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Effect of storage on physicochemical, microbiological, and sensory properties of Thawai Dueankao mango jelly

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ABSTRACT

Observing the quality changes of food products during storage can assist in determining their shelf life. The Thawai Dueankao mango (TM) jelly was evaluated during 4 weeks of storage at 25±5 °C for the physicochemical characteristics, sensory evaluation, and microbiological characteristics. The TM jelly maintained physicochemical characteristics without modification over time storage (P>0.05). The storage period did not affect its acceptance, and microbiological qualities were safe for human consumption during storage. Furthermore, the TM jelly presented potential functional properties: total phenolic content (TPC), vitamin C content, and antioxidant activities (2,2-Diphenyl-1-picryhydrazyl (DPPH) and oxygen radical absorbance capacity (ORAC) were 81.53±0.68 mg GAE/100g, 5.51±0.37 mg/100g, 36.49±1.51 and 2,365.17±9.43 µmol TE/g, respectively. The results suggest that jelly preparation from TM could improve the shelf life of fruit and make it a promising option in the jellies market due to its health advantages.

Keywords: Thawai Dueankao mango, jelly, gelatin, shelf life

INTRODUCTION

Mango (*Mangifera indica* L.) is a tropical fruit highly valued and widely consumed worldwide because of its appealing texture, flavor, taste, and abundant nutritional content. It contains a variety of beneficial substances, such as carotenoids, vitamin C, vitamin E, phenolic compounds, minerals, and fiber, which have potent antioxidant properties (Charles et al., 2013; Asif et al., 2016). Mango consumption can supply the body with significant quantities of bioactive compounds to help prevent degenerative conditions such as cancer and cardiovascular disease when included in the daily diet (Derese et al., 2017; Alothman et al., 2010). Thawai Dueankao mango (TM) is a local variety of mango in Chachoengsao; its simplicity in cultivation and production yields large fruit. Its sour taste and commonly consumed raw and semi-ripe; when ripened, it becomes sweet but has an unpleasant odor that makes it less popular for consumption. However, the fruit is produced considerably during the season, so the selling price of natural products may fall due to increased supply in the market. Therefore, farmers or producers prefer to process the fruit into products rather than selling the raw fruits for consumption which can create added value and generate additional income.

Gelatinous confectionery, especially jelly candy, has an elastic texture and glossy appearance and comes in various shapes and colors, making it attractive to people of all ages and genders. These sweets are usually made by gelatinizing a sugar mixture containing sucrose and corn syrup and adding flavorings, acids, and colorants using pectin, agar, or gelatin. However, their excessive sugar content and poor nutritional value can lead to dental cavities, obesity, and hyperglycemia when consumed in large quantities (Gallo et al., 2020). The addition of fruit to jelly can reduce the amount of added sugar needed in the recipe, as fruit naturally contains sugar. It can also add natural flavor and color to the jelly, reducing or eliminating the need for artificial flavoring and dyes. Moreover, fruit contains fiber which can slow down the absorption of carbohydrates, further helping to regulate blood sugar levels; using natural ingredients can provide additional nutritional benefits. Thus, this study developed the Thawai Dueankao mango flavored jelly (TM jelly), produced from gelatin, sucrose, glucose syrup, citric acid, and the addition of fresh TM juice to their formulation. Nutritional compositions, antioxidant activities, total phenolic and vitamin C contents were evaluated initially. The sensory evaluation, physicochemical and microbiological characteristics were analyzed over 4 weeks of storage.

MATERIALS AND METHODS

Preparation of TM juice

Raw TM was bought directly from the farmer in Bangkla, Chachoengsao, Thailand. TM was washed under running water and manually peeled, sliced into small pieces, and pulps mixed with water (1:1 w/w), blended, and filled. The diluted juice was bottled and stored at 4±1 °C before jelly preparation.

Jelly preparation

For the preparation of TM jelly, 60% TM juice, 17% sucrose, 12.8% glucose syrup, 10% gelatin, and 0.2% citric acid were used. At first, gelatin and part of TM juice were mixed, and the mixture sat for 10 minutes to hydrate and soften before adding. Sugar and glucose syrup was added to the remaining TM juice, mixed and heated to its boiling point, and cooled down by 85-90 °C. After that, the hydrated gelatin and citric acid were added to the juice sugar and mixed until dissolved and clarified. The hot solution was poured into silicone molds and refrigerated (4±1 °C) for 24 hours for the jelly to settle; after that, the jellies were taken out of the molds and packed in polyethylene bags.

Nutritional compositions

The TM jelly was determined total energy, total fat, protein, dietary fiber, moisture, ash, total sugar, and sodium contents according to AOAC (2012). Carbohydrate content were calculated by difference (100 - (%moisture + %protein + %fat + %ash)).

Total phenolic and vitamin C contents

The total phenolic content of the TM jelly was determined using the Folin-Ciocalteu method as modified by Amarowicz et al. (2004). The results were expressed as mg gallic acid equivalents (GAE) per 100g of sample (mg GAE/100 g).

Vitamin C content of the TM jelly was evaluated by 2,4-Dinitrophenylhydrazine (2,4-DNPH) method, according to Duais et al. (2009). The results were expressed as mg per 100 g of product.

Antioxidant activities

DPPH assay (1,1-Diphenyl-2-picrylhydrazyl radical scavenging activity) was determined according to the method described by Katsube et al. (2004). The results were expressed as µM Trolox equivalent per 100 g of sample (µmoles TE/100 g).

ORAC assay (Oxygen radical absorbance capacity) was determined according to Ou et al. (2001) method. The final ORAC values were calculated using the differences in area under the fluorescence decay curve (AUC) between the blank and the sample. The area under the fluorescence decay curve (AUC) was calculated according to the following equation:

$$AUC = 0.5 + f_1/f_0 + f_i/f_0 + \ldots + f_{89}/f_0 + 0.5(f_{90}/f_0)$$

Where $f0$ = initial fluorescence reading at 0 min and fi= fluorescence reading at the time i min. Final ORAC values were calculated as follows and expressed as µmol TE/100g of sample (dry basis):

$$\text{ORAC value} = [(AUC_{sample} - AUC_{blank})/(AUC_{trolox} - AUC_{blank}) \times \text{dilution}]$$

Storage test

The TM jellies were packed in polyethylene bags and stored at ambient temperature (approximately 25±5 °C) for 4 weeks. The samples were determined the physicochemical, microbiological, and sensory properties immediately after production (time zero) and after 1, 2, 3, and 4 weeks.

pH measurement

The pH values were measured at room temperature (25±1 °C) using a pH meter (Mettler, Mettler-Toledo International Inc., Greifensee, Switzerland). Three replicate readings (three different samples) were taken for each pH of the samples.

Water activity (Aw)

It was determined using a water activity meter (MIS-Aw, Nobasina Aair Ltd, Zurich, Switzerland) in triplicate at room temperature (25±1 °C). The samples were placed in a plastic sample holding container and put inside the meter.

Color values

The measurement of color in the CIE (L*, a*, b*) system and hue angle (ho) were evaluated using a spectrophotometer (ColorFlex EZ, Hunter Associates Laboratory Inc., Virginia, USA). In this color system, L* value is a measure of lightness to darkness (0 = black and 100 = white); a* is a measure of redness (+) to greenness (-); and b* is a measure of yellowness (+) to blueness (-).

Texture profile analysis

The texture profile of TM jelly was evaluated by Texture Analyzer (TA.XT plus, Stable Micro Systems Ltd, YL, UK) with a cylinder probe (50 mm diameter). The analysis was conducted at room temperature (25±1 °C) and set in compression mode with a pre-test speed of 2 mm/s, test speed of 2 mm/s, post-test speed of 2 mm/s, distance between probe and sample of 10 mm, trigger force of 5 g and the delay between two compressions was 2s. The data were analyzed using Texture Expert Version 1.22 Software (Stable Micro System Ltd, Scarsdale, NY) to measure jelly hardness, cohesiveness, and springiness as described by Bourne (1978).

Sensory evaluation

Fifty volunteers participated in the sensory analysis, evaluating the samples using a nine-point hedonic scale described by Stone et al. (2012). The scale ranged from a score of 9 for "like extremely" to a score of 1 for "dislike extremely." The attributes assessed by the volunteers included color, flavor, taste, texture, and overall acceptability.

Microbiological analysis

The total plate count, yeast, and molds were determined according to BAM (2001). The results were reported in CFU/g.

Statistical analysis

A completely randomized design (CRD) with three replications was conducted for physicochemical properties, antioxidant content, and antioxidant activities. The statistical program, SPSS software for window version 18.0 (SPSS Inc., Illinois, USA), was used to perform the statistical analysis. Means comparison was performed using Duncan's new multiple range tests at the 95% significance level.

A randomized complete block design (RCBD) with three replications was conducted for sensory properties. The statistical program, SPSS software for window version 18.0 (SPSS Inc, Illinois, USA), was used to perform the statistical analysis. Means comparison was performed using Duncan's new multiple range tests at the 95% significance level.

RESULTS AND DISCUSSION

Compositions of TM jelly

The total energy of TM jelly per serving size (30 g) was 60 kcal. The protein, fat, carbohydrate, dietary fiber, and total sugar contents per serving size were 22.15%, <0.01%, 28.91%, 1.35%, and 19.68%, respectively (Table 1). The data indicated that TM jelly exhibited antioxidant activity and contained phenolic compounds and vitamin C (Table 1). The results were consistent with the other potentially functional jelly candies: Cappa et al. (2015) reported total anthocyanin content of 430.1-564.0 mg Mal eq/kg, total flavonol content of 140.1-176.5 mg Que eq/kg and antioxidant activity (FRAP): 16-45 mmol Fe(II)/kg for fruit candies enriched with grape skin. Also, Novelina et al. (2016) showed lycopene content: 18.32-18.76 mg/100 g, vitamin C content: 9.51-17.70 mg/100 g, and antioxidant activity (DPPH): 24.55-54.59%. While De Oliveria Nishiyama-Hortense et al. (2022) found total anthocyanins of 686.78 mg malvidin-3,5-glucoside/kg for jelly candy enriched with BRS Violeta grape juice. Recently, Piechowiak et al. (2023) indicated that the addition of young pine shoots in the jellies generated an increase of 150% in ascorbic acid level, 98% in total phenolics level, and 173-178% in antioxidant activity (DPPH-ABTS). Mangoes are known as a rich source of dietary antioxidants, including ascorbic acid, carotenoids, and phenolic compounds (Riberio et al., 2007). Hence, adding mango to jelly can contribute to its antioxidant capacity.

Table 1. Nutritional compositions, total phenolic, vitamin C contents, and antioxidant activity of TM jelly

Compositions	Contents
Total energy (kcal/100g)	204.28±0.53
Protein (%)	22.15±0.11
Total carbohydrate (%)	28.91±0.25
Total dietary fiber (%)	1.35±0.03
Total fat (%)	<0.01
Moisture (%)	48.74±0.15
Ash (%)	0.19±0.02
Total sugar (%)	19.68±0.06
Sodium (mg/100g)	27.28±0.72
Total phenolic (mg GAE/100g)	81.53±0.68
Vitamin C (mg/100 g)	5.51±0.37
[1]DPPH (µmol TE/g)	36.49±1.51
[2]ORAC (µmol TE/g)	2,365.17±9.43

[1]DPPH (2,2-diphenyl-l-picrylhygrazyl) and [2]ORAC (Oxygen radical absorbance capacity)

Physicochemical characteristics of TM jelly

As shown in Table 2, the pH, water activity (A_w), and color values of TM jelly showed no significant difference (P>0.05) over the storage period. The TM jelly produced, which had an acidic pH level ranging from 3.41 to 3.47 and an intermediate water activity between 0.70 and 0.73, exhibited significant microbiological stability at room temperature. A previous study reported pH values and water activity of jelly candies as 3.42-3.54 and 0.67-0.68, respectively (De Moura et al., 2019). In another study, the pH values and water activity of jelly candies were reported as 3.81-3.87 and 0.71-0.73, respectively (Miranda et al., 2020).

All values of color parameters (L*, a*, and b*) did not differ significantly (P>0.05) over time of storage. Muzzaffar et al. (2016) also reported non-significant differences in chromatic parameters L*, a*, and b* during two months of storage for pumpkin candy. Miranda et al. (2020) suggested that adding jucara and passion fruit pulp to the jelly candies can substitute synthetic dyes once they have color stability during storage.

Table 2. pH, water activity (Aw), and color values of TM jelly during storage at 25±5 °C for 4 weeks

Weeks	pH[ns]	A_w[ns]	Color		
			L*[ns]	a*[ns]	b*[ns]
0	3.43±0.02	0.70±0.01	52.32±0.46	4.35±0.25	29.25±1.29
1	3.41±0.01	0.72±0.06	50.97±0.84	3.93±0.34	29.80±0.87
2	3.43±0.04	0.71±0.03	51.08±1.12	4.12±0.56	31.07±1.51
3	3.47±0.01	0.73±0.04	49.93±1.33	3.97±0.22	29.90±1.03
4	3.45±0.03	0.73±0.02	49.95±0.70	4.07±0.16	30.54±0.76

[ns] Means values in the same column are not significantly different (P>0.05). Values are means of triplicate ± standard deviation.

Texture profile analysis

The hardness, cohesiveness, and springiness of TM jelly did not present significant (P>0.05) changes during storage for 4 weeks at ambient temperature (25±5 °C) (Table 3). However, the hardness was slightly increased along the shelf life; this behavior in the texture variable could be due to the decrease in humidity. The increase in the hardness of jelly during storage time is in agreement with Rubio-Arraez et al. (2018), Seremet et al. (2020), and Rivero et al. (2021), who reported that the hardness was changed with a significant influence on time storage. Furthermore, it is essential to reduce the amount of moisture lost from gelatin-based candies to preserve the structural quality of these products (Kopjar et al., 2016).

Table 3. Texture parameters of TM jelly during storage at 25±5 °C for 4 weeks

Weeks	Hardness (g)[ns]	Cohesiveness[ns]	Springiness[ns]
0	1796.77±80.71	0.67±0.05	1.01±0.03
1	1802.19±96.35	0.68±0.02	0.98±0.04
2	1854.51±91.66	0.71±0.07	0.98±0.01
3	1911.23±75.43	0.70±0.04	1.03±0.02
4	1930.38±83.04	0.73±0.03	1.05±0.01

[ns] Means values in the same column are not significantly different (P>0.05). Values are means of triplicate ± standard deviation.

Sensory evaluation

The use of sensory assessment proved crucial in examining the effects of adding fruit juice as natural colorants and flavor and evaluating the impact of storage duration on TM jelly. According to Table 4, all the sensory attributes of the sample obtained scores above 7.0 (like moderately), and there was no significant (P>0.05) influence of the duration of storage; they were assessed as sensorial acceptable.

Table 4. Sensory attribute scores of TM jelly during storage at 25±5 °C for 4 weeks

Weeks	Color[ns]	Flavor[ns]	Taste[ns]	Texture[ns]	Overall acceptability[ns]
0	7.38±0.89	7.43±1.14	7.55±1.03	7.67±0.95	7.53±0.48
1	7.40±1.02	7.33±0.96	7.45±1.21	7.68±0.72	7.48±0.99
2	7.35±0.72	7.26±0.88	7.48±0.75	7.70±1.24	7.62±0.85
3	7.44±1.13	7.30±0.65	7.52±0.68	7.50±0.97	7.55±1.08
4	7.29±1.11	7.34±1.05	7.50±0.42	7.51±0.86	7.47±0.79

[ns] Means values in the same column are not significantly different (P>0.05). Values are means of triplicate ± standard deviation.

Microbiological analysis

The total plate count, yeast, and molds of TM jelly during storage are presented in Table 5. The finding demonstrated that the sample kept at ambient temperature (25±5 °C) for 0 weeks met the acceptable limit according to the Thai community product standard: liquid jelly (Thai Industrial Standard Institute, 518-2547). After 2 weeks of storage, the total plate count of the sample was slightly increased but still within the acceptable limit according to the Thai community product standard: liquid jelly ($1x10^4$ CFU/g) (TISI, 2004). While, yeast and molds of the sample after storage for 1, 2, 3, and 4 weeks at ambient temperature (25±5 °C) were within the acceptable limit according to the Thai community product standard: liquid jelly (100 CFU/g) (TISI, 2004). Similar results were reported by Thongsook et al. (2008) and Yuenyongputtakal et al. (2018), which confirmed that the assessment of the total plate count, yeast, and molds verified the safety of the jelly for consumption during the entire storage period. These results were probably because the concentration of citric acid was lower the pH of TM jelly to 3.4, and microbiological stability of jelly depended on the high concentration of their sugar (Pilgrim et al., 1991).

Table 5. Total plate count, yeast, and molds of TM jelly during storage at 25±5 °C for 4 weeks

Weeks	Total plate count (CFU/g)	Yeast and Molds (CFU/g)
0	<10	<10
1	<10	<10
2	27	<10
3	35	<10
4	46	<10

CONCLUSIONS

TM juice can serve as a natural additive in jelly and provide flavor, color, and antioxidant properties to the product without altering the sensory acceptable, physicochemical, and microbiological characteristics throughout the storage period.

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REFERENCES

Alothman, M., Kaur, B., Fazilah, A., Bhat, R., and Karim, A.A. 2010. Ozone-induced changes of antioxidant capacity of fresh-cut tropical fruits. Innovative Food Science and Emerging Technologies. 11:666-671.

Amarowicz, R., Pegg, R.B., Rahimi-Moghaddam, P., Barl, B., and Weil, J.A. 2004. Free-radical scavenging capacity and antioxidant activity of selected plant species from the Canadian prairies. Food Chemistry. 84: 551-562.

AOAC. 2012. Official methods of analysis (19th ed). Association of Official Chemists International. Gaithersburg, Maryland.

Asif, A., Farooq, U., Akram, K., Hayat, Z., Shafi, A., Sarfraz, F., Sidhu M.A.I., Rehman, H., and Aftab, S. 2016. Therapeutic potentials of bioactive compounds from mango fruit wastes. Trends in Food Science & Technology. 53: 102-112.

BAM. 2001. Bacteriological analysis manual. Chapter 3: Aerobic Plate Count. http://www.fda.gov/Food/FoodScience Research/LaboratoryMethods/ucm063346.htm.

Bourne, M.C. 1978. Texture profile analysis. Food Technology. 32: 62-66.

Cappa, C., Lavelli, V., and Mariotti, M. 2015. Fruit candies enriched with grape skin powder: physicochemical properties. LWT - Food Science and Technology. 62: 569-575.

Charles, F., Vidal, V., Olive, F., Filgueiras, H., and Sallanon, H. 2013. Pulsed light treatment as new method to maintain physical and nutritional quality of fresh-cut mangoes. Innovative Food Science & Emerging Technologies. 18: 190-195.

De Moura, S.C.S.R., Berling, C.L., Garcia, A.O., Queiroz, M.B., Alvim, I.D., and Hubinger, M.D. 2019. Release of anthocyanins from the hibiscus extract encapsulated by ionic gelation and application of microparticles in jelly candy. Food Research International. 121: 542-552.

De Oliveria Nishiyama-Hortense, Y.P., De Paula Rossi, M.J., Shimizu-Marin, V.D., Janzantti N.S., Gomez-Alonso, S., Da-Silva, R., and Lago-Vanzela, E.S. 2022. Jelly candy enriched with BRS Violeta grape juice: Anthocyanin retention and sensory evaluation. Future Foods. 6: 100179. https://doi.org/10.1016/j.fufo.2022.100179.

Derese, S., Guantai, E.M., Yaouba, S., and Kuete, V. 2017. *Mangifera indica* L. (Anacardiaceae). In: Medical spices and vegetables from Africa: Therapeutic potential against metabolic, inflammatory, infectious and systemic diseases. Elsevier Inc. p.451-483.

Duais, M.A., Hohbein, J., Werner, S., Böhm, V., and Jetschke, G. 2009. Contents of vitamin C, carotenoids, tocopherols and tocotrienols in the subtropical plant species cyphostemma digitatum as affected by processing. Journal of Agricultural and Food Chemistry. 57: 5420-5427.

Gallo, M., Ferrara, L., Calogero, A., Montesano, D., and Naviglio, D. 2020. Relationships between food and disease: what to know to ensure food safety. Food Research International. 137: 109414. https://doi.org/10.1016/j.foodres.2020.109414.

Katsube, T., Tabata, H., Ohta, Y., Yamasaki, Y., Anuurad, E., Shiwaku, K., and Yamane, Y. 2004. Screening for antioxidant activity in edible plant products: comparison of low-density lipoprotein oxidation assay, DPPH radical scavenging assay, and Folin-Ciocalteu assay. Journal of Agricultural and Food Chemistry. 52(8): 2391-2396.

Kopjar, M., Pichler, A., Turi, J., and Pilizota V. 2016. Influence of trehalose addition on antioxidant activity, colour and texture of orange jelly during storage. International Journal of Food Science and Technology. 51: 2640-2646.

Miranda, J.S., Costa, B.V., De Oliveria, I.V., De Lima, D.C.N., Martins, E.M.F., De Castro Leite Junior, B.R., Do Nascimento Benevenuto W.C.A., De Queiroz, I.C., Da Silva, R.R., and Martins, M.L. 2020. Probiotic jelly candies enriched with native Atlantic Forest fruits and Bacillus coagulans GBI-30 6086. LWT – Food Science and Technology. 126: 109275.

Muzzaffar, S., Baba W.N., Nazir, N., Masoodi, F.A., Bhat, M.M., and Bazaz, R. 2016. Effect of storage on physicochemical, microbial and antioxidant properties of pumpkin (*Cucurbita moschata*) candy. Cogent Food & Agriculture. 2: 1163650. http://dx.doi.org/10.1080/23311932.2016.1163650.

Novelina, Nazir, N., and Adrian, M.R. 2016 The Improvement lycopene availability and antioxidant activities of Tomato (*Lycopersicum esculentum*, Mill) jelly drink. Agriculture and Agricultural Science Procedia. 9: 328-334.

Ou, B., Hampsch-Woodill, M., and Prior, R. L. 2001. Development and validation of an improved oxygen radical absorbance capacity assay using fluorescein as the fluorescent probe. Journal of Agricultural and Food Chemistry. 49(10): 4619-4626.

Piechowiak, T., Balawejder, M., Grzelak-Blaszczyk, K., Oracz, J., and Matlok, N. 2023. Antioxidant activity of fruit jellies enriched with phytochemicals from *Pinus sylvestris* L. LWT – Food Science and Technology. 173: 114262. https://doi.org/10.1016/j.lwt.2022.114262.

Pilgrim, G.W., Walter, R.H., and Oakenful, D.G. 1991. Jams, jellies, and preserves. In: Walter, R.H. (ed) The chemistry and technology of pectin. Academic Press, Inc., San Diego. p. 23-50.

Ribeiro, S.M.R., Queiroz, J.H., De Queiroz, M.E.L.R., Campos, F.M., and Santana, H.M.P. 2007. Antioxidant in mango (*Mangifera indica L.*) pulp. Plant Foods for Human Nutrition. 62: 13-17.

Rivero, R., Archaina, D., Sosa, N., and Schebor, C. 2021. Development and characterization of two gelatin candies with alternative sweeteners and fruit bioactive compounds. LWT - Food Science and Technology. 141: 110894.

Rubio-Arraez, S., Benavent, C., Ortola, M.D., and Castello, M.L. 2018. Influence of low glycaemic index sweeteners on antioxidant, sensory, mechanical, and physicochemical properties of a watermelon jelly. Journal of Food Quality. https://doi.org/10.1155/2018/8412017.

Seremet, D., Mandura, A., Cebin, A.V., Martinic, A., Galic, K., and Komes, D. 2020. Challenges in confectionery industry: development and storage stability of innovative white tea-based candies. Journal of Food Science. 85(7): 2060-2068.

Stone, H., Bleibaum, R. N., and Thomas, H.A. 2012. Sensory evaluation practices. 4thed. Academic Press. New York.

TISI. 2004. Thai community product standard: liquid jelly, tcps. 518-2547. Thai Industrial Standard Institute. Bangkok.

Thongsook, T., Ratanatriwong, P. and Nammakuna, N. 2008. Use of Palm sugar in jelly and gum. Journal of Community Development Research. 2(2): 1-16.

Yuenyongputtakal, W., Wichienchot, S., Thongdeang, J., and Srichot, W. 2018. Quality evaluation of Riceberry rice mixed fruit jelly during chilled storage. Agricultural Science Journal. 49(2)(Suppl.): 89-92.