Development of sorbet from sweet pickled mango syrup*

การพัฒนาผลิตภัณฑ์ซอร์เบท์จากน้ำเชื่อมที่ผ่านการแช่อิ่มมะม่วงเบา

Received:	*August*	*8, 2019*
Revised:	*December*	*20, 2019*
Accepted:	*December*	*27, 2019*

Noppawan Uthairungsri (นพวรรณ อุทัยรังษี)**
Kongkarn Kijroongrojana (ก่องกาญจน์ กิจรุ่งโรจน์)***
Punnanee Sumpavapol (ปุณณาณี สัมภวะผล)****

Abstract

Sweet pickled mango (SPM) or Ma-muang Bao Chae-im is a famous souvenir of Songkhla province. During the production, syrup was discarded as waste. It has unique aroma and flavor with high sugar and acid contents. Nowadays, the residual syrup from production is generated more than 1,000 liters per day. The use of waste by developing to be a value-added product is able to increase the value of the original product and reduce environmental problem. This study aimed to develop sorbet from SPM syrup and to evaluate properties and qualities of developed sorbet. Among all samples, sorbet with 89.7% syrup was diluted from an original to contain 24% sugar, 10% pulp and 0.3% carboxymethylcellulose had the highest mean scores of flavor, texture and overall liking attributes. Properties of developed sorbet including viscosity, overrun, hardness, melting rate and total soluble solid were 112.67 cp, 28.38%, 4.18 kg, 0.33 g/min and 28.70%, respectively. In addition, colors of sorbet were 72.44, -2.02 and 11.87 for lightness (L*), redness (a*) and yellowness (b*), respectively. Furthermore, microbial quality was determined according to microbial criteria of the Ministry of Public Health notification (No.354) B.E.2556. From the results, total bacteria count, mold, *Escherichia coli*, *Salmonella* spp. and *Staphylococcus aureus* could not be detected while yeast was detected at 1.1±0.1 Log CFU/g which was lower than the criteria mentioned above. Moreover,

* This manuscript is a part of the thesis during study as the degree of Food Science and Technology Program.

** Graduate Student, Department of Food Technology, Faculty of Agro-Industry, Prince of Songkla University, Noppawan.rungsri@gmail.com, 08-7633-6417
นักศึกษาปริญญาโท ภาควิชาเทคโนโลยีอาหาร คณะอุตสาหกรรมเกษตร มหาวิทยาลัยสงขลานครินทร์
*** Assistant Professor Dr., Department of Food Technology, Faculty of Agro-Industry, Prince of Songkla University, kongkarn.k@psu.ac.th, 0-7428-6336
ผู้ช่วยศาสตราจารย์ ดร. ภาควิชาเทคโนโลยีอาหาร คณะอุตสาหกรรมเกษตร มหาวิทยาลัยสงขลานครินทร์
**** Assistant Professor Dr., Department of Food Technology, Faculty of Agro-Industry, Prince of Songkla University, punnanee.s@psu.ac.th, 0-7428-6366 (Corresponding Author)
ผู้ช่วยศาสตราจารย์ ดร. ภาควิชาเทคโนโลยีอาหาร คณะอุตสาหกรรมเกษตร มหาวิทยาลัยสงขลานครินทร์

this product is suitable for ice cream consumers who are allergic to milk and gluten. Based on the current study, the waste generated is used as raw material for new product.

Keywords: Sorbet, Sweet pickled mango, Syrup, Value-added product, Food security

Introduction

Ma-muang Bao is a local mango, which is found only in the Southern part of Thailand and in Malaysia. This mango is consumed in various forms as raw mango, ripe mango and mango products such as SPM, ice cream and beverage, etc. SPM is a well-known product of Songkhla province. This product has a large scale production in Songkhla area and is distributed to many areas of Thailand. In the production of SPM, mango is peeled, seed are carved out and then mango is immersed in brine and sugar syrup. During production, SPM syrup has been discarded as a waste. This syrup has a special flavor and sweet-sour taste. Nowadays, the residual syrup from production is generated more than 1,000 liters per day. Thus, utilization of this waste by developing to be a new product will be helpful to the producer, increase a value of the product and reduce environmental problem.

Ice cream and frozen desserts are popular worldwide. They are consumed by all age groups. The consumption makes people feel fresh and cold. Nowadays, frozen desserts are available in many varieties. Sorbet is one type of frozen desserts that consumers pay attention because it is made from juice and sugar and contain neither milk nor milk product. This product is suitable for ice cream consumers who are allergic to milk. Thus, it is a low fat and calories product compare with ice cream and sherbet (Goff and Hartel, 2013).

Based on the current study, the waste generated from SPM production was used as raw material for another value-added product. Since SPM syrup had unique aroma and flavor and contained high sugar and acid contents, it was suitable to be developed to sorbet. In addition, qualities and properties of sorbet were evaluated.

Materials and Methods

Materials

SPM SPM was produced from Ma-muang Bao (*Mangifera indica* L. Var.) which were harvested at 60 days after flowering.

SPM syrup 1 and 2 SPM syrup 1 and 2 were by-products from sugar soaking step of SPM production. Briefly, Ma-muang Bao was soaked in syrup 1 which contained 30% of sugar for at least 24 hours. Then it was soaked in syrup 2 which contained 50% of sugar for additional 24 hours.

All raw materials were divided into 2 portions. The first portion was used for evaluating qualities and properties while the second portion was used for sorbet production.

Methods

1. Property and quality analyses of raw materials

1.1 Preparation of raw materials

SPM For quality and property analyses, SPM was cut into small pieces and blended. Distilled water was added at a ratio of 1:4 then SPM was homogenized and filtrated through a white cloth sheet (Sombatpaiwan *et. al.,* 2012). While blended SPM without an addition of distilled water was used for sorbet production.

SPM syrup SPM syrup was filtered through a white cloth sheet before quality and property analyses and sorbet production.

1.2 Chemical and Physical Property analyses

Chemical property analyses Chemical properties, including pH, total sugar, total acidity and salt content, were analyzed according to AOAC methods (AOAC, 2000). Briefly, total sugar was quantified by volumetric method of Lane and Eynon (titration with Fehling reagents). Total acidity was determined by simple direct titration with 0.1 M sodium hydroxide, using phenolphthalein as an indicator and expressed in gram of citric acid in 100 ml or 100 g of sample. Salt content was analyzed by direct titration of sodium chloride in sample with standard silver nitrate. Ethanol was extracted by distillation followed by oxidation using potassium dichromate in a sulphuric acid medium and then determination of excess dichromate using ferrous ammonium sulphate in the presence of ferrous 1, 10 phenathroline as an indicator (ISO 2448, 1998).

Physical property analysis Total soluble solid was analyzed according to the method of Machado *et al.* (1999).

1.3 Microbial quality analysis

SPM and its syrups (1 and 2) were subjected to microbial analysis, including total bacteria count and yeast and molds count, using 3M™ Petrifilm™ according to the method of the Association of Official Analytical Chemists (AOAC) (AOAC, 2000)

Veridian E-Journal, Science and Technology Silpakorn University
Volume 6 Number 6 November – December 2019 ISSN 2408 - 1248

2. Production of sorbet from SPM syrup

2.1 Sorbet production

Sorbet was produced from different formulations as shown in Table 1, followed the sorbet production process in Figure 1.

Table 1. Formulations of sorbet from SPM syrup

Ingredients	Formulation* (%)			
	F1	F2	F3	F4
SPM	10.00	-	10.00	-
SPM syrup 1	39.87	44.31	-	-
SPM 2	29.09	32.34	58.18	64.67
Water	20.74	23.05	31.52	35.03
Stabilizer (CMC)	0.30	0.30	0.30	0.30

*Adapted from the method of Noiduang and Pooldech (2010)

Mixing of grinded SPM and filtered syrup

↓

Heating the mixture to 78.4°C 10 mins with adding CMC

(mixing until CMC was thoroughly dissolved and ethanol was released)

↓

Pasteurizing the mixture at 80 °C for 25 seconds* or appropriate pasteurizing condition

↓

Cooling the mixture immediately on ice

(until the temperature of sorbet reaches 4 °C)

↓

Aging the mixture at 4 °C for 4 hours

↓

Spinning the cooled mixture in an ice cream machine for 25 mins

↓

Filling sorbet in a 1-ounce plastic cup and storing in freezer at -18 ° C (hardening)

for at least 24 hours

Figure 1. The process of sorbet production.

*Followed the notification of the Ministry of Public Health (No.354) B.E.2556 (2013)

Source: Adapted from the method of Noiduang and Pooldech (2010)

2.2 Chemical and physical property analyses

Chemical property analysis pH was measured in triplicate for a treatment by using a digital pH meter (Mettler Toledo, FEP20, Switzerland).

Physical property analyses Physical property analyses including viscosity, melting rate, overrun, hardness, color and total soluble solid were analyzed. Briefly, the viscosity of sorbet (500 ml) after aging at 4 °C in 600 ml beaker was assessed using Brookfield viscometer (Brookfield, DVII+, USA) with 3 spindles at a speed of 100 rpm. The values were recorded after a 30 second spin (Chanasith *et al.,* 2017). Eighty grams of sorbet sample was used for melting rate analysis by placing it on a wire mesh and allowing to melt at room temperature (25 ± 1 °C). A funnel was placed beneath the mesh to collect the melted sorbet and the duration of dripping time was started when sorbet temperature reached –15 ± 0.5 °C (1 cm depth, using thermocouple) (Goff and Hartel, 2013). Dripped volume was recorded at 5-min intervals from the start time until sorbet was thoroughly melted. The melting rate was recorded in g/min unit (Pon *et al.,* 2015). Overrun was measured by a comparison between weight of sorbet mixture and freezing sorbet at the same volume. Overrun was calculated by the following equation (Goff and Hartel, 2013)

$$\% \text{ Overrun} = \frac{(\text{Weight of sorbet mixture} - \text{Weight of freezing sorbet}) \times 100}{\text{Weight of freezing sorbet}}$$

For hardness, texture analysis was measured using texture analyzer (Stable Micro Systems, TA-XT2i, England). Force and deformation data were recorded. Briefly, sorbet samples were placed at room temperature (25 °C) until temperature reached –15 ± 0.5 °C (1 cm depth, using thermocouple) (Goff and Hartel, 2013), before analysis. Texture analyzer was fitted with a multiple penetration probe and then set up to record the force, which used to penetrate the sample to a depth of 10 mm at a speed of 2 mm/s (Pon *et al.,* 2015). The colors of the sorbet samples were measured by a colorimeter (Hunterlab, Colorflex, England), which was standardized by black and white glasses and evaluated in the CIE system as L * (lightness), a * (redness), and b * (yellowness). Total soluble solid was analyzed following the method of Machado *et al.* (1999).

2.3 Microbial quality analysis

Pasteurized sorbet mixture and finished sorbet products from SPM syrup were subjected to microbial analysis according to the notification of the Ministry of Public Health (No.354) B.E.2556 (2013). Microbial analysis was analyzed by AOAC methods (AOAC, 2000) using

Veridian E-Journal, Science and Technology Silpakorn University
Volume 6 Number 6 November – December 2019 ISSN 2408 - 1248

3M™ Petrifilm™. Pasteurized sorbet mixture was analyzed for total bacteria and yeast and mold counts. While finished sorbet products were analyzed for total bacteria, yeast and mold, coliform and *E. coli*, *S.aureus* and *Salmonella* counts.

2.4 Acceptance test

Sorbet samples from each formulation were served 1 sample at a time in 1-ounce plastic cups. Before being served to 30 panelists, sorbet was temperated at room temperature until it reached -15 ± 0.5 °C at 1 cm depth using thermocouple, according to Goff and Hartel (2013). Panelists were tasted and rated the sorbet samples for the sensory attributes of appearance, color, flavor, texture and overall satisfaction by using a 9 points hedonic scale.

3. Statistical analysis

A randomized complete block design (RCBD) was performed for acceptance test. A completely randomized design (CRD) was used for statistical analysis of quality and property analyses. Analysis of variance (ANOVA) and compare treatment mean were analyzed using Duncan's multiple range test at a significant level $p < 0.05$ with the Statistical Package for Social Science (SPSS for Windows, SPSS Inc., USA).

Results and Discussion

1. Property and quality analyses of raw materials

For chemical and physical properties of raw materials, results are shown in Table 2. It was found that SPM contained higher acid content than SPM syrup. Moreover, SPM syrup 1 contained higher acid content than SPM syrup 2. In accordance with acid content, pH of SPM was lower than SPM syrup. Because mango (Ma-muang Bao) used for the production of SPM was unripe stage and was sour, organic acids in mango could be released into the SPM syrup during production and thus generated the acidic environment.

For total sugar content in SPM and SPM syrup, it was found that SPM contained lower percentage of sugar than syrup did. While sugar contents in both syrups were lower than the initial concentration. According to Yuthachit (1998), the concentration in the syrup has effects on the mass transfer kinetics during osmotic dehydration. An increase in the sugar concentration of syrup leads to a greater rate of water loss until equilibrium level is achieved. Then an increase in sugar concentration with slow adjustment process leads to a reduction in the water loss. Because the slow diffusion of water from the mango changed the volume a little bit, so sugar was better transported into the mango pieces as compared with soaking in a high concentration of sugar. This mass flow rely on some factors, e.g. the variables like maturity, variety, pretreatments, temperature, nature and concentration of osmotic agent, agitation, geometry of the material, fruit pieces to osmotic solution ratio, physico-chemical properties, additives, structure and pressure affecting the osmotic dehydration process (Ahmed *et al*., 2016)

Moreover, salt contents in SPM and SPM syrups were around 2.04 - 2.38 g because soaking mango in brine at the initial process of SPM production could prevent oxidative and non-enzymatic browning. Salt in SPM syrup was released from the SPM during the osmotic dehydration process. Salt provides the driving force for mass transfer (Azoubel and Murr, 2004). However, it has limited use in fruit dehydration because of salty taste.

Table 2. Chemical and physical properties of SPM and SPM syrup

Properties	SPM	SPM syrup1	Syrup2
Chemical			
pH	2.64 ± 0.01^{c}	2.78 ± 0.01^{b}	2.86 ± 0.01^{a}
Total sugar (%)	21.11 ± 0.04^{c}	26.11 ± 0.14^{b}	36.51 ± 0.28^{a}
Total acid (%)	0.87 ± 0.00^{a}	0.83 ± 0.01^{b}	0.58 ± 0.01^{c}
Salt (%)	2.15 ± 0.05^{b}	2.38 ± 0.03^{a}	2.04 ± 0.03^{c}
Ethanol (%)	0.47 ± 0.03^{c}	1.34 ± 0.06^{b}	1.51 ± 0.03^{a}
Physical			
Total soluble solid (%)	32.62 ± 0.10^{b}	30.01 ± 0.08^{c}	40.87 ± 0.05^{a}

Values expressed as means ± standard errors. Different superscript letters within a row indicate significant differences ($p<0.05$).

Microbial qualities of raw materials are shown in Table 3. From the results, it was found that all samples were contaminated with yeasts at concentrations higher than 6 Log CFU/g while total bacteria counts were lower than 4 Log CFU/g. It indicated that this product was a fermented food and yeasts played a major role in the fermentation process. Organic acids, such as citric and acetic acids, may liberate from mango during soaking in syrup which provided an acidic environment that could reduce the number of bacteria (Medina *et al*., 2016). While yeast could tolerate the acidic environment with high sugar content. Then yeasts consumed sugar and produced aromatic compounds and ethanol under aerobic conditions. Thus, SPM and SPM syrup were contained ethanol at the concentration ranging from 0.47 to 1.51%.

Table 3. Microbial qualities of SPM and SPM syrup

Microbial qualities	SPM	SPM syrup1	SPM syrup2
Total bacteria (Log CFU/g)	3.83 ± 0.06[a]	3.11 ± 0.10[b]	3.70 ± 0.02[a]
Yeasts (Log CFU/g)	6.62 ± 0.03[b]	7.29 ± 0.03[a]	7.26 ± 0.05[a]

Values expressed as means ± standard errors. Different superscript letters within a row indicate significant differences (*p*<0.05).

2. Production of sorbet from SPM syrup

Sorbet was produced from 4 different formulations as shown in Table 1, followed the sorbet production process in Figure 1. Formulas 1 and 3 contained 10% of SPM while formulas 2 and 4 were produced without the addition of SPM. In addition, formulas 1 and 2 used both SPM syrups while formulas 3 and 4 used only SPM syrup 2 which contained low concentrations of salt and acids. Moreover, all formulas used CMC as a stabilizer at the concentration of 0.3%.

The chemical and physical properties of sorbet samples are presented in Table 4. According to the results, the pH of sorbet decreased when the 10% SPM was added because of its acidic character. Moreover, pH of sorbet made from SPM syrup 1 mixed with SPM syrup 2 was lower than sorbet made with only SPM syrup 2.

The viscosity and melting rate of sorbet samples were affected significantly ($P < 0.05$) by the addition of 10% SPM. The viscosity of sorbet samples with 10% SPM was increased because of pulp while the melting rate decreased when pulp was added. The melting rate depended on the transfer of heat from the environment into the sorbet which caused the melting of ice crystal. Similar results were reported in cape gooseberry-added ice cream. Erkaya *et al*. (2009) reported that the complete melting times of the ice cream samples were significantly longer for cape gooseberry-added samples and the period of complete melting times was longer as the fruit content was increased. This can be due to some components situated in cape gooseberry could absorb water.

However, sorbet samples had no significant difference in the overrun and hardness ($P > 0.05$). There was no significant difference ($P > 0.05$) in the hardness value because total soluble solid and total sugar in sorbet samples were not significantly different ($P > 0.05$). The results are in accordance with Güven and Karaca (2002) who reported that increasing fruit concentration had no effect on the properties of frozen yogurts.

In addition, the lightness (L*) and redness (a*) of sorbet samples with 10% pulp were decreased while yellowness (b*) was increased when compared with sorbet sample without pulp. Thus, the colors of sorbet samples with 10% pulp were yellow to green.

Table 4. Chemical and physical properties of sorbet from SPM syrup after hardening for 24 hours

Properties	Sorbet formula			
	1	2	3	4
Chemical				
pH	3.09 ± 0.01^{d}	3.31± 0.01^{b}	3.17 ± 0.03^{c}	3.34 ± 0.00^{a}
Total sugar (%)	25.05 ± 0.72^{ns}	25.11 ± 0.14^{ns}	25.86 ± 0.44^{ns}	25.92 ± 0.15^{ns}
Physical				
Viscosity (cp)	111.00 ± 0.57^{a}	57.00 ± 1.00^{b}	112.67 ± 0.33^{a}	56.00 ± 1.00^{b}
Melting rate (g/min)	0.38 ± 0.00^{ab}	0.40 ± 0.04^{a}	0.33 ± 0.03^{b}	0.37 ±0.02^{ab}
Overrun (%)	27.32 ± 0.91^{ns}	28.66 ± 0.93^{ns}	28.38 ± 1.21^{ns}	28.88 ± 0.96^{ns}
Hardness (kg)	4.43 ± 0.19^{ns}	4.44 ± 0.84^{ns}	4.18 ± 0.50^{ns}	4.39 ± 0.42^{ns}
Total soluble solid (%)	28.83 ± 0.82^{ns}	28.41 ± 0.11^{ns}	28.70 ± 0.46^{ns}	28.26 ± 0.07^{ns}
Color L*	71.16 ± 0.30^{b}	74.95 ± 1.48^{a}	72.44 ± 0.43^{b}	74.23 ± 0.13^{a}
a*	-1.91 ± 0.17^{b}	-0.72 ± 0.01^{a}	-2.02 ± 0.03^{b}	-0.68 ± 0.02^{a}
b*	12.02 ± 0.12^{a}	3.72 ± 0.10^{b}	11.87 ± 0.10^{a}	3.59 ± 0.03^{b}

Values expressed as means ± standard errors. Different superscript letters within a row indicate significant difference (p<0.05). ns: no significant difference.

Furthermore, the microbial qualities of sorbet mixtures after pasteurization found that total bacteria and yeast and mold counts could not be detected. The results implied that pasteurization step (80°C for 25 second) in the sorbet production could kill all microorganisms which may be contaminated during the production of SMP. Pasteurization is used to inactivate relatively heat-sensitive microorganisms, such as vegetative bacteria, yeassts and molds, which are responsible for food spoilage (Lewis and Heppell, 2000).

In addition, microbial quality of sorbet was determined according to microbial criteria of the Ministry of Public Health notification (No.354) B.E.2556. Total bacteria, mold, *E. coli*, *Salmonella* spp. and *S. aureus* could not be detected in all samples except that yeasts were detected at concentrations ranging between 1.1 ± 0.17 and 1.42 ± 0.10 Log CFU/g. However, it was lower than above criteria. In sorbet products, organic acids that provided an acidic environment (low pH), leaded to thermal processing that destructed spoilage microorganisms or inactivation of specific enzymes for protecting food quality in high-acid foods. Thereby, foods that are at a pH lower than 4.6 will not support growth of pathogenic microorganism (Rojo *et al*., 2017). The most important factor affecting microbial spoilage is acidity, and thermal processing requirements for various foods depend mainly on pH. Then yeasts in sorbets may be contaminated during the production after pasteurization from environment such as machine, air and water. In addition, the good hygiene during the sorbet production site is most important.

Table 5. Microbial qualities of sorbet from SPM syrups after hardening for 24 hours

Sample	Microbial qualities (Log CFU/g)	Sorbet formula 1	Sorbet formula 2	Sorbet formula 3	Sorbet formula 4
Sorbet mixture	Total bacteria	ND	ND	ND	ND
	Yeasts	ND	ND	ND	ND
Sorbet	Total bacteria	ND	ND	ND	ND
	Yeasts	1.42 ± 0.10^{a}	1.36 ± 0.10^{ab}	1.10 ± 0.17^{b}	1.10 ± 0.17^{b}
	E. coli	ND	ND	ND	ND
	Salmonella spp.	ND	ND	ND	ND
	S. aureus	ND	ND	ND	ND

Values expressed as means ± standard errors. Different superscript letters indicate significant differences (p<0.05). ND: Not be detected, *E. coli*: *Escherichia coli*, *S. aureus*: *Staphylococcus aureus*.

The sensory properties of sorbet samples were conducted using a 9 points hedonic scale. The results are shown in Table 6. From the results, formulas 1,3 and 4 were significantly different from formula 2 in overall liking attribute. Sorbet formulas 1 and 3 contained SPM and gained higher scores from a sensory test. Moreover, the addition of SPM could increase appearance and color scores with significant differences ($P < 0.05$) while there was no significant difference in flavor and texture attributes ($P > 0.05$). Thus, fruit in sorbet could increase curiosity to and enhanced the perception of healthiness. It could provide flavor and texture contrast as well as an attractive product appearance of the product (HipÓlito *et al*., 2016). Thus, sorbet formulas 1 and 3 were mostly preferred by the panelists.

Table 6. Sensory properties of sorbet from SPM syrups after hardening for 24 hours

Sorbet formulas	Appearance	Color	Flavor	Texture	Overall
1	7.73 ± 0.58^{a}	7.70 ± 0.75^{a}	7.57 ± 1.19^{ns}	7.57 ± 1.04^{ns}	7.70 ± 0.92^{a}
2	7.07 ± 0.94^{b}	6.70 ± 1.29^{b}	7.20 ± 0.96^{ns}	7.53 ± 0.86^{ns}	7.27 ± 0.87^{b}
3	7.60 ± 0.67^{ab}	7.53 ± 0.90^{a}	7.60 ± 1.07^{ns}	7.73 ± 0.83^{ns}	7.70 ± 0.84^{a}
4	7.23 ± 0.97^{ab}	6.90 ± 1.40^{b}	7.30 ± 1.18^{ns}	7.87 ± 0.94^{ns}	7.70 ± 0.79^{a}

Values expressed as means ± standard errors. Different superscript letters within a column indicate significant differences (p<0.05). ns: no significant differences.

Conclusion

SPM is a fermented food containing high acid and sugar contents as well as aromatic compounds. To produce sorbet, formulas 1 and 3 which contained 10% SPM were mostly preferred by the panelists. Based on the current finding, the waste generated from SPM production can be used as a raw material for a value-added product and reduce the waste emission to the environment.

References

Ahmed, I., Qazi, I. M. and Jamal, S. (2016). Developments in osmotic dehydration technique for the preservation of fruits and vegetables. Journal of Innovative Food Science and Emerging Technologies, 34, 29-43.

AOAC. (2000). Official methods of analysis of AOAC. 17th edn. Arlington: Association of Official Analytical Chemists (AOAC) International.

Azoubel, P. M. and Murr, F. E. X. (2004). Mass transfer kinetics of osmotic dehydration of cherry tomatoes. Journal of Food Engineering, 61, 291 –295.

Chanasith, K., Paemongkol, P. and Pooripakdee, S. (2017). Product development of Karanda fruit (*Carissa Carandas* Linn.): Sorbets and yogurt ice-cream. Journal of Engineering and Applied Sciences, 12, 4687-4692.

Erkaya, T., Dağdemir, E. and Şengül, M. (2012). Influence of Cape gooseberry (*Physalis peruviana* L.) addition on the chemical and sensory characteristics and mineral concentrations of ice cream. Food Research International, 45, 331-335.

Goff, H. D. and Hartel, R. W. (2013). Ice Cream (7th ed.). New York: Springer.

Güven, M. and Karaca, O. B. (2002). The effects of varying sugar content and fruit concentration on the physical properties of vanilla and fruit ice-cream-type frozen yogurts. International Journal of Dairy Technology, 55, 27-31.

HipÓlito, C., Ramalheira, R., da Costa, S. B. and Moldão-Martins, M. (2016). The effect of fruit cultivar/origin and storage time on sorbets quality. LWT - Food Science and Technology, 68, 462-469.

ISO 2448. (1998). Fruit and Vegetable Products. Determination of Ethanol Content, Geneve, Switzerland: International Organization for Standardization.

Lewis, M. and Heppell, N. (2000). Continuous thermal processing of foods. USA: Aspen Publishers, Inc.

Machado, M. F., Oliveira, F. A. and Cunha, L. M. (1999). Effect of milk fat and total solids concentration on the kinetics of moisture uptake by ready-to-eat breakfast cereal. International Journal of Food Science and Technology, 34, 47-57.

Medina, E., de Castro, A., Romero, C., Ramírez, E. M. and Brenes, M. (2016). Safety of fermented fruits and vegetables. In *Regulating Safety of Traditional and Ethnic Foods* (pp. 355-367). Academic Press.

Noiduang, P. and Pooldech, S. (2010). kān̄phalit ʻaisakrīm phalangngān tam čhāk phon talingpling [Production of low calories ice cream from *Averrhoa bilimbi* Linn. Fruit]. Research Report. Siam University, Thailand.

Notification of the Public Health (No.354) B.E.2556. (2013). Ice Cream. The Government Gazette Vol. 130 Special Part 87 Ngor.

Pon, S. Y., Lee, W. J. and Chong, G. H. (2015). Textural and rheological properties of stevia ice cream. Journal of International Food Research, 22, 1544-1549.

Rojo, M. C., Palazzolo, C. T., Cuello, R., Gonzβlez, M., Guevara, F., Ponsone, M. L., Mercado, L.A., Martínez, C. and Combina, M. (2017). Incidence of osmophilic yeasts and *Zygosaccharomyces rouxii* during the production of concentrate grape juices. Journal of Food Microbiology, 64, 7-14.

Sombatpaiwan, S., Tipwimon, T. and Treeaumnak, G. (2012). Postharvest Changes in Quality Characteristics of Nam Dokmai Mango (*Mangifera indica* L.). Proceeding of the 13th Thai Society of Agricultural Engineering Conference (pp. 518-525). Thailand.

Yuthachit, P. (1998). The development of process for mango glacé production. Master. Thesis. Prince of Songkla University, Thailand.