

Research Article

Production and Quality Evaluation of Dried Banana Stem Flavored with Miang-Kham Sauce

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ABSTRACT

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The production and quality evaluation of dried banana stem (BS) flavored with Miang-kham sauce (MS) were investigated. This research was focusing on three aspects. Firstly, conduct an evaluation of the effect of herbal ingredients on the quality of MS. Four treatments were studied, including 1) Control-MS, 2) Nutmeg-MS, 3) Ginger-MS, and 4) Nutmeg/Ginger-MS. It was found that nutmeg and ginger contributed to the color quality by significantly ($p < 0.05$) decreasing the brightness (L^*) value, redness (a^*) value, and yellowness (b^*) values. Additionally, the type of herb was found to have significant influence on the preference of the panelists. The highest sensory evaluation score was recorded for Ginger-MS: "Like Very Much" in color (8.00) and "Liking Extremely" in other characteristics, aroma (8.23), taste (8.73), texture (8.63), and overall acceptability (8.70). Second, find a suitable preparation method of BS. Acid immersion (acetic acid solvent) co-operated with the steaming or boiling method was chosen for the designation of seven different treatments. Results showed that the steaming or boiling method had significantly ($p < 0.05$) lower color (brightness (L^*), redness (a^*), and yellowness (b^*)) and Whiteness Index than the combination method. The 1.0% w/w acetic acid immersion co-operated with the steaming method (1.0AIS) and was the appropriate treatment. Finally, determine the appropriate concentration of MS on dried BS quality in the drying process, hot air dryer at 65°C. Using four different Ginger-MS concentration: 0%, 20.00%, 25.00%, and 33.33%. The result presented that 33.33% Ginger-MS was the optimal concentration, with the dried BS yielding 23.60%. Dried-Ginger-MS-BS had a moisture content and water activity that did not exceed the standard limit specified in Thai Community Product Standard "Dried Fruit and Vegetable" 136/2015. The liking mean score of sensory acceptability was described as "Like Extremely" in all characteristics. The investigation from this research provided a guideline for the potential to produce the BS flavored with MS for a healthy dried food product high in dietary fiber. Nevertheless, further research should investigate strategies for appropriate packaging method and product shelf life.

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1. Introduction

Drying is a type of food preservation based on the principle of removing water from food. In the past, the common sunlight method was to evaporate water from food. Later, with the development of science, various techniques of dry food processing were developed, such as using the evaporation principle with a solar oven, an electric oven, microwave ovens,

spray dryers, and using the vacuum principle with the freeze-drying method. Each method has different advantages and disadvantages, but the products will be in the same quality: lightweight and convenient to store and transport. Hot air drying is a widely used method because the equipment and maintenance are low cost. Upholsin (2010) reported that blanching fresh pandan leaves at 90°C for 3 min and drying at

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50°C for 6 h is the most appropriate. Tabklang *et al.* (2021) reported the optimal drying condition for pickled santol is 60°C for 8 h.

The banana stalk is the pseudo-stem of the banana tree, an herbaceous plant that grows well in all regions of Thailand. It is commonly consumed and used as an ingredient in savory dishes such as spicy curry with coconut milk and sour curry. Yasaswini *et al.* (2021) reported the nutritional composition of banana pseudo-stem flour from the inner tender core. The moisture content was 7.46%, protein 6.72%, fat 2.86%, ash 28.91%, carbohydrate 39.17%, crude fiber 14.86%, and total phenol 172.27 mg of GAE/100 g. Banana pseudo-stems are rich in dietary fiber, which helps to treat constipation and weight loss. They are also rich in antioxidants, antimicrobial, antitumor, antiallergic, and antiurolithiatic properties, which helps to fight against various diseases and keep the human body healthy.

Miang-kham is an ancient Thai food. It is found in the royal composition "Kap He Chom Khrueang Wang or Poem praising snake set" by King Rama VI, Thailand (Na-Songkhla, n.d.). In 2014, the Department of Cultural Promotion, Ministry of Culture, announced the registration of "Miang-kham" as a national cultural heritage (Sanamchandra Palace Library, 2018). This food has been popular until today because it has a unique herbal composition of side dishes with MS. The definition is provided in the Thai Community Product Standards 671/2004. "Miang-kham sauce" means a product made by simmering sugar with water and adding spices such as galangal, ginger, and shallots. It may be mixed with glucose syrup or corn syrup, dried shrimp, roasted coconut, fish sauce, grilled or roasted shrimp paste or not until it has the right thickness (Thai Industrial Standards Institute, 2004). There has been research to develop Miang-kham flavored products. Deepanya (2013) reported on the development of Miang-kham Khao Luem Pua products with a ratio of 1 part Miang-kham ingredients to 1 part MS. The Miang-kham components are comprised of puffed rice, 1 part; roasted peanuts, 1 part; dried shrimps, 0.25 parts; dried betel leaves, 0.05 parts; and roasted coconut, 1 part. Banthat *et al.* (2023) reported the development of a healthy Miang-kham stick product. The formulated product comprised dry ingredients,

including soy protein (12.84%), roasted coconut (11.85%), puffed rice (14.81%), cashew nuts (9.75%), dried betel leaves (0.50%), and garden chili (0.25%). The liquid phase consisted of MS prepared with ginger (1.44%), galangal (1.92%), lemongrass (1.60%), shallots (6.89%), vegetarian shrimp paste (3.21%), coconut sugar (16.35%), isomalt (5.77%), vegetarian soy sauce (3.21%), Indian gooseberry juice (4.81%), glucose syrup (3.21%), and lime juice (1.60%). However, in the commercial market, the only industrial product with Miang-kham flavor was potato chips. Therefore, it was an interesting research issue to apply Miang-kham flavor to another product different from the above data. In this research, we focused on the application of MS to BS, available locally and commonly used as an ingredient in various food menus, to obtain the Miang-kham flavored dried food product.

The objectives of this study were to investigate the production of dried BS flavored with MS, focusing on three aspects: (1) conducting an evaluation of the effect of herbal ingredients on the quality of MS, (2) finding a suitable preparation method of BS, and (3) determining the appropriate concentration of MS on dried BS quality in the drying process.

2. Materials and Methods

2.1 Effect of herbal ingredients on the quality of MS

The experiment was conducted using Completely Randomized Design (CRD), with the MS formula as a factor of the experimental treatments, totaling four experimental treatments. Each experimental treatment contained the basic ingredients of the Control-MS formula as follows: coconut sugar (57.51%), fish sauce (23.57%), dried shrimp (7.42%), shrimp paste (3.16%), galangal (2.78%), lemongrass (2.78%), and shallots (2.78%) adapted from Wongnai (2018). The treatments were as following Table 1.

The preparation steps of MS in all treatments can be illustrated as shown in Figure 1 and Figure 2. In the treatment with herb addition, ginger or nutmeg was cleaned, cut, and added into the mixture of the cut galangal, lemongrass and shallots. MS from all treatments were analyzed for quality.

Table 1 Experimental treatments of MS formula.

Treatment		Description of MS formula
1	Control-MS	Control-MS
2	Nutmeg-MS	Nutmeg (4%w/w) in control-MS
3	Ginger-MS	Ginger (4%w/w) in control-MS
4	Nutmeg/Ginger-MS	Nutmeg (4%w/w) and ginger (4%w/w) in control-MS

2.2 Effect of the preparation methods on the quality of BS

In this study, BS of Kluai namwa (*Musa sapientum* Linn) were used by selecting the 3rd-6th layer next to the core of BS. They were washed with clean water and cut into pieces

measuring 3x6 cm. The experimental design was CRD. The BS preparation method was the factor of the experimental treatments. There were seven experimental treatments, as in the following Table 2.

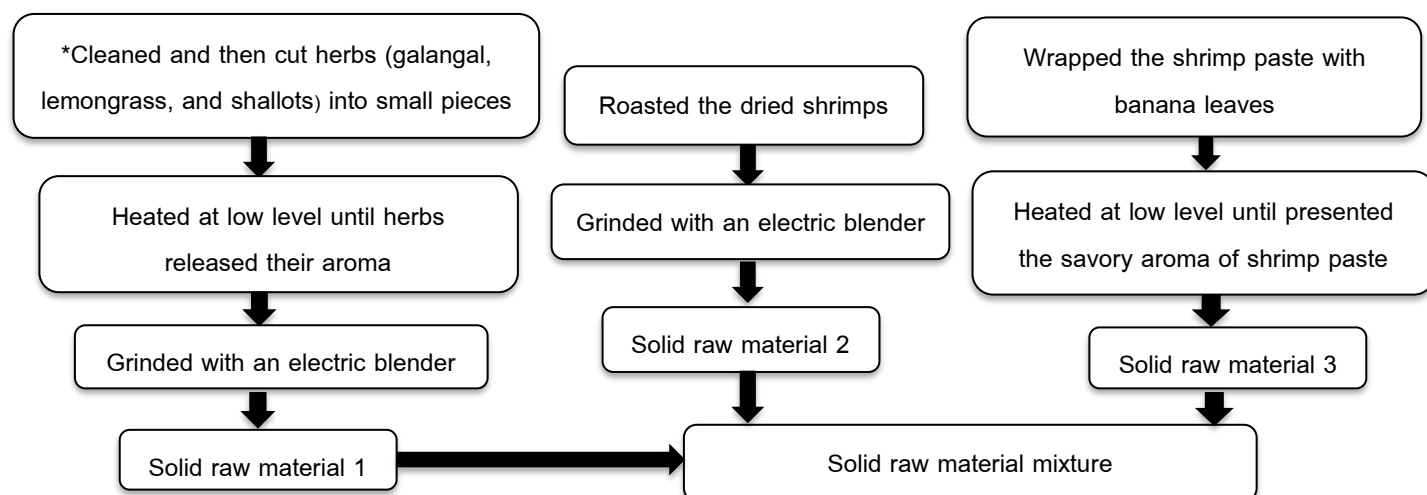


Figure 1 Flow chart of solid raw material preparation in Miang-kham sauce process in treatment 1: *Treatment 2, 3, and 4, the ginger or nutmeg was mixed in this step.

Source: Kongphan,2018.

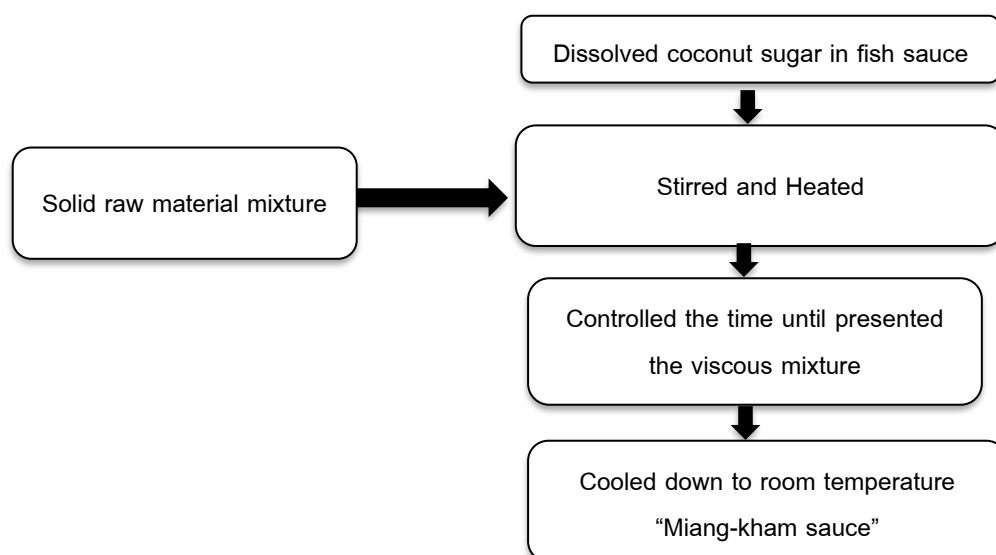


Figure 2 Flow chart of Miang-kham sauce process.

Source: Kongphan,2018.

Table 2 Experimental treatments of BS preparation.

Treatment	Description of BS preparation	
1	F-BS	Fresh BS
2	S-BS	BS steamed 15 min
3	B-BS	BS boiled 15 min
4	0.5AIS-BS	BS immersed in 0.5% w/w acetic acid solvent 30 min and steamed 15 min
5	1.0AIS-BS	BS immersed in 1.0% w/w acetic acid solvent 30 min and steamed 15 min
6	0.5AIB-BS	BS immersed in 0.5% w/w acetic acid solvent 30 min and boiled 15 min
7	1.0AIB-BS	BS immersed in 1.0% w/w acetic acid solvent 30 min and boiled 15 min

2.3 Effect of the different concentrations of MS on dried BS quality in the drying process

The experimental design was CRD. The concentrations of Ginger-MS were the factor of the experimental treatment. The Ginger-MS was diluted with water by weight. There were four experimental treatments, as in the following Table 3.

1.0 AIS-BS were boiled for 30 min in different concentrations of Ginger-MS. Then, the surface of boiled BS was washed with water. Afterward, all treated BS were placed in a hot air dryer

and heated at 65°C. During heating, samples were taken at intervals to monitor changes in the moisture content with an infrared moisture analyzer (SARTORIUS MA37-1, Goettingen, Germany). Sample heating was ended when the moisture content was < 10.0%. The standard limit specified for moisture content was 12% in Thai Community Product Standard “Dried Fruit and Vegetable” 136/2015. The quality of finished products was analyzed.

Table 3 Experimental treatments of the Ginger-MS concentration.

Treatment		Description of the ginger-MS concentration
1	NGinger-MS	None-ginger-MS
2	20Ginger-MS	Ginger-MS 20.00% concentration (Ratio of ginger-MS to water 1: 4 w/w)
3	25Ginger-MS	Ginger-MS 25.00% concentration (Ratio of ginger-MS to water 1: 3 w/w)
4	33Ginger-MS	Ginger-MS 33.33% concentration (Ratio of ginger-MS to water 1: 2 w/w)

2.4 Quality analysis

2.4.1 Color measurement

The color of the samples was evaluated with a colorimeter (UltraScan VIS, HunterLab, Virginia, United States of America) and recorded in the CIE $L^* a^* b^*$ system. The instrument was calibrated with a white standard plate and illuminant D65. The brightness (L^*) value (light-dark spectrum) ranges from 0 (darkness) to 100 (brightness), the a^* value (green-red spectrum) ranges from green (-) to red (+) and the b^* value (blue-yellow spectrum) ranges from blue (-) to yellow (+). The value of the total color difference (ΔE) was calculated by using the following Equation (1) (Ruttarattanamongkol *et al.*, 2016) where L_o^* , a_o^* , and b_o^* are the control values (dried NGinger-MS-BS). The summary of ΔE values with their associated level of human perception was as follows: <1 = not perceptible by human eyes, 1-2 = perceptible through close observation, 3-10 = perceptible at a glance, 11-49 = colors are more similar than opposite, and 100 = colors are exact opposites (Minaker *et al.*, 2021).

$$\Delta E_{ab} = \sqrt{(L^* - L_o^*)^2 + (a^* - a_o^*)^2 + (b^* - b_o^*)^2} \quad (1)$$

2.4.2 Whiteness index (WI)

The whiteness index is an optical index used to qualitatively evaluate the “whiteness” of a material. The whiteness index was calculated according to Equation (2) (Li and Lee, 1996).

$$WI = 100 - \sqrt{(100 - L^*)^2 + (a^*)^2 + (b^*)^2} \quad (2)$$

2.4.3 Proximate composition

The moisture content was determined using the air oven method of AOAC Method 934.01 (AOAC, 2000). The AOAC Method 960.52 (AOAC, 2000) was used for crude protein using Kjeldahl equipment (BUCHI, Zurich, Switzerland). Ash

content of the samples was determined by the dry ashing method according to AOAC method 923.03 (AOAC, 2000). Crude fat was determined using an automated Soxhlet method (VELP SCIENTIFICA, Usmate, Italy) according to AOAC Method 963.15 (AOAC, 2000). The AACC Method 32-05.01 (AACC, 1999) was used for crude fiber using a fiber analyzer (VELP SCIENTIFICA, Usmate, Italy). Water activity was measured with a water activity analyzer (AquaLab, Washington, United States of America).

2.4.4 Sensory evaluation

The evaluation was conducted by the selected thirty panelists (the 4th-year undergraduate students of the Department of Food Innovation and Management, Faculty of Agro-Industry, Rajamangala University of Technology Srivijaya). All panelists were accustomed to consuming the ancient Thai dish Miang-kham. Panelists had directed to rinse their mouths with water in between evaluations for more accurate results. The characteristics of the samples were evaluated for color, aroma, taste, texture and overall acceptability using a 9-point hedonic scale, with 1 and 9 representing the least score (dislike extremely) and the highest score (like extremely), respectively (Anprung, 2008).

2.4.5 Statistical analysis

Completely Randomized Design (CRD) was used for physical and chemical quality analysis. The obtained data were analyzed statistically in terms of mean, standard deviation, and variance (Analysis of Variance; ANOVA). The difference in mean values between groups was analyzed using Duncan's multiple range test at 95% ($p < 0.05$) level of significance (Saiyos and Saiyos, 2001).

Randomized Complete Block Design (RCBD) was used for sensory quality analysis. The obtained data were analyzed statistically in terms of mean and standard deviation. The mean

of the liking score was described as follows: 8.12-9.00 (like extremely), 7.23-8.11 (like very much), 6.34-7.22 (like moderately), 5.45-6.33 (like slightly), 4.56-5.54 (neither like nor dislike), 3.67-4.55 (dislike slightly), 2.78-3.66 (dislike moderately), 1.89-2.77 (dislike very much), and 1.00-1.88 (dislike extremely) (Moreno and Solar, 2022).

3. Results and Discussion

3.1 Effect of herbal ingredients on the quality of MS

The results indicated there was a significance ($p < 0.05$) effect of the herbal ingredients, ginger and nutmeg, on the color value (brightness (L^*), redness (a^*), and yellowness (b^*)) of MS (Table 4). The brightness (L^*) value decreases significantly ($p < 0.05$) in all herbal treatments compared to Control-MS. The brightness (L^*) values of Control-MS > Ginger-MS > Nutmeg/Ginger-MS > Nutmeg-MS were 16.99 > 15.28 > 14.54 > 14.17, respectively. Both ginger and nutmeg are cellulose-rich structures, which increased solidity and reduced brightness. The positive a^* value represents redness, with a higher redness (a^*) value indicating greater browning as reported by Chansri and Kongkham (2022) in fresh sliced eggplant. The results of this study showed that Control-MS (12.42) had a significantly higher redness (a^*) value than the other groups. There was no significant ($p > 0.05$) difference in redness (a^*) value among all herbal-MS samples: Nutmeg-MS (10.72), Ginger-MS (10.57), and Nutmeg/Ginger-MS (10.36). This implies that adding herbs to MS helps reduce the formation of browning compounds. The positive b^* value referred to the yellowness color. The yellowness (b^*) value of MS showed a change in the same direction as the redness (a^*) value. All herbal-MS samples decreased the yellowness (b^*) value significantly compared to the Control-MS (17.23). There was no significant difference in yellowness (b^*) value among all herb-treated samples: Nutmeg-MS (14.04), Ginger-MS (14.07), and Nutmeg/Ginger-MS (14.14).

The sensory evaluation results in a mean of liking scores of samples for all characteristics (color, aroma, taste, texture, and overall acceptability) presented in Table 5. Color is a crucial indicator of food and is an essential quality parameter influencing the purchase decision of consumers. The results of color evaluation showed that the Control-MS, Nutmeg-MS, Ginger-MS, and Nutmeg/Ginger-MS mean scores were 7.83, 8.02, 8.00, and 8.07, respectively, described as "like very much". This implies that the application of herbs in MS did not affect the sensory evaluation of the product's color, even though the color value (brightness (L^*), redness (a^*), and yellowness (b^*)) obtained from instrumental measurements showed significantly different results. "Aroma" refers to the distinctive smell or fragrance of a substance, often associated with food. It is largely determined by volatile compounds released during cooking, ripening, or fermentation processes. Aroma is one of the most important factors in evaluating the physical and chemical quality attributes of food and is directly associated with product

acceptance by the consumers. The aroma evaluation presented that the liking of the aroma attribute received "like extremely" in Ginger-MS (8.23), "like very much" in both Control-MS (8.00) and Nutmeg-MS (7.27), and "like slightly" in Nutmeg/Ginger-MS (6.17). Ginger has aroma substances, which yield phenylpropanoids, monoterpenes, and other phenolic chemicals. Its volatile oils zingiber, zingiberene, phellandrene, and linalool, produce improved new food products (Rakhi *et al.*, 2018). Limpaphayom *et al.* (2014) reported the analysis of fresh ginger in both young and mature stages, grown in Nakhon Si Thammarat province, Thailand, found the highest content of zingiberene. The amount of ginger commonly used to enhance the flavor of food was 1.0-1.25% (El-Sayed and Youssef, 2019). Konsue and Chuemchaitrakul (2004) used 2.70% dry ginger in the development of a ready-to-drink ginger jelly formula. In this experiment, MS was added with 4% fresh ginger. Sipahelut *et al.* (2020) reported that nutmeg pulp oil contains 32 components, with major constituents including α -pinene (18.0%), myristicin (14.1%), α -terpineol (9.4%), β -pinene (8.9%), limonene (8.5%), and terpinene-4-ol (8.4%). Although nutmeg contains essential oils, it was found that Nutmeg-MS received lower mean scores for the aroma attribute than the Control-MS. Taste, or gustation, refers to the sensation that occurs when chemicals stimulate taste receptors. Food taste is the overall sensory experience (sweet, sour, salty, bitter, and umami combined experience of taste, smell (aroma), texture, and temperature, known as flavor) that is interpreted by the brain, which is consumers' willingness to buy/eat a product. Any small amount can be eaten or consumed to assess the influence on sensory receptors. In this research, after conducting the taste test, the panelists were instructed to rinse their mouths with water following the evaluation of each sample treatment. In this experiment, the results of the taste attribute showed that Ginger-MS had the highest mean score of 8.73, described as "like extremely". The use of nutmeg had a significant ($p < 0.05$) impact on taste perception. Nutmeg-MS, with the mean score of 7.27, described as "like very much," while Control-MS, with the mean score of 8.17 described as "like extremely". This implies that ginger addition did not affect to the taste characteristic because Ginger-MS and Control-MS had in close proximity result. The use of nutmeg and ginger got the Nutmeg/Ginger-MS with the lowest mean score of 5.23, described as "neither like nor dislike". Texture is the physical characteristic of food that is generally perceived by the sense of touch. Food texture plays an important role in whether the consumers like or dislike the food product. In addition to the direct contribution to consumer acceptance, texture also has a vital secondary role in modulating flavor release and perception. The results of texture evaluation showed that the liking of the texture attribute was "like extremely" in both Control-MS (8.43) and Ginger-MS (8.63). In Nutmeg-MS and Nutmeg/Ginger-MS the mean score was the same, at 7.76, described as "like very much". Overall

acceptability is a sensory evaluation measure that encapsulates the general preference and satisfaction of consumers for a product based on sensory attributes. It evaluates how well products are received by assessors, focus to the importance of sensory characteristics in determining consumer approval. In this research, the mean score of Control-MS was 8.05, described as "like very much", Nutmeg-MS was 7.13, described as "like moderately", and Nutmeg/Ginger-MS was 5.87, described as "like slightly". The highest mean score was Ginger-MS, which has a mean of 8.70, described as "like extremely".

Therefore, in this experimental step, Ginger-MS was selected for further study in the appropriate concentration of MS on dried BS quality in the drying process.

Nutritional value was expressed in terms of proximate composition. The mean value result of proximate composition of Ginger-MS showed that it contained 26.79% moisture content, 0.36% crude fat, 4.81% crude protein, 6.00% ash content, and 1.14% crude fiber. Its water activity was 0.66, which did not exceed 0.85, the standard limit specified in Thai Community Product Standard "Miang-kham Sauce" 671/2004.

Table 4 Effect of herbal ingredients on color value (brightness (L^*), redness (a^*), and yellowness (b^*)) of MS.

Treatment	Brightness (L^*) value	Redness (a^*) value	Yellowness (b^*) value
1. Control-MS	16.99±0.62 ^a	12.42±0.35 ^a	17.23±0.25 ^a
2. Nutmeg-MS	14.17±0.67 ^c	10.72±0.49 ^b	14.05±0.25 ^b
3. Ginger-MS	15.28±0.25 ^b	10.57±0.78 ^b	14.07±0.38 ^b
4. Nutmeg/Ginger-MS	14.54±0.36 ^c	10.39±0.15 ^b	14.14±0.52 ^b

Mean value of 3 replicate measurements ± standard deviation.

^{abc} Different letters in a column are significantly different level ($p < 0.05$) according to Duncan's multiple range test.

Table 5 Effect of herbal ingredients on liking score of sensory evaluation of MS.

Treatment	Color	Aroma	Taste	Texture	Overall acceptability
1. Control-MS	7.83±0.65 Like very much	8.00±0.46 Like very much	8.17±0.80 Like extremely	8.43±0.50 Like extremely	8.05±0.51 Like very much
2. Nutmeg-MS	8.02±0.89 Like very much	7.27±0.91 Like very much	7.27±0.74 Like very much	7.67±0.89 Like very much	7.13±0.78 Like moderately
3. Ginger-MS	8.00±0.46 Like very much	8.23±0.44 Like extremely	8.73±0.52 Like extremely	8.63±0.50 Like extremely	8.70±0.47 Like extremely
4. Nutmeg/Ginger-MS	8.07±0.91 Like very much	6.17±0.80 Like slightly	5.23±1.55 Neither like nor dislike	7.67±1.27 Like very much	5.87±1.22 Like slightly

Mean value of 30 replicate measurements ± standard deviation.

3.2 Effect of the preparation methods on the BS quality

In drying agricultural materials, substance preparation is crucial since enzymes cause browning. Phenolic oxidation first produces unstable quinones, which then react with other compounds to form browning pigment (Robards *et al.*, 1999). Anusuya *et al.* (2013) reported the total phenolic and total flavonoids in various solvent extracts of pseudo-stem of different banana cultivars vary from 7.58 to 291 mg gallic acid equivalent and from 4 to 80 mg catechin equivalent, respectively. Ramirez-

Bolanos *et al.* (2021) reported phenolic compounds in dried banana pseudo-stem (% dw): 49.02 mg protocatechuic acid, 1.26 mg ferulic acid, 0.48 mg *p*-coumaric acid, and 0.05 mg *p*-coumaric acid ethyl ester. The browning reaction could be prevented by inactivating the enzyme with different methods such as heat, reducing the pH on the material surface (e.g., adding citric acid or another acids), reducing the amount of available oxygen (e.g., vacuum or modified atmosphere packaging), or by adding certain preservative chemicals (such

as sulfur dioxide). Since the browning from the enzymatic browning reaction will affect the product's color in the step of the study of the appropriate concentration of MS in the BS drying process, an optimal method of BS preparation had to be researched to reduce the error problem from the above causes. Supapvanich *et al.* (2015) found that 1% ascorbic acid with blanching at 80°C for 8 min effectively inhibited browning in banana syrup. Constant *et al.* (2021) reported reduced browning in fresh eggplant by heat treatment at 65°C for 30 min, while Paengkanya *et al.* (2021) showed that thermal preparation lowered enzyme activity and browning in fresh banana. Blanching banana slices with heat and steaming can reduce PPO activity by 91.2% and 92%, respectively, when compared to untreated bananas. As for peroxidase activity (POD), it was found that both sample preparation methods reduced POD activity by 100%. According to the previous research data, the combined methods were chosen to study in this experiment, including acid solution (two level of acetic acid, 0.5% and 1.0% w/w) and heat (steaming and boiling). The results showed that preparation methods significantly ($p < 0.05$) affected on the BS quality. The initial brightness (L^*) value was 70.78 in F-BS. The brightness (L^*) value of S-BS (66.36) was significantly higher than B-BS (47.56) (Table 6). Both S-BS and B-BS had the brightness (L^*) value significantly lower than F-BS. This difference is because heating by boiling causes the plant cell tissue to break down, while steaming, on the other hand, does not cause the breakdown of plant cell tissue. The breakdown of tissue layers eliminates gaps between layers, leading to increased tissue overlap and a decrease in brightness (L^*) value. In the case of steaming, although there is no rupture of the cell structure, the heat applied softens the tissue structure, resulting in a denser structure than plant tissue in its natural state. Immersion of BS in an acidic solution lowers its pH, inhibiting browning caused by enzyme reactions. The results presented that higher acid concentration was significantly higher brightness (L^*) value of BS in both boiling and steaming. The brightness (L^*) values of S-BS < 0.5AIS-BS < 1.0AIS-BS were 66.36 < 69.02 < 72.95, respectively, and B-BS < 0.5AIB-BS < 1.0AIB-BS were 47.56 < 59.33 < 63.97, respectively. The changes in brightness (L^*) value of BS of this experimental method were in the same direction as the report by Kaweewong and Sombatma (2020), who soaked banana blossoms in citric acid solutions at concentrations of 0.0, 1.0, and 3.0% for 5 min, with brightness (L^*) values 46.32, 56.18, and 65.19, respectively. The redness (a^*) value of BS in this experiment was found to be changing in the same direction as the brightness (L^*) value. A boiling state made the plant cells rupture, and in a neutral solution, the enzyme that causes browning can leak from the cell wall into boiling water and then contact oxygen, causing a reaction that produces brown matter. Therefore, B-BS had the highest redness (a^*) value. Various research used acidic solvents to lower the pH of substances to

inhibit enzymatic reactions that cause browning. Chansri and Kongkum (2022) reported that the increased positive a^* value in fresh eggplant fruit indicated more browning. Supapvanich *et al.* (2015) reported that blanching with ascorbic acid significantly inhibited browning. Pizzocaro *et al.* (1993) reported that a citric acid concentration of 0.2–1.0% could inhibit browning in fresh-cut apple. In steaming, the BS immersed in a higher concentration acid solution exhibited the lowest redness (a^*) value. Boiling treated BS presented the redness (a^*) value in the same direction as the steaming method. The redness (a^*) values of S-BS, 0.5AIS-BS, and 1.0AIS-BS were 0.28, 0.16, and -0.30, respectively, whereas those of B-BS, 0.5AIB-BS, and 1.0AIB-BS were 11.09, 0.73, and -0.68, respectively. The effect of preparation methods on the yellowness (b^*) value of BS was as follows: all methods significantly decreased the yellowness (b^*) values compared to F-BS. However, differences in heating methods did not result in a significant difference in the yellowness (b^*) values between BS samples S-BS (15.41) and B-BS (15.98), nor did the combined method: 0.5AIS-BS (12.50), 1.0AIS-BS (11.10), 0.5AIB-BS (11.88), and 1.0AIB-BS (9.02). The changing of the whiteness index was in the same direction as the same changing in the brightness (L^*) value and the redness (a^*) value. It presented that the acid and heat treated to BS affected the whiteness index. The whiteness index of S-BS < 0.5AIS-BS < 1.0AIS-BS was 62.99 < 66.59 < 70.75, respectively, and B-BS < 0.5AIB-BS < 1.0AIB-BS was 44.07 < 57.61 < 62.85, respectively. Therefore, an appropriate preparation method of BS was 1.0AIS-BS.

3.3 Effect of the difference concentration of MS on dried BS quality in drying process

The highest sensory evaluation score sample, Ginger-MS, was selected to study the effect of the different concentrations of MS on the BS quality in the drying process. In this step, the BS from the appropriate preparation method, 1.0% AIS-BS, were boiled in different concentrations of Ginger-MS. Then, the surface of the boiled BS was washed with water before drying. The washing step was necessary to remove any adhering substances such as sugar and others to prevent the error effect from creating a blocking condition on the surface (Thammaratwasik, 1989 and Atiwirakul, 1984). This study found that MS concentration significantly affected the color value (brightness (L^*), redness (a^*), and yellowness (b^*)) (Table 7). In NGinger-MS-BS, the brightness (L^*) value was 70.21. Increasing the concentration of MS resulted in a decrease in brightness (L^*) value as follows: 20Ginger-MS-BS (47.32), 25Ginger-MS-BS (44.80), and 33Ginger-MS-BS (42.74). This indicates that the solid compounds in the Ginger-MS had adhered to the dried BS. Sinchaiphani *et al.* (2000) reported on the drying of morning glory. They found that the characteristics of the drying process could be divided into 3 stages. The first stage was called setting down, which created an equilibrium between the surface of the solid and the drying environment.

The second stage, the constant rate period of drying, occurred from the saturation of the liquid or water at the surface of the food from the movement of water in the food to the surface at a rate higher than the rate of evaporation from the surface of the food. The third stage, the drying process, had a reduced rate of movement of water within the food to the surface, and the surface of the food was dry, making drying more difficult. In this study, drying at 65°C was adapted from Thianchai and Soponronnarit (1991), who reported the optimum temperature for drying preserved pineapple at 55–65°C. Conversely, increasing the concentration of the Ginger-MS resulted in a significantly higher redness (a^*) value as follows: NGinger-MS-BS (2.59), 20Ginger-MS-BS (7.77), 25Ginger-MS-BS (8.52), and 33Ginger-MS-BS (8.67). The redness (a^*) value indicated the formation of a browning reaction commonly found in heat-

dried products. The yellowness (b^*) values in dried Ginger-MS-BS showed a slight increase in the yellowness (b^*) values, but the difference was statistically significant. However, the change in the yellowness (b^*) values was not related to the increasing concentration of the Ginger-MS. The yellowness (b^*) values of NGinger-MS-BS, 20Ginger-MS-BS, 25Ginger-MS-BS, and 33Ginger-MS-BS were 21.01, 22.75, 23.73, and 22.05, respectively. The delta E value is based on the delta L^* , delta a^* , and delta b^* color value. It is a standard measurement that indicates the color difference between the sample and the control that appear on a screen. The results showed that the dried Ginger-MS-BS presented in a similar color between the Ginger-MS-treated samples and the control (NGinger-MS-BS). The delta E values of 20Ginger-MS-BS, 25Ginger-MS-BS, and 33Ginger-MS-BS were 23.54, 26.23, and 28.16, respectively.

Table 6 Color value (brightness (L^*), redness (a^*), yellowness (b^*)) and whiteness index of BS prepared with different methods.

Treatment	Brightness (L^*) value	Redness (a^*) value	Yellowness (b^*) value	Whiteness index
1. F-BS	70.78±3.44 ^{ab}	0.37±0.61 ^{bc}	19.09±4.88 ^a	65.03±5.50 ^b
2. S-BS	66.36±0.35 ^c	0.28±0.13 ^{bc}	15.41±0.53 ^{bc}	62.99±0.10 ^b
3. B-BS	47.56±0.05 ^e	11.09±0.78 ^a	15.98±0.25 ^{ab}	44.07±0.07 ^d
4. 0.5AIS-BS	69.02±0.41 ^b	0.16±0.11 ^{bc}	12.50±0.85 ^{bcd}	66.59±0.69 ^b
5. 1.0AIS-BS	72.95±0.52 ^a	-0.30±0.14 ^{cd}	11.10±0.44 ^d	70.75±0.56 ^a
6. 0.5AIB-BS	59.33±0.96 ^d	0.73±0.24 ^b	11.88±1.24 ^{cd}	57.61±0.62 ^c
7. 1.0AIB-BS	63.97±0.52 ^c	-0.68±0.08 ^d	9.02±0.28 ^d	62.85±0.56 ^b

Mean value of 3 replicate measurements ± standard deviation.

^{abcd} Different letters in a column are significantly different level ($p < 0.05$) according to Duncan's multiple range test.

Table 7 Effect of the concentration of MS on color value (brightness (L^*), redness (a^*), and yellowness (b^*)) and delta E of dried BS.

Treatment	Brightness (L^*) value	Redness (a^*) value	Yellowness (b^*) value	Delta E
1. NGinger-MS-BS	70.21±0.48 ^a	2.59±0.17 ^c	21.01±0.45 ^c	-
2. 20Ginger-MS-BS	47.32±2.13 ^b	7.77±0.27 ^b	22.75±0.74 ^{ab}	23.54±2.10
3. 25Ginger-MS-BS	44.80±1.86 ^{bc}	8.52±0.51 ^a	23.73±0.49 ^a	26.23±2.08
4. 33Ginger-MS-BS	42.74±1.42 ^c	8.67±0.08 ^a	22.05±0.13 ^{bc}	28.16±1.65

Mean value of 3 replicate measurements ± standard deviation.

^{abc} Different letters in a column are significantly different level ($p < 0.05$) according to Duncan's multiple range test.

Delta E = 11-49 (Color are more similar than opposite).

The concentration of Ginger-MS significantly affected the yield of dried BS. In this experiment, it was found that the of dried 33Ginger-MS-BS > 25Ginger-MS-BS > 20Ginger-MS-BS; however, there was no statistically significant difference in the yield between 20Ginger-MS-BS and 25Ginger-MS-BS. The yield of dried BS obtained from using different concentrations of Ginger-MS was as follows: NGinger-MS-BS (13.58%), 20Ginger-MS-BS (17.82%), 25Ginger-MS-BS (19.18%), and 33Ginger-MS-BS (23.60%). This was consistent with Kabuo *et*

al. (2014), who reported the yield of dried pineapple and banana as follows: pineapple and bananas that were not soaked in a sugar solution before drying had yields of 13.78% and 20.76%, respectively, which were lower than pineapple and bananas that were soaked in sugar solution of 50% concentration at 40°C for 8 hr, which had yields of 21.42% and 23.88%, respectively. The concentration of Ginger-MS did not significantly affect the water activity of dried BS. The water activity of dried BS ranges from 0.24–0.27, which did not exceed the specified recommendation

of 0.6 according to the Thai community product standards for dried fruits and vegetables 136/2015. The moisture content of dried Ginger-MS-BS was significantly higher than dried NGinger-MS-BS (5.43%); however, there was no significant difference in moisture content among all Ginger-MS-BS: 20Ginger-MS-BS (7.33%), 25Ginger-MS-BS (7.37%), and 33Ginger-MS-BS (7.73%). Their moisture content did not exceed the specified recommendation of 12.0, according to the Thai Community Product Standards for dried fruits and vegetables 136/2015 (Table 8).

Dried Ginger-MS-BS was evaluated for sensory acceptability by using it as a filling for fried wonton sheets. The mean liking scores were described as “like extremely” in all characteristics: color (8.47), aroma (8.27), taste (8.13), texture (8.13), and overall acceptability (8.30) (Table 9). Proximate composition (%) of dried Ginger-MS BS was moisture content 7.73, crude protein 2.39, crude fat 0.26, ash content 6.71, and crude fiber 16.39 (Table 10). Its water activity was 0.24.

Table 8 Effect of the concentration of MS on yield, water activity and moisture content of dried BS.

Treatment	Yield (%)	Water activity ^{ns}	Moisture content (%)
1. NGinger-MS-BS	13.58 ± 1.20 ^c	0.26 ± 0.02	5.43 ± 0.35 ^b
2. 20Ginger-MS-BS	17.82 ± 1.26 ^b	0.27 ± 0.02	7.33 ± 0.25 ^a
3. 25Ginger-MS-BS	19.18 ± 2.00 ^b	0.25 ± 0.02	7.37 ± 0.67 ^a
4. 33Ginger-MS-BS	23.60 ± 1.51 ^a	0.24 ± 0.02	7.73 ± 1.07 ^a

Mean value of 3 replicate measurements ± standard deviation.

^{abc} Different letters in a column are significantly different level ($p < 0.05$) according to Duncan's multiple range test.

Table 9 Liking score of sensory evaluation of dried Ginger-MS-BS.

Sensory evaluation	Liking score	Description
Color	8.47 ± 0.51	Like extremely
Aroma	8.27 ± 0.58	Like extremely
Taste	8.13 ± 0.57	Like extremely
Texture	8.13 ± 0.57	Like extremely
Overall acceptability	8.30 ± 0.65	Like extremely

Mean value of 30 replicate measurements ± standard deviation.

Table 10 Proximate composition of dried Ginger-MS-BS.

Proximate composition		Thai community product standards 136/2015 “Dried fruit and vegetable”
Water activity	0.24 ± 0.02	0.6
Moisture content (%)	7.73 ± 1.07	≤ 12
Crude protein (%)	2.39 ± 0.08	Not specified
Crude fat (%)	0.26 ± 2.16	Not specified
Ash content (%)	6.71 ± 0.12	Not specified
Crude fiber (%)	16.39 ± 2.04	Not specified

Mean value of 3 replicate measurements ± standard deviation.

4. Conclusion

This research found that the herbs used as ingredients in the MS formula, the BS raw material preparation method, and the concentration of the MS applied to BS in the drying process significantly affected in the color value (brightness (L^*), redness (a^*), and yellowness (b^*)) and sensory acceptability. The best

choice for the herbal MS formula was Ginger-MS, adding 4.0% ginger into the Control-MS formula. The optimal conditions for the preparation method of the BS raw materials were using the 1.0% acetic acid solution combined with steaming (1.0AIS-BS). The appropriate concentration of Ginger-MS was 33.33%. The resulting dried Ginger-MS-BS received the highest mean liking score, described as “like extremely”, in all evaluation attributes:

color (8.47), aroma (8.27), taste (8.13), texture (8.13), and overall acceptability (8.30). It had water activity, and moisture content did not exceed the standard values in Thai Community Product Standard “dried fruit and vegetable” 136/2015. This study presented the information for the basic knowledge in the production of dried BS flavored with Ginger-MS, which is a healthy food product. Further, research should be developed to market this product placement by focusing on the appropriate packaging method and product shelf life.

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