Journal of Food Health and Bioenvironmental Science
Journal homepage : http://jfhb.dusit.ac.th/

Development of Healthy Ready-to-Cook Sauce for Thai Food

Varaporn Vittayaporn[a]*, Ekapon Onnompun[a] & Weerapong Wirunthanakrit[b]

[a] *School of Culinary Arts, Suan Dusit University, Bangkok, 10300 Thailand*
[b] *Research and Development Institute, Suan Dusit University, Bangkok, 10300 Thailand*

Article info

Article history:
Received: 20 July 2023
Revised: 21 August 2023
Accepted: 25 August 2023

Keywords:
Ready-to-cook, Sauce, Thai food, Tea seed oil, Gac fruit

Abstract

Thai cuisine is widely popular both domestic and international. Thai cuisine is characterised by the use of herbs and spices as ingredients to provide unique flavors. However, due to the vast variety of ingredients and the delicacy in preparing or even the difficulty in acquiring the ingredients indicated in the recipes, the flavors of the dish are very likely to be distorted from authenticity. This research therefore developed ready-to-cook sauces for Thai food to increase convenience for consumers and to survey consumers' acceptance of these products. Additionally, tea seed oil and powdered Gac fruit were utilised for their health-wise beneficial values. The developed ready-to-cook sauces included Pad Thai sauce and Ka Phrao (Holy basil) sauce. The results of product acceptance test indicated that consumers rated the liking scores for Pad Thai sauce and Ka Phrao sauce in the range between like moderately and like very much (8.2±1.3 and 7.8±1.2). Over 92% of the consumers accepted both sauce products, and more than 89% decided to purchase the products. Hence, the development of the healthy ready-to-cook sauces as products are viable for commercial distribution.

Introduction

Thai cuisine combines a variety of ingredients to create deliciousness as well as offering health advantages, such as using less oil in cooking especially for vegetables, as the raw foods have great nutritional value. Nowadays, Thai food has gained wide popularity both within Thailand and abroad. The highlight of Thai food is the use of herbs and spices as ingredients to create a unique aroma. As a result of the numerous ingredients and seasonings used in Thai cuisine, it can be challenging to create, and occasionally it may be impossible to locate all the necessary components, which results in the cooked dish tasting different from the original recipe. In addition, Thai cuisine preparation involves complicated processes and steps, and it takes a long time to cook. Therefore, this inconvenience may be solved by getting instant meals. The application of current manufacturing processes and raw ingredients to enable easier Thai cooking is fascinating. Consequently, the research team has created ready-to-cook seasoning sauce formulas for Thai food that are popular with both Thais and foreigners, including Pad Thai sauce and Ka Phrao sauce, which consumers may use to prepare a range of

* Corresponding Author
e-mail: Varaporn_vit@dusit.ac.th

foods. The convenience of usage and storage were both considered by the researchers in order for it to be utilized internationally.

The Codex Alimentarius defines sauces as "substances added to food to enhance aroma and taste". They have always been a significant component of culture across the world, and now that they are being used more often in daily life, they are becoming more significant from both a nutritional and financial perspective (García-Casal et al., 2012). Many different factors can be used to categorize sauces, such as their geographical origin (e.g., Italian, Indian, or Japanese sauces), serving temperature (e.g., warm or cold sauces), flavor (e.g., mild or hot sauces), acidity (e.g., low-acid or acid sauces), sweetness (e.g., sweet or salty sauces) and color (e.g., brown, pink, or green sauces). Sauces are an essential part of the human diet and have a significant added value. It's interesting to use healthy ingredients as components of ready-to-cook sauces. Tea seed oil and Gac (*Momordica cochinchinensis*) fruit aril powder were employed as sauce ingredients in this study. Unsaturated fatty acids found in tea seed oil, which include 81–87% oleic (Omega-9), 13–28% linoleic (Omega-6) and alpha-linoleic acid (Omega-3), can lower levels of harmful cholesterol, encourage the production of healthy cholesterol and reduce the risk of developing chronic non-communicable diseases such as cardiovascular disease, diabetes, and obesity (Kim et al., 2008). Tea seed oil also contains a number of antioxidants, which assist in cancer prevention (Liu et al., 2022). In an application test for soy sauce, Choi et al. (2018) determined green tea seed extract as a healthy food preservative and reported antibacterial substances that eliminated all yeast below the minimum inhibitory concentration (MIC) value.

Color is an important factor for enhancing attractive value and consumer acceptability of foods and beverages. For a variety of purposes, including to ensure uniformity, maintain stability throughout the shelf life, and contribute to a desired flavor, color is added to soups, sauces and condiments (Corradini, 2019). Depending on the physical form and end-user usage, different colors may be needed for these applications. Color performance can be considerably affected by processing issues including heat, pressure, pH and interactions with other ingredients (Dey & Nagababu, 2022). For stability in sauces, soups and condiments, a variety of synthetic food colors are provided. However, the scientific community has turned its attention to natural colorants that serve to replace their synthetic harmful counterparts due to the belief in bio-safety measures, health advantages and the nutritional significance of food colors (Manzoor, 2021). The use of natural colorants like the carotenoid pigment in Gac fruit arils may be beneficial for the consumers' health because they have outstanding antioxidant properties (Kha, 2010). Nevertheless, there is still little research on the use of Gac fruit aril as a natural colorant in food and beverages. Thuy et al. (2023) investigated the addition of Gac fruit aril and xanthan gum with functional properties and natural coloring compounds to macaroni. They found the physicochemical components, bioactive compounds, firmness, microstructure and cooking quality of the products highlighted the significance of the ingredients utilized in the outcomes. Kumkong et al. (2020) studied the color quality of whey protein-mixed gelatin with Gac fruit aril powder that changed to a dull color during storage. El Haggar et al. (2023) developed a new tomato-free sauce formula fortified with beneficial oils and contained in nanometer capsules that enhanced the product's nutritional value and antioxidant capacity and may have beneficial effects on general health in relation to biochemical factors including lipid profile and liver function. The ultimate goal is to market this new mixture as a beneficial product that can boost immunity and potentially even enhance health. The investigation of the impacts and advantages of the novel product will involve biological studies. Therefore, in this study, we used tea seed oil and Gac fruit aril powder to develop healthy formulas for ready-to-cook sauces for Thai cuisine, analyzed their properties, including sensory, physical and chemical properties and tested the customer acceptability of these sauces.

Materials and methods

1. Materials

The following ingredients were used to make ready-to-cook sauces: tea seed oil (Patpat, Chiang Rai, Thailand), Gac fruit (Kanchanaburi, Thailand), fish sauce (Tiparos, Bangkok, Thailand), sugar (Mitr Phol, Bangkok, Thailand), coconut sugar (Lin, Bangkok, Thailand), chili sauce (Mabin, Samutsakhon, Thailand), tamarind paste (Aro, Pathumthani, Thailand), red chili (Thewet Market, Bangkok, Thailand), holy basil (Thewet Market, Bangkok, Thailand), and Xanthan gum (Ziboxan® F80, China).

2. Preparation of Gac fruit aril powder

Freeze-dry Gac fruit aril sample has been generated in accordance with the method indicated by Kumkong et al. (2018). The Gac aril sample was processed by filtering and separating the seeds before being mixed with maltodextrin DE10 at a ratio of 5 g/100 g (w/w) and freeze dried at the National Food Institute, Thailand. Condenser temperature was -20 C and pressure was 250 Pa for 48 hr during operation. Before usage, a powder sample of freeze-dried aril was stored at 4°C and packaged individually in aluminum foil.

3. Formulation of healthy ready-to-cook sauce

3.1 Pad Thai Sauce

The prototype Pad Thai sauce consisted of tamarind paste, fish sauce, sugar, coconut sugar, chili sauce, vinegar and chili powder (Onnompun, 2012). The formulation was developed by replacing unhealthy ingredients with healthy ones, such as vegetable oil was substituted with tea seed oil, to prevent the noodles from sticking during the stir-frying process. As well as using Gac fruit aril powder as a coloring agent for the sauce to have even color and antioxidants from Gac fruit. According to research by Kha et al. (2015), Gac fruit aril powder can be used in a variety of foods, including yogurt, cake and pasteurized milk, to maintain color consistency during processing, enhance the amount of beta-carotene and lycopene and lessen the peroxide value or rancid smell. The prototype Pad Thai sauce formulation and the other sauce with gac fruit aril powder and tea seed oil replacement are shown in Table 1.

Table 1 The ingredients of the prototype Pad Thai sauce and the tea seed oil and Gac fruit aril powder replacement formulation

Ingredients (%)	Prototype*	Tea seed oil and Gac fruit aril powder replacement
Tamarind paste	17.05	16.12
Fish sauce	17.05	16.12
Sugar	21.24	20.15
Coconut sugar	21.24	20.15
Chili Sauce	8.48	8.05
Vinegar	8.48	8.05
Chili powder	1.70	1.61
Vegetable oil	4.76	-
Tea oil seed	-	9.67
Gac fruit aril powder	-	0.08

Source: *Onnompun (2012)

3.2 Ka Phrao sauce

Pad Ka Phrao is one of the most famous dishes in Thailand. It is a single-dish meal that can be stir-fried with multiple choices of meat. Table 2 presents a modified formula for Ka Phrao sauce that substitutes tea seed oil for vegetable oil and the prototype formula from Onnompun (2012).

Table 2 The ingredients of the prototype Ka Phrao sauce and the tea seed oil replacement formulation

Ingredients (%)	Prototype*	Tea seed oil replacement formulation
Chopped garlic	11.1	11.1
Chopped bird-chili	11.1	11.1
Holy basil	11.1	11.1
Fish sauce	11.1	11.1
Oyster sauce	5.6	5.6
Sugar	5.6	5.6
Water	22.2	22.2
Vegetable oil	22.2	-
Tea seed oil	-	22.2

Source: *Onnompun (2012)

3.3 Production process of ready-to-cook sauce

Each sauce was put into 250 ml glass bottles, which was pasteurized in boiling water at 90°C. They were then kept at room temperature until cooled, as indicated in Fig. 1.

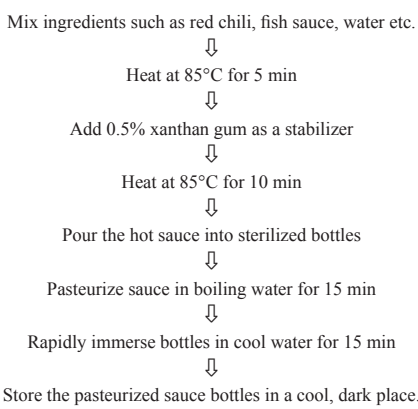

Fig. 1 Production process of ready-to-cook sauce (250 mL)

4. Sensory evaluation of ready-to-cook sauce

4.1 Preparation of ready-to-cook sauce

Pad Thai sauce

Noodles should be stir-fried with 60 g of Pad Thai sauce for every 100 g of noodles.

Ka Phrao sauce

Stir-fry chicken diced (1.0x1.0 cm) in Ka Phrao sauce with 50 g of sauce for every 100 g of chicken were stir-fried and served with rice.

4.2 Sensory evaluation

Sensory evaluation was conducted with 50 panelists who lived in Bangkok, Thailand. Target

panelists were chosen based on how frequently they used ready-to-cook sauce, at least once per month. They were asked to rate ready-to-cook sauce samples for a degree of liking regarding color, aroma, saltiness, sweetness, sourness, spiciness and overall liking using a 9-point hedonic scale (1: "Dislike extremely", 9: "Like extremely") (Lawless & Heyman, 1998).

5. Physical and chemical properties of ready-to-cook sauce

5.1 Color (L*, a*, b*) of the ready-to-cook sauce, measured using a colorimeter (MiniScan EZ, model MSEZ-4500L, USA).

5.2 Viscosity was performed with Brookfield Viscometer (Brookfield LVDV-E, US).

5.3 pH value was determined using the digital pH meter (Mettler Toledo, Switzerland).

6. Microbiological qualities of ready-to-cook sauce

Microbiological qualities of ready-to-cook sauce was determined by total plate count and yeast and mold according to AOAC. (2000).

7. Acceptability test

A survey was conducted to determine the acceptance of target consumers who consume ready-to-cook sauce at least once a month. The survey used questionnaires that included demographic information, data on consumer liking scores for the product using a 9-point hedonic scale, and data on the acceptance of 100 panelists using a binary (yes/no) scale. The sample preparation process for the acceptability test followed the same methods as the sensory evaluation section.

8. Statistical analysis

Formulation data of ready-to-cook sauce compared the means with t-test. The results of acceptance test comprised of the frequency (percentage) and the average "like" score of consumers toward the developed ready-to-cook sauce. Statistically difference was established at $p<0.05$.

Results and discussion

1. Formulation of healthy ready-to-cook sauce

1.1 Pad Thai sauce

Using the prototype Pad Thai sauce and the Pad Thai sauce with tea seed oil and gac fruit aril powder to prepare Pad Thai, the results from testing sensory characteristics using the 9 point hedonic scale (1: "dislike extremely", 9: "like extremely") (Lawless & Heyman, 1988) with 50 participants are shown in Table 3.

Table 3 Mean liking scores of the prototype ready-to-cook Pad Thai sauce and the developed ready-to-cook Pad Thai sauce with tea seed oil and Gac fruit aril powder

n=50

Sensory attributes	Mean liking score	
	Prototype formula	Developed formula
Color	7.0±1.1[b]	7.6±1.3[a]
Aroma [ns]	7.1±1.3	7.2±1.1
Saltiness [ns]	7.1±1.0	7.2±1.6
Sweetness [ns]	7.2±1.2	7.4±1.4
Sourness [ns]	7.1±1.1	7.2±1.5
Spiciness [ns]	7.2±1.3	7.2±1.4
Overall liking	7.1±1.3[b]	7.5±1.2[a]

Remark: Means in rows followed by different letters represent significant differences ($p\leq0.05$)

[ns] = Means in row do not have significant differences ($p>0.05$)

The results were statistically analyzed by comparing the means of the 2 Pad Thai sauce groups using T-test. The liking scores for the aroma, saltiness, sourness and spiciness have no significant difference between the 2 groups ($p>0.05$). Meanwhile, the liking scores for the color, sweetness and overall liking of the Pad Thai sauce with tea seed oil and gac fruit aril powder were higher than the prototype formula with statistical significance ($p\leq0.05$) since the added gac fruit aril powder provided a more appealing red-orange color to the Pad Thai which positively affects the overall liking of the participants (Do et al., 2019).

1.2 Ka Phrao sauce

Using the prototype Ka Phrao sauce and the tea seed oil-substituted Ka Phrao sauce to prepare Chicken Ka Phrao, the results from testing sensory characteristics using the 9 Point hedonic scale (1: "dislike extremely", 9: "like extremely") (Lawless & Heyman, 1988) with 50 participants are shown in Table 4.

Table 4 Mean liking scores of the prototype ready-to-cook Ka Phrao sauce and the developed ready-to-cook Ka Phrao sauce with tea seed oil

n=50

Sensory Attributes	Mean liking score	
	Prototype formula	Developed formula
Appearance	7.0±1.0[b]	7.4±1.2[a]
Aroma	7.0±1.4[b]	7.4±1.2[a]
Saltiness [ns]	7.1±1.1	7.1±1.3
Sweetness [ns]	7.2±1.2	7.4±1.2
Spiciness [ns]	7.1±1.3	7.2±1.2
Overall liking	7.2±1.3[b]	7.5±1.2[a]

Remark: Means in rows followed by different letters represent significant differences ($p\leq0.05$)

[ns] = Means in row do not have significant differences ($p>0.05$)

The results were statistically analyzed by comparing the means of the 2 Ka Phrao sauce groups using T-test. The liking scores of the saltiness, sweetness and spiciness had no significant differences ($p>0.05$). However, the liking scores of the appearance, aroma and overall liking for the tea seed oil-substituted Ka Phrao sauce were significantly higher than the prototype formula ($p\leq0.05$) due to the tea seed oil's sensory characteristics being accepted by the participants-colorless and has no undesirable flavors (Chen, 2007), which positively influenced the overall liking score for the tea seed oil-substituted Ka Phrao sauce.

2. Physical and chemical properties of ready-to-cook sauce

2.1 Pad Thai sauce

The Pad Thai sauce with tea seed oil and gac fruit aril powder underwent chemical and physical characteristics testing, including the pH value, color value and viscosity. As shown in Table 5, the pH value of the sauce was 3.2-3.4, which is due to acidic ingredients, i.e., tamarind paste, vinegar and chili sauce. The color value of the Pad Thai sauce is brown-orange; when measured with MiniScan EZ MSEZ-4500L colorimeter, the L* (perceptual lightness) value was 10.4-10.6 showing that the sauce was slightly dark in color since many ingredients were dark-colored; the a* value was marginally positive meaning the sauce had a slight red color, due to the addition of gac fruit aril powder which gave a red-orange color; the b* value was positive, signifying the yellowness of the sauce. The prototype formula sauce had a higher viscosity than the developed formula sauce, as indicated by the viscosity measurement with the Brookfield LVDV-E, since the formula had fewer liquid components than the other sauce.

Table 5 Chemical and physical characteristics of Pad Thai sauce with tea seed oil and Gac fruit aril powder

Chemical and physical characteristics	Prototype formula	Developed formula
pH^{ns}	3.2 ± 0.0	3.4 ± 0.0
Color values		
L* ^{ns}	10.6 ± 0.3	10.4 ± 0.5
a* ^{ns}	0.8 ± 0.3^{b}	1.0 ± 0.4^{a}
b* ^{ns}	8.0 ± 0.7^{a}	7.7 ± 0.9^{b}
Viscosity (centipoise; cP)	23212.25 ± 598.12^{a}	22758.55 ± 634.24^{b}

Remark: L* is the perceptual lightness, value in the range 0 – 100 where
0 signifies black-colored subject, 100 signifies white-colored subject
a* (+) signifies subject with red color, (–) signifies subject with green color
b* (+) signifies subject with yellow color, (–) signifies subject with blue color
Means in rows followed by different letters represent significant differences ($p\leq0.05$)
^{ns} = Means in row do not have significant differences ($p>0.05$)

2.2 Ka Phrao sauce

The tea seed oil-substituted Ka Phrao sauce was tested for its chemical and physical characteristics, which includes the pH value, color value and viscosity. As listed in Table 6, the pH value of the Ka Phrao sauce is 4.4-4.5 and the color of the sauce is brown. When measured with MiniScan EZ MSEZ-4500L colorimeter, the L* value is 17.0-17.3 meaning the sauce has a dark color; the a* is marginally positive meaning the sauce is slightly red; the b* value is positive signifying the yellowness of the sauce. The developed Ka Phrao sauce has a lighter color and a higher viscosity than the developed Pad Thai sauce, as the Ka Phrao sauce contains holy basil leaves, minced chili and garlic, which adds to the viscosity of the sauce.

Table 6 Chemical and physical characteristics of tea seed oil-substituted Ka Phrao sauce

Chemical and physical characteristics	Prototype formula	Developed formula
pH^{ns}	4.5 ± 0.0	4.4 ± 0.0
Color values		
L* ^{ns}	17.3 ± 1.4	17.0 ± 1.6
a* ^{ns}	2.1 ± 0.8	2.3 ± 0.9
b* ^{ns}	16.9 ± 1.0	16.7 ± 0.9
Viscosity (centipoise; cP)^{ns}	41178.23 ± 398.56	41229.33 ± 421.58

Remark: L* is the perceptual lightness, value in the range 0 – 100 where
0 signifies black-colored subject, 100 signifies white-colored subject
a* (+) signifies subject with red color, (–) signifies subject with green color
b* (+) signifies subject with yellow color, (–) signifies subject with blue color
^{ns} = Means in row do not have significant differences ($p>0.05$)

3. Microbiological qualities of ready-to-cook sauce

Microbiological qualities of the Pad Thai sauce with tea seed oil and gac fruit aril powder and tea seed oil-substituted Kra Phrao sauce were determined as shown in Table 7, which indicates the microorganisms growing and yeast and mold meets the standard of Thailand Ministry of Public Health Notification No 355 B.E. 2556 (2013) Food in a Hermetically Sealed Container.

Table 7 Microbiological qualities of Pad Thai sauce with tea seed oil and Gac fruit aril powder and tea seed oil-substituted Kra Phrao sauce

Microorganism type	Pad Thai sauce with tea seed oil and Gac fruit aril powder	Tea seed oil-substituted Kra Phrao sauce	Ministry of Public Health Notification No 355 B.E. 2556 (2013) Food in a Hermetically Sealed Container
Total Plate Count (CFU/g)	< 10	< 10	< $1x10^3$
Yeast and mold (CFU/g)	< 10	< 10	< $1x10^2$

4. Acceptability test

Table 8 presents the results of the study on consumer acceptance of the developed ready-to-cook Pad Thai sauce. The study included 100 panelists from the Bangkok Metropolitan Area and covered demographic information as well as consumer liking and acceptability tests.

Table 8 Demographic data

Demographic attributes	Frequency (percentage)
1. Gender	
- Male	50
- Female	50
2. Age	
- 20 – 31 years old	30
- 31 – 40 years old	25
- 41 – 50 years old	20
- More than 50 years old	25
3. Education level	
- High school diploma	7
- Bachelor's degree	48
- Higher than bachelor's degree	45
4. Occupation	
- Student	32
- Government official	34
- Housewives	5
- Private company employees	25
- Personal business	4
5. Average monthly income	
- Less than 10,000 THB	18
- 10,001 – 20,000 THB	41
- 20,001 – 30,000 THB	27
- More than 30,000 THB	14

4.1 Pad Thai sauce

The results of investigating consumers' liking on the 9-point hedonic scale of the developed ready-to-cook Pad Thai sauce in its color, aroma, saltiness, sweetness, sourness, spiciness and overall liking revealed that consumers' likings scored in every characteristic at the "like very much" level (7.7-8.2), as shown in Table 9.

Table 10 presents the results of customers' acceptability and purchase decisions about the created ready-to-cook Pad Thai sauce.

Table 9 Mean liking scores of the developed ready-to-cook Pad Thai sauce

n=100

Sensory attributes	Mean liking scores
Color	8.2 ± 1.4
Aroma	7.8 ± 1.6
Saltiness	7.7 ± 1.3
Sweetness	8.0 ± 1.1
Sourness	7.7 ± 1.5
Spiciness	7.8 ± 1.3
Overall liking	8.2 ± 1.3

According to the findings of the survey of customers' acceptance and decision to purchase the developed ready-to-cook Pad Thai sauce, 98% accepted the product and 92% chose to purchase the developed ready-to-cook Pad Thai sauce.

Table 10 Consumers' acceptance on the developed ready-to-cook Pad Thai sauce

n=100

Data	Frequency (percentage)
Consumers' acceptance on the developed ready-to-cook Pad Thai sauce	
- Accept	98
- Not accept	2
Decision on purchasing the developed ready-to-cook Pad Thai sauce	
- Purchase	92
- Not purchase	8

4.2 Ka Phrao sauce

Results of the investigation into consumers' preferences for the ready-to-cook Ka Phrao sauce in terms of color, aroma, saltiness, sweetness, spiciness and overall preference on 9-point hedonic scale revealed that consumers' preferences scored in each category at the "like moderately" to "like very much" level (7.5-7.9), as shown in Table 11.

Table 12 illustrates the findings of the survey of customers' acceptance and purchase decision regarding the developed ready-to-cook Ka Phrao sauce.

Table 11 Mean liking scores of the developed ready-to-cook Ka Phrao sauce

n=100

Sensory attributes	Mean liking scores
Appearance	7.8 ± 1.1
Aroma	7.9 ± 1.5
Saltiness	7.5 ± 1.3
Sweetness	7.6 ± 1.3
Spiciness	7.5 ± 1.0
Overall liking	7.8 ± 1.2

Table 12 Consumers' acceptance on the developed ready-to-cook Ka Phrao sauce

n=100

Data	Frequency (percentage)
Consumers' acceptance on the developed ready-to-cook Ka Phrao sauce	
- Accept	94
- Not accept	6
Decision on purchasing the developed ready-to-cook Ka Phrao sauce	
- Purchase	90
- Not purchase	10

A survey of customers' acceptance and decision to purchase the developed ready-to-cook Ka Phrao sauce found that 94% accepted the product and 90% decided to purchase the developed ready-to-cook Ka Phrao sauce.

Conclusion

This study incorporates the use of tea seed oil as a replacement of vegetable oil in various types of ready-to-cook sauce, to utilize the benefits of tea seed oil as it is trans-fat free and has high levels of unsaturated fatty acids, which reduces LDL cholesterol and increases HDL cholesterol. Moreover, Gac fruit aril powder was used to enhance the color consistency of Pad Thai sauce, while reducing rancidity and benefiting from antioxidants. Overall, the study has been able to develop a guideline in developing healthy ready-to-cook sauces. The acceptability test for the ready-to-cook sauces also showed consumer acceptability in the levels of "Moderately Like" to "Like Very Much", which confirms the feasibility of commercializing the production of these ready-to-cook sauces for Thai food, to satisfy the consumers' demand for convenience in food preparations and health benefits. Furthermore, the knowledge of ready-to-cook sauces for Thai food can be applied to cooking in both domestic and international Thai restaurants. The developed ready-to-cook sauces may also be utilized as alternatives for people who are concerned about their health.

Acknowledgments

Appreciation is given to the National Research Council of Thailand (NRCT) and Suan Dusit University for the financial support.

References

Onnompun, E. (2012). *Principles of Thai cuisine.* Bangkok: Suan Dusit Rajabhat University Book Center.

AOAC. (2000). *Official method of analysis* (17th ed.). Arlington, Virginia: Association of Official Analytical Chemists.

Chen, Y.H. (2007). *Physicochemical properties and bioactivities of tea seed (Camellia oleifera) oil* (Master's thesis). South Carolina: Clemson University.

Choi, J.H., Kim, J., Jeong, E.T., Choi, T.H., & Yoon, T.M. (2018). Preservative effect of *Camellia sinensis* (L.) Kuntze seed extract in soy sauce and its mutagenicity. *Food Research International, 105,* 982 – 988.

Corradini, M.G. (2019). Synthetic food colors. *Encyclopedia of Food Chemistry, 1,* 290-296.

Dey, S., & Nagababu, B.H. (2022). Applications of food color and bio-preservatives in the food and its effect on the human health. *Food Chemistry Advances, 1,* 100019.

Do, T.V.T., Fan, L., Suhartini, W., & Girmatsion, M. (2019). Gac (Momordica cochinchinensis Spreng) fruit: A functional food and medicinal resource. *Journal of Functional Foods, 62,* 103912.

El Haggar, E.F., Mahmoud, K.F., Ramadan, M.M., & Zahran, H.A. (2023). Tomato-Free wonder sauce: A functional product with health-boosting properties. *Journal of Functional Foods, 109,* 105758.

García-Casal, M.N., Peña-Rosas, J.P., & Malavé, H.G. (2016). Sauces, spices and condiments: Definitions, potential benefits, consumption patterns and global markets. *Annals of the New York Academy of Sciences, 1379*(1), 3–16.

Kha, T.C., Nguyen, M.H., & Roach, P.D. (2010). Effects of spray drying conditions on the physicochemical and antioxidant properties of the Gac (*Momordica cochinchinensis*) fruit aril powder. *Journal of Food Engineering, 98,* 385 – 392.

Kim, N.H., Choi, S.K., Kim, S.J., Moon, P.D., Lim, H.S., Choi, I.Y., … Na, H.J. (2008). Green tea seed oil reduces weight gain in C57BL/6J mice and influences adipocyte differentiation by suppressing peroxisome proliferator-activated receptor-gamma. *Pflügers Archiv: European Journal of Physiology, 457*(2), 293–302.

Kha, T.C., Nguyen, M.H., Roach, P.D., & Stathopoulos, C.E. (2015). A storage study of encapsulated gac (*Momordica cochinchinensis*) oil powder and its fortification into foods. *Food and Bioproducts Processing, 96*(10), 113-125.

Kumkong, N., Thumthanaruk, B., & Banjongsinsiri, P. (2018). Factors affecting stability of lycopene and ß-carotene from Gac aril powder by freeze drying. *Journal of Food Science and Agricultural Technology, 4,* 73-78.

Kumkong, N., Banjongsinsiri, P., Laohakunjit, N., Vatanyoopaisarn, S., & Thumthanaruk, B. (2020). Influence of natural colour blends of freeze-dried Gac aril and pulp on the quality of whey protein-mixed gelatin-based chewables. *Heliyon, 6,* e05817.

Lawless, T.H., & Heyman, H. (1998). *Sensory evaluation of food-principles and practices.* New York: International Thomson Publishing.

Liu, G., Zhu, W., Zhang, J., Song, D., Zhuang, L., Ma, Q., … Yang, X. (2022). Antioxidant capacity of phenolic compounds separated from tea seed oil *in vitro* and *in vivo. Food Chemistry, 371,* 131122.

Manzoor, M., Singh, J., Gani, A., & Noor, N. (2021). Valorization of natural colors as health-promoting bioactive compounds: Phytochemical profile, extraction techniques and pharmacological perspectives. *Food Chemistry, 362,* 130141.

Thailand Ministry of Public Health. (2013). *The standard of Thailand Ministry of Public Health Notification No 355 B.E. 2556* [A.D. 2013]. Food in a Hermetically Sealed Container, Bangkok: Thailand Ministry of Public Health.

Thuy, N.M., Phung, N.T.T., Giau, T.N., Tien, V.Q., Tai, N.V., & Minh, V.Q. (2023). Gac aril and gum xanthan supplementation in wheat macaroni pasta production. *Acta Sci. Pol. Technol. Aliment, 22*(1), 71–80.