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Product Development of Sweet Fish Sauce from Dried White Shrimp: Sensory Evaluation, Physical and Chemical Quality and Nutrition

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Abstract

This research aimed to study the product development of sweet fish sauce from dried white shrimps (shrimp weight 5.0-6.7 g). All of the samples were compared. Data showed that the modified recipe containing 30% palm sugar, 25% unbleached sugar cane, 9% fish sauce, 13.8% water, 5.5% dried white shrimp, 16% shallot and 0.7% chili had a higher satisfaction and acceptance score than the basic recipes, with a statistically significant difference at $p< 0.05$. The CIE LAB values of both the basic recipes and the modified one had statistically significant differences at $p< 0.05$ as the modified recipe had a lighter color. At the same time, there were no statistically significant differences at $p\geq0.05$ in terms of the viscosity of liquid and a_w. The Guideline Daily Amounts (GDAs) of the modified recipe indicate that one package (five servings) of 230 g consists of 600 kcal, 115 g of sugar, 0 g of fat and 1,050 g of sodium. The shelf life of the modified recipe was 60 days. The CIE LAB values, viscosity of liquid and a_w had no statistically significant differences at $p\geq0.05$. The modified recipe also had an overall acceptance level of 7.98 on the nine-point hedonic scale, which means that the 100 consumers who tasted the final products were highly satisfied. With regard to acceptance of this newly modified recipe (MC1), 98% and 95% of consumers would be highly likely to be willing to buy the products when they were released. Most of the consumers agreed that the selling price was reasonable (86%) and 82% were satisfied with the packaging. The enterprise would gain 40% more income, the compensation for members would increase by 24% and 175 kg of small white shrimps would be purchased from shrimp farmers for drying and producing the sweet fish sauce.

Introduction

Sweet fish sauce is one type of Thai dipping sauce with a unique intense sweetness and a slightly salty and spicy taste. This sauce is not too thick and not too watery, and is generally served with sour or sweet and sour fruits. Sour and unripe mango with sweet fish sauce is the classic combination. However, in the present, sweet fish

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sauce is modernized and adapted to be served with both Thai seasonal fruits and foreign fruits such as santol, salacca, rose apple, guava, plango, apple and strawberries. Sweet fish sauce is a simple dipping sauce with simple preparation. Each recipe has its own distinctive details, yet main ingredients are usually similar, consisting of palm sugar, cane sugar, fish sauce, shallot, dried shrimp and chili. Currently, sweet fish sauce is now distributed and sold in superstores or various souvenir shops depending on packaging. It is generally produced in glass packaging and sealed tight to prolongate its shelf life and make it easy to store if unconsumed (Phungbunhan, 2016; Songsuk, 2008). This is correlated with the rising trends in entrepreneurs or food industry dealers taking an interest in sweet fish sauce, which could become a supplementary vocation or profession and lead to selling both offline and online. More than 150 packages of some sweet fish sauce brands could be sold per day (Chumkam, 2019; Sentangsedtee Online, 2021; PPTV Online, 2021). Due to the rising demands in the market, ingredients required to produce sweet fish sauce are highly sought-after, resulting in higher earnings for farmers, e.g. chili, shallot and shrimp farmers.

Dried white shrimp is one of the essential ingredients for sweet fish sauce since dried shrimp adds texture and thickness to the sauce. Also, the full-flavored, balanced and rich taste of the sauce comes from dried shrimp. *Litopenaeus vannanmei* comes from shrimp farms in Ongkharak District, Nakhon Nayok Province. According to the white shrimp farming statistics from Nakhon Nayok Provincial Fisheries Office (2021), there are approximately 424 shrimp farmers in Ongharak District with roughly 8,670.50 rai of farming area, total producing 2,030.45 tons of shrimp annually. Upon interviewing the director of shrimp processing community enterprise, Buranasuont (2020) on the shrimp farming context and sweet fish sauce processing issues, it became obvious that there are two categories of shrimp farming in Ongkharak District: farming with Nile Tilapia fish, and sole and shrimp farming. Combined farming with Nile Tilapia fish usually produces shrimp four times per annum and shrimp sizes differ in each catch. It is due to the fact that this type of farming relies on natural correlation of the fish and shrimp. Shrimp collect oxygen from fish and consume fish feed products and fish waste, while fish consume shrimp waste and dead shrimp, keeping the water clean. Therefore, shrimp caught from such farming differ in size and shrimp weighing 5.0-6.7 g are usually unwanted in the market. Generally, shrimp farmers use such shrimp as fertilizer or process it into other animal feed products. The shrimp processing community enterprise acknowledges the issue and purchases such shrimp from local farmers to produce small dried white shrimp for sweet fish sauce.

Due to that reason, the researchers focused on developing sweet fish sauce using dried shrimp weighing 5.0-6.7 g. The developed recipe was investigated and modified to create a stable and standard taste in every product. Consequently, the researchers analyzed the sensory evaluation of each sweet fish sauce recipe in order to select the most satisfying recipe based on data collected from research samples. Not only the sensory evaluation was tested, but the researchers also conducted a study on physical and chemical quality, nutrition, shelf life and consumer approval of the modified sweet fish sauce, consistent with the previous research on sweet fish sauce, e.g. the study of Khumwachirapithak et al. (2017). According to Khumwachirapithak et al. (2017), the optimum recipe of sweet fish sauce consisted of palm sugar, fish sauce, dry shrimp, shallot, dry chili and water to produce this sweet fish sauce, dry shrimp are put in boiling water for 10 seconds, palm sugar and fish sauce are then added, controlling the temperature at 160°C during the process, then cool down to 80°C. The total soluble solid should be 75°Brix. Then added dry chili, shallot, ground dry shrimp, and boiled dry shrimp and mix well. Check total soluble solids again; the designated value is 75°Brix. After that, fill in glass bottles.

Hence, this research produced a ready-to-sell sweet fish sauce product, evaluating product processing from community materials and creating a new product for the community enterprise. This product is considered as one of Nakhon Nayok Province's OTOP products, creating career opportunities, increasing members' revenue and supporting local shrimp farmers. This corresponds to the RMUTT Flagship Strategy on Agro-food Innovation, aiming to develop innovation, provide academic output and develop agricultural and processing skills for those who are interested. By doing so, value could be added to local materials (Policy and Planning Division, RMUTT, 2020). Not only is it correlated with the RMUTT plan but it is also in line with the National Strategy 2018-2037 on developing competitive skills in agro-processing using agricultural products to create new products (Economic and Social Development Board, 2018).

Materials and methods

1. Raw material preparation

The ingredients used to produce sweet fish sauce, which were purchased from supermarkets and market stores, included palm sugar (Mitr Phol, Mitr Phol Group., Thailand), unbleached sugar cane (Mitr Phol, Mitr Phol Group., Thailand), shrimp paste (Trachang, Tang Thai Chiang Fish-sauce Manufacturing Co.Ltd., Thailand), fish sauce (Trachang, Tang Thai Chiang Fish-sauce Manufacturing Co.Ltd., Thailand), dried shrimp (community enterprise in the group of shrimp processing, Nakhon Nayok, Thailand), shallot (fresh market., Thailand), dried chili (fresh market, Thailand) and water (Nestle, Perrier Vittel (Thailand) Co.Ltd.).

2. Preparation for drying small white shrimp

The white shrimp weighing 5.0-6.7 g, purchased from shrimp farmers, were thoroughly washed as the first preparation step. The heads were then peeled off and the peeled shrimps were washed again. The shrimp were boiled in boiling water for 5 minutes. After boiling, the boiled shrimp were rinsed and added to the Chaichana 12-storey gas dryer, produced by the Chaichana company, Thailand. The drying process took 30 minutes at 100°C. After that, the heat was lowered to 70°C and the process was continued for 3 h, each time with 30 kg of boiled shrimp. Once all the shrimp were completely dried, it was found that approximately 3 kg of small dried white shrimp had been produced, as displayed in Fig. 1.

Fig. 1 Dried white shrimp

3. The study on the standard recipe

The research investigated three recipes, as shown in Table 1. The research was conducted as follows. Sugar was added to fish sauce and water and gently mixed. Then it was brought to the boil. Shrimp, shallot and dry chili were added to the thickened mixture and stirred until it boiled. The samples were stored at room temperature. The results were analyzed in terms of sensory evaluation by following the nine-point hedonic scale criteria (1 = dislike extremely and 9 = like extremely). The sweet fish sauce was evaluated on its appearance, color, smell, salty flavor, sweetness, spiciness, viscosity and overall acceptance. Testers for this research were 30 trained panelists from the Department of Food and Nutrition, Rajamangala University of Technology Thanyaburi.

Table 1 Basic sweet fish sauce recipes

Ingredients	Basic recipe 1 (%) (BC1)	Basic recipe 2 (%) (BC2)	Basic recipe 3 (%) (BC3)
Palm sugar	30	40	40
Unbleached sugar cane	25	-	5
Shrimp paste	-	6	5
Fish sauce	8	12	15
Water	15	20	19
Dried shrimp	7	10	5
Shallot	14	9	6
Dried chili	1	3	5

Remark: Basic recipe 1 (BC1) was modified from Khumwachirapithak et al. (2017), Basic recipe 2 (BC2) was modified from Manuntapong (2019) and Basic recipe 3 (BC3) was modified from Chumkaew (2018)

4. Development of the basic recipes and the production process

The basic sweet fish sauce recipe (BC1), which received the highest satisfaction scores in the sensory evaluation test, was selected, and the recipe was developed and modified resulting in a new recipe (Table 2) which was based on the evaluation results and suggestions. The novel recipe was then evaluated in comparison to the basic one as follows.

Table 2 Sweet fish sauce recipes

Ingredients	Basic recipe 1 (%) (BC1)	Modified recipe (%) (MC1)
Palm sugar	30	30
Unbleached sugar cane	25	25
Fish sauce	8	9
Water	15	13.8
Dried shrimp	7	5.5
Shallot	14	16
Dried chili	1	0.7

4.1 Sensory evaluation of the basic sweet fish sauce and the modified recipe

The basic sweet fish sauce recipe, which received highest acceptance score, was later analyzed in comparison with the modified recipe by using the nine-point hedonic scale (1 = dislike extremely and 9 = like extremely). The plain sweet fish sauce was

evaluated on its appearance, color, smell, salty flavor, sweetness, spiciness, viscosity and overall acceptance scores. Testers for this research were 30 trained panelists from the Department of Food and Nutrition, Rajamangala University of Technology Thanyaburi. All of samples were served with unripe mango. During the tasting test, panelists are required to drink water prior to the next sample testing. Results were used to further develop the recipe.

4.2 Analysis of the physical and chemical quality of the basic and modified recipes

The physical quality of the plain sweet fish sauce was analyzed under the CIE LAB L* a* b* system by using a Minolta colorimeter CR-300 model (Minolta Co., Ltd., Osaka, Japan) and the viscosity analysis was performed five times with a CSC Scientific Bostwick consistometer model 1-800-458-2558. The chemical quality analysis on water activity (a_w) was performed five times with an Aqualab water activity meter and the basic recipe was compared with the modified one.

4.3 Nutrition study of the modified recipe

The modified recipe was analyzed based on the criteria of one serving weighing 100 g. The nutritional criteria consisted of total energy and energy from fat (Ralph, 1995), total fat (AOAC, 2019), saturated fat and cholesterol (in-house method) (Bureau Veritas AQ Lab (Thailand) Limited, 2021), sodium (in-house method TPT-FS-252TM)(Bureau Veritas AQ Lab (Thailand) Limited, 2021), total carbohydrate (Ralph, 1995), dietary fiber (AOAC, 2019), sugar and protein (in-house method)(Bureau Veritas AQ Lab (Thailand) Limited, 2021), vitamin A (in-house method TPT-FS-262TM) (Bureau Veritas AQ Lab (Thailand) Limited, 2021), vitamin B1 and vitamin B2 (in-house method TPT-FS-271TM) (Bureau Veritas AQ Lab (Thailand) Limited, 2021), calcium and iron (in-house method TPT-FS-252TM) (Bureau Veritas AQ Lab (Thailand) Limited, 2021) and moisture and ash (AOAC, 2019)

5. The study on sweet fish sauce shelf life

The sweet fish sauce in glass packaging stored at a room temperature of 30°C was tested for its shelf life according to physical quality. The plain sweet fish sauce was analyzed by using the CIE LAB L* a* b* system and the color analysis was performed by using Minolta colorimeter CR-300 model (Minolta Co., Ltd., Osaka, Japan), and the viscosity analysis was performed five times with a CSC Scientific Bostwick consistometer model 1-800-458-2558. The chemical properties were tested five times with an Aqualab water activity meter at 0, 10 ,20, 30, 40, 50 and 60 days after production to define the shelf life of the sweet fish sauce.

6. The study on consumer acceptance of the sweet fish sauce product

The study was conducted by simple random sampling from 100 consumers in Rajamangkala University of Technology Thanyaburi and by using a questionnaire. The questionnaire consisted of three parts: Part 1 Personal Information, such as gender, age, profession, income and frequency of sweet fish sauce consumption; Part 2 Sensory Evaluation, performed using the nine-point hedonic scale (1 = dislike extremely and 9 = like extremely). The plain sweet fish sauce was evaluated on its appearance, color, smell, salty flavor, sweetness, spiciness, viscosity and overall acceptance. The sample preparation is similar to part 4.1. Part 3 of the questionnaire was based on attitude toward the sweet fish sauce product: approval and acknowledgment, purchase decision, proper selling price and proper packaging.

7. The study on production and distribution of sweet fish sauce products from the shrimp processing community enterprise

The researchers instructed the shrimp processing community enterprise on the production process of the sweet fish sauce and shared technology and innovation with them in order that entrepreneurs could later use such knowledge to produce their products and distribute them as Nakhon Nayok Province's OTOP products. The researchers collected selling data from October 2020-July 2021 on the following categories; the amount of small dried white shrimp for sweet fish sauce (kg), total sold (packages), total income (baht), increase in income from sweet fish sauce distribution (%) and increase in compensation for the shrimp processing community enterprise members (%).

8. Statistical analysis

Both the study on basic sweet fish sauce recipes and the study on shelf life involved analysis using descriptive statistics: mean and standard deviation. Analysis of Variance (ANOVA) and average comparison using Duncan's New Multiple Range Test (DNMRT) at a 95% confidence interval were also conducted. Furthermore, the sensory evaluation and physical and chemical quality of both the basic recipe and the modified one were analyzed by Dependent T Test at a 95% confidence interval. The study on consumer approval of sweet fish sauce was carried out by using SPSS program, version 22, in terms of statistical analysis. (SPSS, 2018).

Results and discussion

1. The study on basic sweet fish sauce recipes

According to the sensory evaluation results of three basic sweet fish sauce recipes, as illustrated in Table 3, basic recipe 1 (BC1) was highly accepted by the 30 panelists in all characteristics with statistically significant differences at $p< 0.05$. Further comments indicated that the panelists found the taste of basic recipe 1 (BC1) most likable due to the lack of shrimp paste, since shrimp paste usually produces an unpleasant smell and sweet fish sauce with shrimp paste normally has a darker shade of color than those without it. In addition to these arguments, shrimp paste causes issues in quality control. Therefore, the researchers selected this basic recipe (BC1) to adapt and develop further.

Table 3 Sensory evaluation scores of three basic sweet fish sauce recipes (n = 30)

Characteristics	Basic recipe 1 (BC1)	Basic recipe 2 (BC2)	Basic recipe 3 (BC3)
Appearance	$8.56^{a} \pm 0.50$	$6.96^{b} \pm 0.61$	$6.23^{c} \pm 0.72$
Color	$8.53^{a} \pm 0.50$	$7.06^{b} \pm 0.69$	$6.50^{c} \pm 0.93$
Smell	$8.43^{a} \pm 0.50$	$6.40^{b} \pm 0.96$	$6.16^{b} \pm 0.94$
Salty Flavor	$8.56^{a} \pm 0.50$	$6.33^{b} \pm 0.80$	$5.90^{c} \pm 0.95$
Sweetness	$8.50^{a} \pm 0.50$	$5.96^{b} \pm 1.09$	$5.33^{b} \pm 0.75$
Spiciness	$8.06^{a} \pm 0.69$	$6.33^{b} \pm 0.99$	$5.63^{c} \pm 0.92$
Viscosity	$8.13^{a} \pm 0.68$	$6.70^{b} \pm 0.83$	$5.80^{c} \pm 0.99$
Overall acceptance	$7.90^{a} \pm 0.66$	$6.30^{b} \pm 0.70$	$6.33^{b} \pm 0.66$

Remark: The *a, b,* and *c* superscripts in the same row indicate the order of ac ceptance with regard to each characteristic ($p< 0.05$), All values are shown as mean ± S.D.

2. The results of recipe development and the production process

According to the sensory evaluation results, basic recipe 1 (BC1) was highly accepted. Thus, basic recipe 1 (BC1) was selected and developed into a new modified recipe (MC1) following suggestions from panelists, by focusing on the production process to create a stable and standard quality product. The adaptation and modification of the recipe was done by adding more fish sauce, reducing the amount of small dried white shrimp (some were finely blended, others were whole shrimp), adding more shallot (peeled, thoroughly rinsed, then finely chopped into 1 mm pieces and baked in air dryers at 100°C for 30 minutes), reducing the amount of chili (rinsed and dried, then chopped into 2 mm pieces) and reducing the amount of water.

The production process was also developed in order to create a stable recipe and standard taste, as shown in Fig. 2. Palm sugar, unbleached sugar cane, and fish sauce were mixed with water and simmered over low heat. After the sugar had dissolved, the mixture was heated over a high heat until it thickened at a temperature controlled at 112°C using a thermometer in order to create a standard viscosity in every production. Once the sauce was stable, whole dried shrimp and blended shrimps, dried shallot and dried chili were added and it was stirred for 3 minutes. The sauce was poured equally into pasteurized glass packages, each containing 230 g, and allowed to cool in order to seal the package. The appearance of the modified sweet fish sauce in comparison to the sauce of the basic recipe is displayed in Fig. 3.

Fig. 2 Sweet fish sauce production process (a) Add palm sugar, unbleached sugar cane, fish sauce and water to the pot; (b) Stir over a low heat until the sugar dissolves; (c) Heat over a high heat at 112°C until it thickens; (d) Add small dried white shrimp, shallot and chili; (e) Stir thoroughly for 3 minutes; (f) Pour into pasteurized glass packaging, each containing 230 g, and seal tightly for later distribution

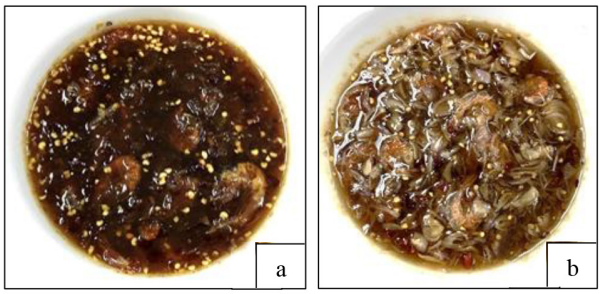

Fig. 3 Sweet fish sauce, basic recipes and modified recipes (a) Basic recipe (BC1) (b) Modified recipe (MC1)

According to the analytical results of the comparison of basic (BC1) and modified recipes (MC1) of sweet fish sauce by 30 panelists, as shown in Table 4, the samples preferred the modified recipe over the basic one with statistically significant differences at $p<0.05$. The scores according to each characteristic indicate that MC1 has higher sensory test scores in all attributes (appearance, color, smell, salty flavor spiciness and overall acceptance). However, the sweetness and viscosity scores of both recipes were slightly different with no statistical significance. Hence, it could be assumed that the modified recipe of sweet fish sauce was preferred over the basic one. Therefore, the researchers adopted the modified recipe (MC1) for further development.

Table 4 Sensory evaluation of basic and modified sweet fish sauce recipes (n=30)

Characteristic	Basic recipe (BC1)	Modified recipe (MC1)
Appearance	$6.43^{b} \pm 0.97$	$8.10^{a} \pm 0.71$
Color	$6.20^{b} \pm 0.84$	$8.50^{a} \pm 0.50$
Smell	$6.13^{b} \pm 1.04$	$8.06^{a} \pm 0.82$
Salty Flavor	$7.26^{b} \pm 0.78$	$7.90^{a} \pm 0.85$
Sweetness^{ns}	7.60 ± 1.06	7.80 ± 0.66
Spiciness	$6.93^{b} \pm 1.01$	$7.53^{a} \pm 0.77$
Viscosity^{ns}	7.83 ± 1.17	7.73 ± 0.58
Overall acceptance	$6.00^{b} \pm 1.11$	$8.36^{a} \pm 0.55$

Remark: $^{a, b}$ superscripts in the same row refer to the order of acceptance regarding characteristics with statistically significant differences at a confidence interval with $p<0.05$

^{ns} refers to no statistically significant differences ($p\geq0.05$)

The comparison of physical and chemical qualities of basic and modified sweet fish sauce recipes, as illustrated in Table 5, reveals that the L* (lightness) a* (redness) and b* (yellowness) of both recipes had statistically significant differences at $p<0.05$ as the L* of the modified recipe was at 17.72, which was higher than the 13.84 of the basic recipe, signifying a lighter shade of color compared to the basic recipe. This was due to the fact that more processes had been added to the modified recipe, the amount of water had been lessened and the diced shallot had been air-dried before being added to the sauce to reduce simmering time and to allow the sauce to reach a constant heat of 112°C 10 minutes faster than the basic recipe. Temperature control is the core factor in producing a constant and stable color of sauce in every production. Without temperature control, the color and viscosity will not be constant since the temperature is likely to differ in every production. For example, the higher the heat or the longer the simmering period, the more likely the sweet fish sauce is of a darker shade. This corresponds to one of the factors of the Maillard reaction, the temperature, due to the fact that the Maillard reaction increases once the temperature rises and the color changes according to the heat (Rattanapanone, 2002). It is also in line with Andrew et al. (2002) statement that the longer the simmering period was, the darker the shade of the sample would be. Furthermore, a process was developed where palm sugar, cane sugar, fish sauce and water are stirred together, dissolving the sugar before turning on the heat in order to reduce the brownish shade of color from the Maillard reaction (Sitachitta, 2012; Khumwachirapithak et al., 2017). By doing so, caramelization from using high heat with sugar is also reduced since caramelization occurs once sucrose is exposed to temperatures higher than 120°C (Fadel & Farouk, 2002; Zhang et al., 2013). The a* and b* color values of the modified recipe were also higher than the basic recipe. The a* value of the modified recipe was 5.18 and the b* value was 10.76, indicating more red and yellow shades compared to the basic recipe. At the same time, the viscosity and water activity (a_w) of both recipes could barely be distinguished, with no statistically significant differences at $p\geq0.05$. This might be due to the fact that temperature control was performed using a thermometer during production; therefore, viscosity and water activity (a_w) of both recipes showed no significant differences.

Table 5 The physiochemical properties comparison of basic and modified sweet fish sauce recipes (n=5)

Characteristic	Basic recipe (BC1)	Modified recipe (MC1)
L*	$13.84^{b} \pm 0.68$	$17.72^{a} \pm 0.61$
a*	$4.10^{b} \pm 0.30$	$5.18^{a} \pm 0.57$
b*	$5.78^{b} \pm 0.40$	$10.76^{a} \pm 1.46$
Consistency (cm./second)^{ns}	0.60 ± 0.06	0.61 ± 0.02
$a_w{}^{ns}$	0.650 ± 0.04	0.670 ± 0.02

Remark: $^{a, b}$ superscripts in the same row refer to the order of acceptance regarding characteristics with statistically significant differences at a confidence interval with $p<0.05$.

^{ns} refers to no statistically significant differences ($p\geq0.05$)

Upon studying the nutrition of the modified recipe, as displayed in Table 6, it was revealed that the modified recipe contained energy equal to 250 kcal per 100 g package and 120 kcal per serving. Energy from fat was equal to 3.24 kcal per 100 g package or 0 kcal per serving. The total amount of fat was equal to 0.36 g per 100 g package and 0 g per one serving. The amount of protein was equal to 4.58 g per 100 g package and 2 g per serving, while the amount of carbohydrate was 57.1 g per 100 g or 26 g per serving. Dietary fiber amounted to 0.88 g per 100 g or 0 g per serving, and the amount of sugar was equal to 50.7 g per package or 23 g per serving. Sodium amounted to 458 mg per 100 g or 210 mg per serving. It could be assumed that one serving of sweet fish sauce (or 46 g), approximately three tablespoons, consisted of nutritional amounts at levels not exceeding the Thai Recommended Daily Intakes (Thai RDI) for people over six years of age based on a daily energy requirement of 2,000 kcal (Ministry of Health, 1998). Thus, it is safe to consume. However, frequency of consumption is a concern and it is not recommended to consume it regularly due to the high amount of sucrose in sweet fish sauce (50.7 g per 100 g). This is correlated with the research of Khumwachirapithak et al. (2017) which established that there was a high amount of sucrose in sweet fish sauce (44.71 g per 100 g of the sauce). Hence, consumers with a hyperglycemia condition need to be cautious and consumers are advised to exercise regularly (Bureau of Nutrition, Department of Health, 2011).

Table 6 Nutrition labeling-Thai RDI

Test Item	Per 100 g	Per Serving (46 g)	%Thai RDI
Total energy (kcal)	250	120	-
Energy from fat (kcal)	3.24	0	-
Total fat (g)	0.36	0	0
Saturated fat (g)	ND	0	0
Cholesterol (mg)	ND	0	0
Protein (g)	4.58	2	-
Total carbohydrate (g)	57.1	26	9
Dietary fiber (g)	0.88	0	0
Sugar (g)	50.7	23	-
Sodium (mg)	458	210	11
Vitamin A (μg)	ND	-	0
Vitamin B1 (mg)	ND	-	0
Vitamin B2 (mg)	ND	-	0
Calcium (mg)	18.7	-	0
Iron (mg)	0.48	-	0
Moisture (g)	35.0	-	-
Ash (g)	2.94	-	-

3. The study on sweet fish sauce shelf life

As displayed in Table 7, regarding the results of the shelf life of sweet fish sauce in glass packaging and its physical and chemical qualities over a period of 0-60 days, it was established that the L* (lightness), a* (redness), b* (yellowness), viscosity and water activity (a_w) values barely indicated any statistical significant differences at $p \geq 0.05$. However, such values are highly likely to increase. The L* value was recorded at 16.68-18.04, the a* at 3.60-4.28 and the b* at 9.88-11.65, while the viscosity was recorded at 0.60-0.65 cm/second. One factor which might affect sweet fish sauce's physical and chemical qualities is the glass packaging since glass packaging prevents air permeability and steam, leaves contained food unaffected and is heat resistant (Soroka, 2002; Petchwattana, 2020). Thus, sweet fish sauce contained in such containers is well preserved, since a fish sauce packaging process which uses glass bottles preserves the quality and color of fish sauce better than one which uses plastic bottles (Kongpun, 2010). In addition to the mentioned factors, the study is also consistent with Bacigalupi et al. (2016), who found that glass packaging could decelerate oxidation in fruit juice better than PET bottles and preserve more antioxidants.

Furthermore, the water activity (a_w) was at 0.67-0.71, befitting of the standards for community products, which state that the water activity (a_w) of sweet fish sauce may not exceed 0.80 (Community Product Standards, 2003). This is also consistent with the research of Khumwachirapithak et al. (2017), which found that the water activity (a_w) of a modified recipe sweet fish sauce was 0.74 and aerobic plate counts at 3.7 x 10^2 with the amount of yeast and mold at < 10 cfu/g. The data in this research, similar to our study, indicated that the number of microbial growths in sweet fish are likely not to affect the quality of product. The water activity value (a_w), however, affects the microbial growth in which water activity (a_w) lower than 0.7 decelerates the microbial growth (Rattanapanone, 2006).

Table 7 Physiochemical properties of the modified recipe affecting its shelf life at 0, 10, 20, 30, 40, 50 and 60 days (n=5)

Day	L^{*ns}	a^{*ns}	b^{*ns}	Consistency (cm./second)^{ns}	$a_w{}^{ns}$
0	17.08 ± 0.66	3.60 ± 0.49	9.88 ± 0.83	0.60 ± 0.05	0.670 ± 0.03
10	16.68 ± 1.21	3.72 ± 0.53	10.30 ± 0.46	0.61 ± 0.05	0.670 ± 0.08
20	16.86 ± 1.35	3.92 ± 0.44	10.70 ± 1.74	0.62 ± 0.02	0.680 ± 0.03
30	17.24 ± 0.75	4.08 ± 0.98	10.80 ± 1.19	0.62 ± 0.02	0.690 ± 0.05
40	17.42 ± 0.99	4.10 ± 1.07	11.05 ± 1.36	0.63 ± 0.02	0.700 ± 0.06
50	17.76 ± 0.86	4.28 ± 1.65	11.40 ± 1.24	0.64 ± 0.02	0.700 ± 0.34
60	18.04 ± 0.36	4.16 ± 0.27	11.65 ± 1.46	0.65 ± 0.03	0.710 ± 0.02

Remark: ^{ns} refers to no statistically significant differences in a column ($p \geq 0.05$)

4. The results of the overall acceptance of consumers

The collected personal information from 100 consumers showed that 79% were female and 21% were male. The dominant age group was 16-20 years of age (52%), followed by age 21-25 (20%), age 26-30 (13%), age 31-35 (10%) and age 36 or above (5%), respectively. In total, 65% of the consumers were students, while 26% were university staff and 9% were lecturers. Consumers' monthly income was categorized as follows: 56% had an average monthly income of 5,000-10,000 baht, 27% had 10,000-20,000 baht of monthly income and 17% had a monthly income higher than 20,000 baht. Moreover, regarding the frequency of sweet fish sauce consumption, 45% consumed it 2-5 times a month, 38% consumed it once a month and 17% consumed it 2-3 times a month.

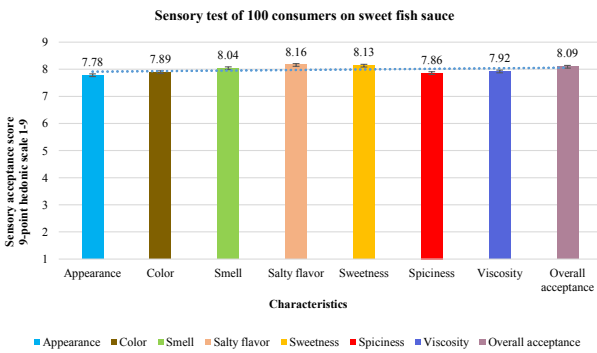

Fig. 4 The results of a sensory test of 100 consumers on sweet fish sauce

According to Fig. 4 the results of a sensory test of 100 consumers on sweet fish sauce, the data proposes that consumers accepted sweet fish sauce in all attributes (7.78-8.16). With regard to consumers' attitude toward sweet fish sauce, analysis showed that 98% of consumers accepted this modified recipe and 95% would be very likely to purchase it once the product was officially released. Most of the consumers agree that a selling price of 65 baht per package is favorable (86%) and 82% see the packaging as suitable and appealing. This is consistent with the research of Chumkaew et al. (2019); Chumkaew (2019); Punfujinda et al. (2019); Chumkaew et al. (2020) on product development. They argued that most consumers are likely to accept and purchase products once they are on the market. However, questionnaire respondents have suggested that there should be a wider variety of packaging and more than one level of spiciness to meet the demands of a range of consumers and the expanding market.

5. The results of sweet fish sauce production and distribution by the shrimp processing community enterprise

According to the shrimp processing community enterprise's financial statement, as displayed in Table 8, the total value of the fish sauce sold was 109,200 baht, or approximately 10,920 baht of monthly income. The income increased by 40% and members' compensation also increased by 24%. Besides, the price is 10-15% cheaper compared to the commercial products. However, there are some commercial products having the same price or within similar price range with our product. This is due to the ingredients added to each product and different qualities.

Table 8 The results of sweet fish sauce production and distribution by the shrimp processing community enterprise

Details of sweet fish sauce production and distribution October 2020-July 2021	Total
Amount of small dried white shrimp for sweet fish sauce (kg)	17.50
Total sales (packages)	1,680
Total sales (baht)	109,200
Increase in income (%)	40
Increase in compensation for members (%)	24

Remark: Community Enterprise in the Group of Shrimp Processing (2021)

Conclusion

The research established and developed modified sweet fish sauce products from small white shrimp consisting of 30% palm sugar, 25% unbleached sugar cane, 9% fish sauce, 13.8% water, 5.5% dried white shrimp, 16% shallot and 0.7% dried chili in 230 g in glass packaging. One package contains five servings (46 g per serving). As indicated by the GDAs, one serving would consist of 120 kcal, 23 g of sugar, 0 g of fat and 210 ml of sodium and the shelf life would be 60 days. The L* (lightness), a* (redness), b* (yellowness), viscosity and water activity (a_w) values barely indicated any statistical significance at $p \geq 0.05$. The a_w was relatively low at 0.67-0.71 and was in line with the standards of community products, which state that it should not exceed 0.80. The sensory evaluation of the final pre-distributed sweet fish sauce resulted in an average acceptance score of 7.89, which means that the testers liked the product extremely, according to the criteria. Furthermore, data collection from October 2020-July 2021 revealed that small white shrimp weighing 5.0-6.7 g were processed into 17.50 kg of dried shrimp, or 175 kg of raw shrimp. This illustrates the economic support for shrimp farmers, which helps

to reduce the problem of low prices for small shrimp. It also shows that it is profitable for the community enterprise to process these shrimps into other products and gain increasing incomes from a wider selection of products, in this case, sweet fish sauce.

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