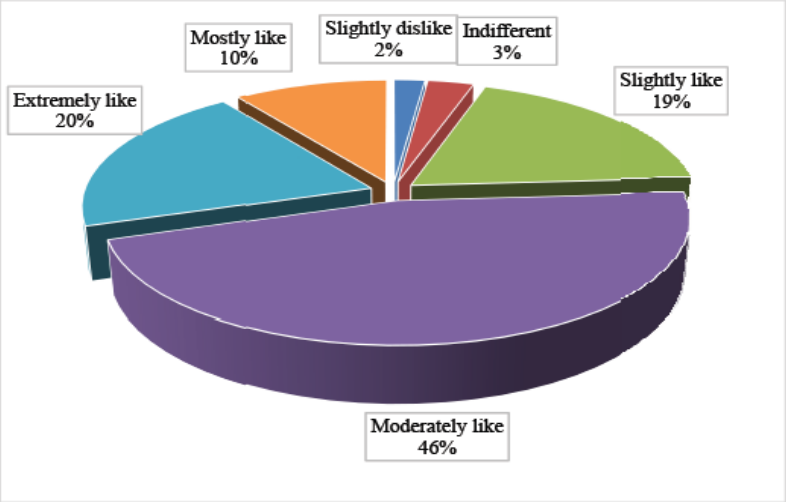

Figure 5. Sensory evaluation of developed fish tofu supplemented with malva nut gum

Discussion

In the development of fish tofu supplemented with malva nut gum, it was discovered that fish tofu supplemented with malva nut gum as the ratio of fish fillet: malva nut gum of 43:3 (formula No.4) had the highest preference scores for the attributes of aroma, taste, and overall liking that was accepted by the

consumers. For the color preference, the consumers did not like darkened fish tofu that was mixed with a high amount of malva nut gum. This could be the the fiber form of malva nut gum that could make small black spots on fish tofu, so the acceptance in the color was reduced according to the concentration of mixing the gum.

For the color parameters, the increasing of the amount of malva nut gum tended to decrease the lightness (L*), whereas the redness (a*) and yellowness (b*) were increased. The reason for this could be the concentration of the malva nut gum increased in the brown color of the fish tofu; therefore, the lightness (L*) of all treatments was reduced and increased the redness (a*) and yellowness (b*) instead as the concentration of the malva nut gum mix. This investigation concurred with Phimolsiripol *et al.* (2017), who indicated that the lightness (L*) of bread decreased with the increased malva nut gum level.

For the evaluation of the firmness, the increasing of malva nut gum decreased the firmness of fish tofu supplemented with malva nut gum. It occurred due to during the formation of the gel of fish tofu, the protein unfolded, thus exposing the functional group imbedded inside the myosin. These functional groups were subsequently involved in the formation of the intra and inter bonds during the aggregation process to form a three-dimensional network (Ketnawa *et al*., 2016). Hence, the addition of malva nut gum (water soluble fiber) could possibly interrupt or disconnect the myofibrilar protein gel network resulting in a loss of the gel's strength. These results corresponded with the consumers' acceptance in the texture parameter, and this preference of acceptance decreased the dependence on the adding of malva nut gum.

For the chemical composition, the increasing of malva nut gum increased the moisture content and fiber of fish tofu supplemented with malva nut gum, while the lipid and protein contents decreased the level of the malva nut. It could be due to the malva nut gum was a water-soluble polysaccharide, which interacted with the hydrogen bond of the water molecule. Therefore the moisture and fiber contents were increased due to the dependence on the adding of the concentration of malva nut gum. It was consistent with Srichamroen (2014) who showed that the extracted malva nut gum significantly increased the loaf volume and moisture content by 1.5-12%, and 8.2-12.8 %, respectively compared to that of the control. Moreover, the level of malva nut gum increased, which affected the increase of the moisture content and water activity.

Then, formula No. 4 was investigated the effect of cold storage on the firmness and microbiological properties. The firmness and viable cell count of the developed fish tofu supplemented with malva nut gum were decreased as a

result of the longer time of cold storage. It could be due to the gel's strength of fish tofu mixed with malva nut gum was initially unstable and soft. The firmness was reduced after a long period of cold storage.

Lastly, from the consumers' testing by utilizing CLT, the results found that most consumers (46%) rated "moderately like". It could be improved by adding other gelling agents, fiber, and herbs in order to modify the most appropriate quality of fish tofu supplemented with malva nut gum.

In conclusion, this study is strongly suggested that our investigation reported as a new product development of fish tofu supplemented with malva nut gum. Moreover, this tofu could be produced as a health food for consumers in the future in terms of high fiber content. On the other hand, for the effects of the health benefits and furtheractual production, the production costs could be monitored. For improving the nutritional value, the addition of probiotic microorganisms combined with other dietary fibers and phytochemicals in fish tofu could be considered as an alternative method.

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