Development of Reduced Calories *Carissa Carandas* Sherbet by Substitution Sugar with Stevia Extract

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Abstract

The objective of this research was to develop *Carissa carandas* sherbet by substitution sugar with stevia extract. Five *Carissa carandas* sherbet samples were studied with different ratios of sucrose (g) and stevia extract (g) of 600:0 (control), 200:1 (T1), 100:2 (T2), 0:1 (T3), and 0:2 (T4), respectively. Results showed that viscosity and %overrun decreased significantly (*p* □ 0.05) in samples without sugar (T3 and T4) and those samples showed higher total phenolic content (102–176 µg gallic acid eq./g) and DPPH free radical scavenging activity (93–96 µg Trolox eq./g) than control sample (65 µg gallic acid eq./g and 69 µg Trolox eq./g). All sherbet samples replacing sugar with stevia extract had significantly higher %melting rate (7.57–13.09%) when compared with the control sample (4.17%) (*p* □ 0.05). Sensory evaluation using 9-point hedonic scale by 50 untrained panelists showed that the highest rating score for color (8.23), odor (8.03), taste (8.36), texture (8.33) and overall acceptability (8.40) was found in ice cream added with 100 g of sugar and 2 g of stevia extract (T2). Our results suggested that the development of *Carissa carandas* sherbet by substitution sugar with stevia extract could be a good potential as a healthy frozen dessert product with natural coloration and antioxidative property.

Keywords: Sherbet, *Carissa carandas*, Sugar, Stevia extract

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1. Introduction

Ice cream is a very popular frozen dessert among consumers of all ages in many countries, including Thailand, mainly because of its refreshing coolness. Ice cream, and all other frozen desserts, usually consist of seven ingredients such as fat, nonfat dry milk, sweeteners, stabilizers, emulsifiers, water and flavoring agents (Badem and Alpkent, 2018.). Sherbet is a frozen product made from sugar, water, fruit acid, color, fruit or fruit flavoring, stabilizer, and a small amount of milk solids added in the form of skim milk, whole milk, condensed milk, or ice cream mix. Citrus and berry sherbets must contain a minimum of 2% and 6% fruit, respectively. Other sherbets must contain a minimum of 10% fruit. Natural and artificial flavors of fruit sherbets have been used as fruit-flavoring ingredients (Arbuckle, 1986).

Carissa carandas L. (*Apocynaceae*), commonly known as Karanda (in Thai called Namdaeng, Manaao ho, Naam khee haet), is a widely used medicinal plant. Fruit is a rich source of iron and vitamin C. Young fruit generally have a light pink color that slowly darken and turn into the red color. Mature fruit is useful for making jellies, jams, squash, syrup and chutney due to its high pectin content (Signh and Uppal, 2015). The juice from the ripe fruit has become very popular among consumers due to its health beneficial biological activities including anthocyanin, phenolic compound and vitamin C (Pewlong *et al.*, 2014). Antioxidant activity of Karanda fruits was relatively high when compared to other tropical fruits (Mamun *et al*., 2012). However, negligible scientific information is available on antioxidant potential as well as physicochemical characteristics of *Carissa carandas* sherbet.

The main sweetener used in sherbet is sucrose although other sugars can be used, such as glucose, fructose and sugar alcohols (Soukoulis *et al*., 2010) and low glycemic index sweeteners (Whelan *et al*., 2008). Higher intake of added sugars is associated with higher energy intake and lower diet quality, which can increase the risk for obesity, pre-diabetes, type-2 diabetes, and cardiovascular disease (Klurfeld, 2013). The replacing of sugar with natural sweeteners in ice cream could provide a good dietary alternative for such consumers.

Stevia is known to be the best alternative natural sweetener and has been used by many food and beverage products. It is a good alternative, due to its high content of steviol glycosides which are natural, non-caloric and with a high sweetener capacity (200–300 times more than sugar) (Panpatil and Polasa, 2008). The development of reduced calories *Carissa carandas* sherbet could provide a good dietary alternative for consumers. Therefore, the objective of this research was to develop *Carissa carandas* sherbet by substitution sugar with stevia extract.

2. Materials and Methods

Fully ripe *Carissa carandas* and commercial products such as sugar, salt, skim milk and stabilizer were purchased from a commercial market in Phathumtani province. Stevia extract powder (SGV002, food grade) was purchased from Chemipan Co. (Bangkok, Thailand). All chemicals used were of analytical grade.

2.1 *Carissa carandas* juice preparation

Fully ripe *Carissa carandas* were washed with clean water for two times, and then cut the fruit in half and removed the seeds. *Carissa carandas* juice was extracted by using electric juicer with mixing *Carissa carandas* in with water at a ratio of 2:1 (w/v).

2.2 *Carissa carandas* sherbet production

Five formulations were studied as shown in Table 1. Each formulation was produced by mixing all ingredients and heated until temperature reaching 50 °C for 30 min. Then, the mixture was homogenized by using blender for 1 min, and pasteurized at 80 °C for 2 min. The heated sample was immediately cooled down to 4 °C and further ripened at 4 °C for 24 h. After ripening, each *Carissa carandas* sherbet formulation was produced using home style ice cream maker (HOMEMATE®, Model HOM-4002, Malta) for 20 min. After this step, each treatment was sampled for analyzing viscosity using a digital Brookfield (Brookfield Viscosmeter, Model DV-II+ Pro, USA), color value using HunterLab colorimeter (ColorFlex, Reston, VA, USA), %overrun, and total solid (AOAC, 2000).

After that, the process continued with placing 50 g of ice cream in plastic cup, covering with a plastic lid, hardening at -18 ± 2 °C for 24 h and storing at -18 ± 2 °C until analyzing. All treatments were analyzed for %melting rate, pH by using pH-meter (CONSORT, Model C830P, Belgium), Total phenolic content by Folin-Ciocalteu method and 2,2-Diphenyl-1-picrylhydrazyl radical scavenging activity assay (DPPH assay).

Table 1. *Carissa carandas* sherbet formulation containing sugar (control) and replacing sugar with stevia extract (T1–T4).

Ingredients (g)	Sample				
	Control	T1	T2	T3	T4
Carissa carandas juice	1000	1000	1000	1000	1000
Sugar	600	200	100	-	-
Stevia powder	-	1	2	1	2
Salt	2	2	2	2	2
Skim milk	2	2	2	2	2

Stabilizer	2	2	2	2	2

2.3 %Overrun

%Overrun was measured by comparing the weight of mix and ice cream in a fixed volume container (Özdemir *et al*., 2003) by using a 250 mL beaker. The %overrun was determined according to the following equation;

$$\%\text{overrun} = \frac{W_m - W_{ic}}{W_{ic}} \times 100$$

Where W_m (g) is the weight of a given volume of ice cream mix and W_{ic} (g) is the weight of same volume of ice cream.

2.4 %Melting rate

Ice cream sample (50 g) was put on a wire mesh attached to a beaker and maintained under a controlled temperature chamber at 25 ºC. The dripped volume was measured at a 10 min (Koxholt *et al*., 2001). The %melting rate was measured as the ratio of meltdown of ice cream to the total weight of ice cream.

2.5 Total phenolic content

Total phenolic content by Folin-Ciocalteu method was performed according to Kähkönen *et al*. (1999). *Carissa carandas* sherbet (50 g) was extracted with 100 mL of 95% ethanol. The mixture was then shaken at room temperature for 1 h with a shaking speed of 150 rpm. Supernatant was collected and filtered through Whatman No.1 filter paper. Then, the extract was subjected to total phenolic content and antioxidant activity assays.

Briefly, 500 µL of each samples were mixed well with 2.5 mL of 0.2 M Folin–Ciocalteu reagent, followed by the addition of 2 mL of 7.5% (w/v) sodium carbonate. The mixture was allowed at room temperature for 60 min and absorbance was measured at 765 nm. The total phenolic content was calculated from the calibration curve, and the results were expressed as µg gallic acid equivalents/g sample (µg gallic acid eq./g).

2.6 Antioxidant activity assay

2,2-Diphenyl-1-picrylhydrazyl radical scavenging activity assay (DPPH assay) was conducted according to Burits and Bucar (2000) with some modifications. Sample (1 mL) was mixed with 1 mL of 0.1 mM DPPH in ethanol solution. The reaction tubes were wrapped in aluminum foil and incubated for 10 min in darkness. The absorbance was monitored at 517 nm. DPPH assay was expressed as µg Trolox equivalents/g sample (µg Trolox eq./g).

2.7 Sensory evaluation

Sensory evaluation of *Carissa carandas* sherbet was evaluated by 50 untrained panelists using 9-Point Hedonic scale (1 = dislike extremely to 9 = like extremely) in color, odor, taste, texture and overall acceptability.

2.8 Statistical analyses

All physical and chemical analyses were carried in duplicate and mean values were presented. The data were analyzed statistically using SPSS statistical software program version 16 (SPSS Inc., Chicago, IL, USA). Analysis of variance (ANOVA) with Duncan's Multiple Range Test (DMRT) was used to determined significant difference among results.

3. Results and Discussion

Five *Carissa carandas* sherbet samples were studied with different ratios of sucrose (g) and stevia extract (g) of 600:0 (control), 200:1 (T1), 100:2 (T2), 0:1 (T3), and 0:2 (T4), respectively (Table 1). The physical properties of *Carissa carandas* sherbet before hardening including viscosity, %overrun, and total solid were presented in Table 2. Viscosity of control sample showed the highest viscosity (56.15 cP), followed by sample T1 (24.75 cP) and T2 (19.50 cP), respectively. Results also showed that control sample gave the highest total solid (41.57%), followed by sample T1 (21.54%), and T2 (13.77%), respectively. It was observed the samples with sucrose (control, T1 and T2) that showed higher %overrun than the samples without sucrose (T3 and T4) (p □ 0.05). These results indicated that the content of total solid greatly affects the viscosity and %overrun of *Carissa carandas* sherbet samples. This trend is in agreement with previous reports that sugar concentration increased the %overrun significantly (Güven and Karaca, 2002). Sonthisawate and Chantarapanont (2015) also reported that the viscosity and %overrun of the samples were increased when the total soluble solid increased.

Table 2. Physical properties of *Carissa carandas* sherbet formulation containing sugar (control) and replacing sugar with stevia extract (T1-T4).

Sample	Viscosity (cP)	Overrun (%)	Total solid (%)	Melting rate (%)
Control	$56.15^a \pm 1.06$	$18.51^a \pm 1.89$	$41.57^a \pm 0.25$	$4.17^d \pm 0.06$
T1	$24.75^b \pm 0.49$	$17.73^a \pm 0.04$	$21.54^b \pm 0.02$	$7.57^c \pm 0.21$
T2	$19.50^c \pm 0.28$	$18.15^a \pm 0.56$	$13.77^c \pm 0.19$	$6.71^c \pm 0.39$
T3	$6.40^d \pm 0.14$	$9.50^b \pm 0.00$	$5.64^d \pm 0.09$	$15.06^a \pm 0.07$
T4	$6.45^d \pm 0.35$	$9.84^b \pm 0.79$	$5.06^e \pm 0.12$	$13.09^b \pm 0.05$

Note: Means of the same column with different superscripts indicate significant difference (*p* □ 0.05).

%Melting rate after hardening at -18 °C for 24 h of all samples were also presented in Table 2. %Melting rate of all samples correlated with their total solid and %overrun by reducing total solid and %overrun resulting in increasing %melting rate. It has been reported that the ice cream formulation with higher viscosity had lower melted mass (Aranda-Gonzalez *et al*., 2016). In addition, Sonthisawate and Chantarapanont (2015) reported that lower total soluble solid resulted in higher %melting rate.

Color appearance of all samples were presented in Figure 1. As the level of sucrose content in ice cream was decreased, the whiteness (L*) and yellowness (b*) of the samples decreased significantly (*p* □ 0.05), while the redness (a*) of the samples increased significantly (*p* □ 0.05) (Table 3). Buyong and Fennema (1988) reported that higher content of sucrose reduced ice crystal growth rate and it can produces smaller ice crystals and higher %overrun. For this reason, the presence of sucrose might contribute to higher the whiteness (L*) in *Carissa carandas* sherbet, resulting sherbet becomes light pink.

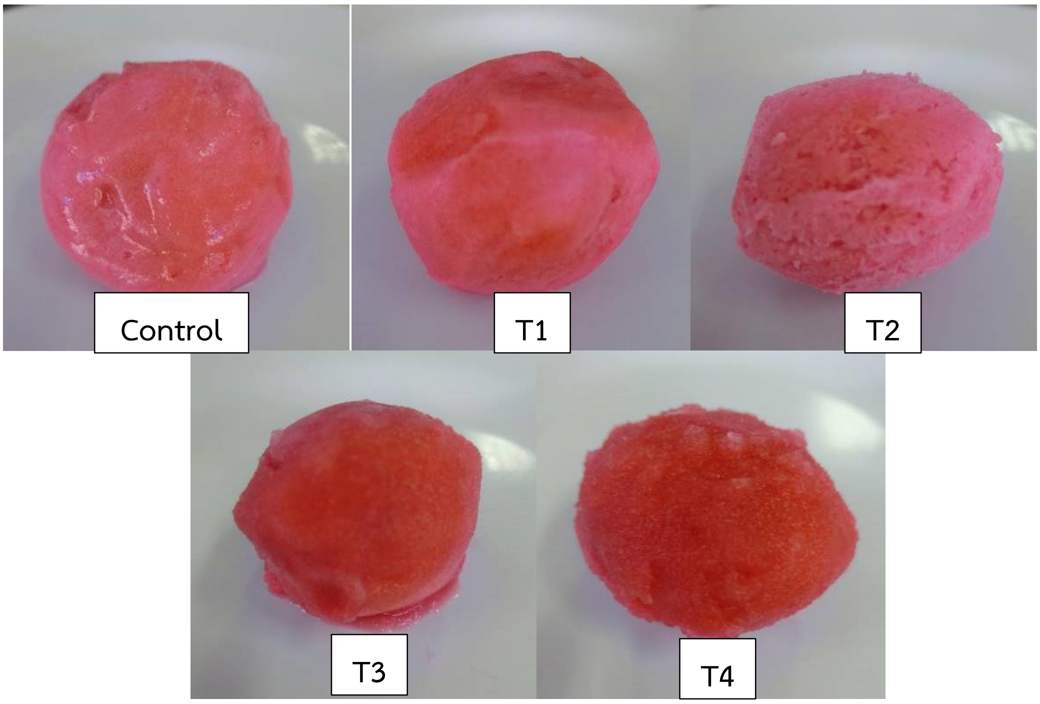

Figure 1 Color appearance of Carissa carandas sherbet formulation containing sugar (control) and replacing sugar with stevia extract (T1–T4).

Table 3. Color parameters (L*, a* and b* values) and pH value of *Carissa carandas* sherbet formulation containing sugar (control) and replacing sugar with stevia extract (T1–T4).

Sample	L*	a*	b*	pH
Control	$57.30^{a} \pm 0.05$	$26.25^{d} \pm 0.07$	$15.35^{a} \pm 0.00$	$2.78^{a} \pm 0.01$
T1	$56.00^{b} \pm 0.21$	$37.80^{c} \pm 0.21$	$13.50^{c} \pm 0.01$	$2.42^{b} \pm 0.02$
T2	$55.65^{c} \pm 0.15$	$45.85^{b} \pm 0.07$	$14.70^{b} \pm 0.14$	$2.43^{b} \pm 0.01$
T3	$34.35^{d} \pm 0.07$	$46.25^{a} \pm 0.21$	$8.00^{d} \pm 0.00$	$2.33^{c} \pm 0.01$
T4	$28.70^{e} \pm 0.14$	$46.20^{a} \pm 0.31$	$6.65^{e} \pm 0.07$	$2.34^{c} \pm 0.00$

Note: Means of the same column with different superscripts indicate significant difference (*p* □ 0.05).

The pH value of *Carissa carandas* juice in this study was 2.43 (data not shown). The addition of sucrose content at 600 g (control sample) significantly increased pH value of final product to 2.78 (*p* □ 0.05), while pH of other samples (2.33–2.43) was similar to pH of *Carissa carandas* juice.

Total phenolic content and DPPH radical scavenging activity of all samples are shown in Table 4. The results showed that the highest total phenolic content was found in T4 (136 μg Gallic acid eq./g), followed by T3 (102 μg Gallic acid eq./g), respectively, which corresponds to the highest of DPPH radical scavenging activity which found in sample T3 and T4 (93–95 μg Trolox eq./g). These results might be associated with the highest content of *Carissa carandas* juice per gram sample in T3 and T4. Pewlong *et al.* (2014) found that fully-ripe *Carissa carandas* fruits contain 4.67 mg Gallic acid/g, 54.80 mg anthocyanin/L and 180.40 mg vitamin C/100g. Prasad *et al.* (2010) also reported that *Carissa carandas* is abundant in anthocyanin which consists of cyanidin-3-O-rhamnoside, pelargonidin-3-O-glucoside and cyanidin-3-O-glucoside. These compounds include phenolic compounds, anthocyanin and vitamin C that act as antioxidant.

Table 4. Total phenolic content (µg Gallic acid eq./g) and DPPH radical scavenging activity (µg Trolox eq./g) of *Carissa carandas* sherbet formulation containing sugar (control) and replacing sugar with stevia extract (T1–T4).

Sample	Total phenolic content (µg Gallic acid eq./g)	DPPH radical scavenging activity (µg Trolox eq./g)
Control	$65.27^{c} \pm 0.48$	$69.27^{b} \pm 2.43$
T1	$61.23^{c} \pm 0.32$	$66.83^{b} \pm 3.24$
T2	$62.80^{c} \pm 1.43$	$66.97^{b} \pm 3.24$
T3	$102.56^{b} \pm 1.75$	$93.35^{a} \pm 2.43$
T4	$136.24^{a} \pm 0.32$	$95.64^{a} \pm 0.00$

Note: Means of the same column with different superscripts indicate significant difference (*p* □ 0.05).

The results of sensory evaluation using 9-point hedonic scale of *Carissa carandas* sherbet were shown in Table 5. The highest rating score for color (8.23), odor (8.03), taste (8.36), texture (8.33) and overall acceptability (8.40) was ice cream added with 100 g of sugar and 2 g of stevia extract (T2). The substitution sugar with stevia extract 100% (T3 and T4) in *Carissa carandas* sherbet resulting in lowest rating score for color, odor, taste, and texture. These results are in agreement with Aranda-Gonzalez *et al.*, (2016) who reported that the replacing sugar with *S. rebaudiana* extracts on sensory properties of strawberry ice cream showed the lowest scoring as compared to the control sample.

Table 5. Sensory evaluation of *Carissa carandas* sherbet formulation containing sugar (control) and replacing sugar with stevia extract (T1–T4).

Sample	Color	Odor	Taste	texture	Overall acceptance
Control	$7.40^{b} \pm 0.28$	$7.20^{b} \pm 0.14$	$7.33^{b} \pm 0.29$	$7.10^{b} \pm 0.21$	$7.10^{b} \pm 0.14$
T1	$7.80^{ab} \pm 0.56$	$7.61^{ab} \pm 0.38$	$7.82^{ab} \pm 0.60$	$8.16^{ab} \pm 0.28$	$7.76^{a} \pm 0.18$
T2	$8.23^{a} \pm 0.25$	$8.03^{a} \pm 0.17$	$8.36^{a} \pm 0.31$	$8.33^{a} \pm 0.34$	$8.40^{a} \pm 014$
T3	$6.23^{c} \pm 0.17$	$6.16^{c} \pm 0.14$	$5.66^{c} \pm 0.27$	$5.50^{c} \pm 0.70$	$5.76^{c} \pm 0.21$
T4	$5.70^{d} \pm 0.36$	$5.54^{d} \pm 0.43$	$4.94^{d} \pm 0.09$	$4.86^{c} \pm 0.11$	$4.70^{d} \pm 0.11$

Note: Means of the same column with different superscripts indicate significant difference (*p* □ 0.05).

4. Conclusion

The replacement of stevia as sweetener with different concentrations has significantly affected on the physical and sensory properties of *Carissa carandas* sherbet. These results reveal that stevia ice cream has a lower viscosity, %overrun and higher %melting rate. In this study, *Carissa carandas* sherbet added with 100 g of sugar and 2 g of stevia extract was the optimum ratio with the highest liking scores for color (8.23), odor (8.03), taste (8.36), texture (8.33) and overall acceptability (8.40). Therefore, Stevia extract can be used as a sugar substitute in formulating *Carissa carandas* sherbet for the health conscious market.

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