International Journal of Agricultural Technology 2021Vol. 17(3):1121-1134
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Effect of production process on physicochemical properties and bioactive compound in Karanda (*Carissa carandas*) tea

Singkhum, U.*

Department of Food Science and Technology, Rajamangala Technology University of Thanyaburi, Pathum Thani, 12130, Thailand.

Singkhum, U. (2021). Effect of production process on physicochemical properties and bioactive compound in Karanda (*Carissa carandas*) tea. International Journal of Agricultural Technology 17(3):1121-1134.

Abstract Karanda flesh consisted of 85.89 ± 0.38% moisture, 0.88 ± 0.17% ash,1.76 ± 0.22% crude protein %, 3.41 ±3.79% crude fat 1.41 ± 0.43% crude fiber, 6.65 ± 3.65% carbohydrate, 120.16 ±0.31 mg GAE/g total phenolic content, 72.10 ±0.65% DPPH antioxidant activity, 3.26 ±1.75 mg TE/g ferric ion reducing antioxidant power (FRAP) assay, 466.65 ±2.25 mg/g total anthocyanins. The study of different temperatures for roasting and rolling (40-50,50-60,70-80 ℃), rolling time (10-20 min), and drying temperature (60 and 80 ℃) on the production of Karanda tea affected moisture content, total phenolic content, antioxidant activity, ferric ion reducing antioxidant power and total anthocyanins in Karanda tea ($p \leq 0.05$), the roasting-rolling and drying at higher temperatures affected an increase in the bioactive compound. As a result, the tea production formula containing the most bioactive compound content drying at 80 ℃ to study the amount of water (80 and 90 ml) and water temperature (70 and 90 ℃) for making tea. The amount of water and water temperature had no effect on the bioactive compound ($p>0.05$). The result of sensory testing by 50 panelists using a 9-point hedonic scale found that difference preference scores to appearance and color ($p \leq 0.05$) but not a significant difference in terms of taste and overall liking for Karanda tea ($p>0.05$). Thus, the appropriate formula for Karanda tea making was 1 g of tea, 80 ml of water and 90 ℃ water temperature.

Keywords: Tea, Karanda (*Carissa carandas*), Bioactive compounds, Antioxidant

Introduction

Carissa carandas is commonly known as Karanda, Carunda and Christ's thorn or other local names such as Manao mairu ho (Central part), Manao ho (Southern Part), Nam khi haet (Chiang Mai), Nam Daeng (Bangkok) (Simla, 2016). Nam Daeng or Mamuang mai ru ho is a local fruit that can be harvest throughout the year, but it comes out a lot during May-July. Its flower is pink or light red with a light fragrance. Its unripe fruit has bright pink and becomes darker to be red until it has black color with six flat seeds (Maheshwari *et al.*,

* **Corresponding Author:** Singkhum, U.; **Email:** anchalins_s@rmutt.ac.th

2012). Based on Karanda's physical appearance that is red to almost black, it is considered a kind of fruit rich in anthocyanin content. An analysis of bioactive compounds in Karanda showed that they contain polyphenolic, flavonoid, flavanone, vitamin C, alkaloid, saponin and tannins. These substances have free radical scavenging capacity, prevent cancer cells in the body (anticancer) and diabetes as well (Kubola *et al*., 2011, Itankar *et al*., 2011, Simla *et al*., 2013, Gupta *et al*., 2014). Karanda fruits are an essential source of anthocyanin, vitamin C, iron and antioxidants. Ripe Karanda fruits have anthocyanin content as high as 427 mg/100 grams and much higher in unripe fruits. In terms of free radical scavenging capacity, ripe Karanda fruits show the most antioxidant properties than unripe Karanda fruits, but the unripe ones are higher in vitamin C content (Simla *et al*., 2013, Pewlong *et al*., 2013, Simla, 2016). Karanda fruits are familiar with eating fresh and the taste is sour. They can be obsessed with food products such as Karanda fruit juice, Karanda chili dip, Karanda roasted chili paste and red wine.

Nowadays, fruit and vegetable products developed to enhance to solve the health problem. They will be interested in many consumers because they focus on their health, university students and senior citizens who enhance the growing market. Furthermore, herb products that are produced by Thai traditional fruits and local vegetables have got high value by healthy vegetables and fruit with the most nutrition. For instance, the antioxidant group in the human body, which composes of the bio-oxidation compound, tea is a great product that integrates healthy and high nutrition fruit to develop the product to become fruit tea.

Tea has gained popularity as a daily drink from Chinese people since in the old days. Tea gives many health benefits as it contains essential compounds called tannin or polyphenols in tea leaves. These compounds mostly found in almost all plants, but each type may have different chemical structures. Tannin in fresh tea leaves or catechins in green tea has significant medicinal properties that scientists discovered that they have anti-disease effects if a person regularly drinks. Catechins possess antioxidant capacity giving substantial benefits to consumers who drink tea. Intense antioxidant activity of catechins contributes to several health benefits such as reducing the risk of cancer, reducing the risk of heart and vascular diseases, controlling glucose levels in diabetic patients and reducing obesity (Theppakorn, 2012).

Therefore, the researcher has the idea to bring Karanda flesh to the product development of fruit tea. The study on nutrient value, bioactive compounds of its fresh meat, developing proper tea production process and study appropriate conditions for making tea to ensure that Karanda fruit tea. Karanda fruit tea has the most antioxidants and has unique taste and flavor to be another choice for consumers who like to drink tea, give added value to the product, promote and develop food products from plants, vegetables and local herbs to be widely known.

Materials and methods

Material preparation

Karanda (*Carissa carandas* Linn) at the 2nd stage of the half-ripened level were purchased from the local market Simummuang market, Pathumthani province, Thailand. The Karanda were washed and sliced in a small size with a stainless steel knife, packed and stored at 4 ℃.

Physicochemical properties of karanda fruits

Color measurement of Karanda: Lightness (L*), redness (a*) value and yellowness (b*) value of Karanda were using a colorimeter (Hunter Lab model Colorflex45/0, USA). The total soluble solid (°Brix) was measured with a hand refractometer at 25 ℃ (Mater-53m Atoga, Japan). pH value was measured with a pH meter (PB-10 Sartorius, Germany).Total acidity (as % citric acid) was determined by titration 9 g of sample with 0.1 NaOH solution using phenolphthalein as an indicator. Proximate composition analysis was performed in triplicate for moisture contents, ash contents, crude protein, crude fat, crude fiber and carbohydrate using the standard method by AOAC (2000).

Bioactive compounds of Karanda

Sample preparation for analysis of bioactive compounds

500 g of Karanda flesh prepared from item one was accurately weighed and mixed with 40 % ethanol solvent of 500 ml and extracted continuously for 3 hr. with 500 ml by a soxhlet extractor. The obtained extract was removed solvent by a rotary evaporator at 45 ℃ until the solution complete to remove. The sample was kept at 4 ℃ for testing bioactive compounds accordingly.

Sample preparation for analysis of anthocyanin content

45 g of oven-dried Karanda fruit were mix with the solvent containing 1% hydrochloric in 250 ml methanol, shaken by a shaker at 150 rounds/min and extracted for 48 hours. When the time was due, the sample was filtered to separate residues. The obtained precipitates extract three times. The extract removed solvent suing an evaporator at 39 ℃ until the solution complete to

remove. Anthocyanin content was analyzed using a modification of the pH-differential method described by Wrolstad *et al*. (2005), Fakngoen and Meerod (2017).

Bioactive compound analysis

The total phenolic content is determined by the Folin-Ciocalteu method using gallic acid as a standard solvent. The method was done in the form of mg gallic acid equivalent/g dry sample (mg GAE/100g), a modification of the method proposed by Hsu *et al*. (2004). Free radical scavenging capacity (DPPH-radical scavenging activity) was reported in the form of mg Trolox equivalent/g dry sample (mgTE/100g) according to the slightly modified method of Burits and Bucar (2000). Ferric reducing capacity (Ferric ion reducing antioxidant power assay; FRAP) reported in the form of mg Trolox /g (mg TE/g) according to the modified method of Langley-Evans (2000). The total anthocyanin content was analyzed using a modification of the pH-differential method proposed by Wrolstad *et al*. (2005), Fakngoen and Meerod (2017).

Fruit tea production process from Karanda fruit

Temperature for roasting and rolling and appropriate oven drying temperature for preparing fruit tea made from Karanda

Fruit tea from Karanda fruit was made by studying temperature used for roasting and rolling and temperature for oven drying modified from the production process of herbal tea (Khonsarn *et al*., 2018) as follows:

Formula 1: Karanda flesh was roasted and rolled in a pan at 40-50 ℃ for 10 min. After that, they were dried by a hot air oven at 60 ℃ for 3 hours.

Formula 2: Karanda flesh was roasted and rolled in a pan at 40-50 ℃ for 20 min. After that, they were oven-dried in a hot air oven at 80 ℃ for 3 hours.

Formula 3: Karanda flesh was roasted, rolled in a pan at 50-60 ℃ for 10 min and oven-dried in a hot air oven at 60 ℃ for 3 hours.

Formula 4: Karanda flesh was roasted, rolled in a pan at 50-60 ℃ for 20 min and oven-dried in a hot air oven at 80 ℃ for 3 hours.

Formula 5: Karanda flesh was roasted, rolled in a pan at 70-80 ℃ for 10 min and oven-dried in a hot air oven at 60 ℃ for 3 hours.

Formula 6: Karanda flesh was roasted, rolled in a pan at 70-80 ℃ for 20 min and oven-dried in a hot air oven at 80 ℃ for 3 hours.

All Karanda flesh had final moisture content lower than 8% before they were contained in a bag and kept in desiccators for quality analysis accordingly.

Physicochemical properties and bioactive compound analysis

Color measurement of Karanda tea: Lightness (*L**), redness (*a**) value and yellowness (*b**) value of Karanda were using a colorimeter (Hunter Lab model Colorflex45/0, USA), water activity (a_w), the total soluble solid (°Brix) was measured with a hand refractometer at 25 °C (Mater-53m Atoga, Japan), pH value was measured with a pH meter (PB-10 Sartorius, Germany), total acidity (as % citric acid) was determined by titration 9 g of sample with 0.1 NaOH solution using phenolphthalein as an indicator, proximate composition analysis was performed in triplicate for moisture contents, ash contents, crude protein, crude fat, crude fiber and carbohydrate using the standard method by AOAC (2000).

Bioactive compounds were analyzed as follows: the total phenolic content is determined by the Folin-Ciocalteu method using gallic acid as a standard solvent. Results were reported in the form of mg gallic acid equivalent/g dry sample (mg GAE/100g), a modification of the method proposed by Hsu *et al*. (2004). Free radical scavenging capacity (DPPH-radical scavenging activity) was reported in the form of mg Trolox equivalent/g dry sample (mgTE/100g) according to the slightly modified method of Burits and Bucar (2000). Ferric reducing capacity (Ferric ion reducing antioxidant power assay; FRAP) reported in the form of mg Trolox /g (mg TE/g) according to the modified method of Langley-Evans (2000). The total anthocyanin content was analyzed using a modification of the pH-differential method proposed by Wrolstad *et al*. (2005), Fakngoen and Meerod (2017).

Appropriate condition for making Karanda fruit tea

The appropriate amount of water and water temperature for making Karanda fruit tea was studied

We selected the best formula for making fruit tea shown in item four to study the appropriate amount of water and water temperature for making tea. 1 g of fruit tea powder was moisture with hot water at the amount and temperature determined in six experimental formulas. The amount of water (ml): temperature (°C) for making tea ranged as follow: 80:70, 90:70, 80:80, 90:80, 80:90, 90:90 for 5 min. All fruit tea kept in glass bottles and water temperature for making tea controlled between 65-70 °C for physicochemical properties and bioactive compound analysis included sensory evaluation for the acceptance test.

Physicochemical properties and bioactive compounds were analyzed as follow

The total phenolic content was determined by the Folin-Ciocalteu method, according to a modification of the method proposed by Hsu *et al*. (2004). Free radical scavenging capacity (DPPH-radical scavenging activity) was reported according to the slightly modified method of Burits and Bucar (2000). Ferric reducing capacity (Ferric ion reducing antioxidant power assay; FRAP) was reported according to the modified method of Langley-Evans (2000). The entire anthocyanin content was analyzed using a modification of the pH-differential method proposed by Wrolstad *et al*. (2005), Fakngoen and Meerod (2017).

Sensory evaluation of Karanda fruit tea

The Karanda fruit tea tested sensory evaluation using a liking scale to measure preference, the 9-point hedonic scale, by 50 taste panelists to select a condition of Karanda fruit tea, making that consumer representative like the most. Variables in the test include color, flavor, taste and overall liking. Tea serving temperatures are controlled at 65-70 ℃. Three samples were tested with a minute break before another three samples were tested.

Statistical analysis

Statistical data were analyzed using computer software. Physicochemical property and bioactive compound data were analyzed using the completely randomized design (CRD); Sensory evaluation analyzed using the random complete block design (RCBD), Analysis of variance (ANOVA) and difference of means between experimental groups were analyzed using Duncan's new multiple range test at 95% confidence.

Results

Physicochemical properties and bioactive compounds of Karanda flesh

Physicochemical properties and bioactive compounds of Karanda flesh are shown in Table 1. Lightness (L*), redness (a*) and yellowness (b*) of Karanda flesh were 20.26 ± 3.59, 43.57 ± 1.92 and 9.86 ± 2.20, respectively. Total soluble solid (°brix), pH and Total acidity (%) of Karanda flesh were 12.2 ± 0.01, 3.89 ± 0.12 and 2.13 ± 0.03, respectively. Karanda flesh fruit was also analyzed for proximate composition, the results showed that Karanda flesh fruit contained moisture (85.89 ± 0.38%), ash (0.88 ± 0.17%), crude protein (1.76 ±

0.22%), crude fat (3.41±3.79%), crude fiber (1.41±0.43%), and carbohydrate (6.65 ±3.65%).

Bioactive compounds of Karanda flesh including total phenolic content, DPPH antioxidant activity, ferric ion reducing antioxidant power (FRAP) and total anthocyanins were 120.16±0.31 mg GAE/g, 72.10±0.65%, 3.26±1.75 mg TE/g and 466.65±2.25 mg/g, respectively.

Table 1. Physicochemical properties of Karanda flesh fruit (*Carissa carandas*)

Component	**Value**	**Component**	**Value**
Color		**Bioactive Compounds**	
L*	20.26±3.59	Total phenolic (mg GAE/g)	120.16±0.31
a*	43.57±1.92	Antioxidant activity	72.10±0.65
b*	9.86±2.20	(% DPPH radical scavenging)	
TSS (°brix)	12.2 ±0.01	FRAP mg Trolox eq. (mg TE/g)	3.26±1.75
pH	3.89±0.12	Total anthocyanins (mg/g)	466.65±2.25
Total acidity (%)	2.13 ±0.03		
Proximate analysis			
Moisture (%)	85.89±0.38		
Ash (%)	0.88±0.17		
Protein (%)	1.76±0.22		
Lipid (%)	3.41 ±3.79		
Crude fiber (%)	1.41 ±0.43		
*Carbohydrate (%)	6.65 ±3.65		

Note: Mean±SD (n=3) *Carbohydrate= 100-Moisture-Lipid-Protein-Ash-Crude fiber

The study on the production process of fruit tea from Karanda fruit

The temperature and time for roasting-rolling and oven drying were investigated for Karanda tea production. The color and water activity (a_w) shown in Table 2. Lightness (L*), redness (a*) and yellowness (b*) for all conditions were found to vary among (-33.34)-(22.65), 45.51-55.25 and (-8.90)-(2.01) respectively. Karanda tea production with 40-50 ℃ 10 min, dried at 60 ℃ 3 hr. was found to have the highest L* and significantly different ($p \leq 0.05$) from other treatments. Karanda tea production with 40-50 ℃ 20 min, dried at 80 ℃ 3 hr. was found to have the highest level of a* and significantly different ($p \leq 0.05$) from other treatments and the color of b) *yellowness (was found Karanda tea production with 40-50 ℃ 10 min, dried at 60 ℃ 3 hr. to have the highest level and non-significantly of tea production with 40-50 ℃ 20 min, dried at 80 ℃ 3 hr., 50-60 ℃ 10 min, dried at 60 ℃ 3 hr. and 50-60 ℃ 20 min, dried at 80 ℃ 3 hr., respectively.

The water activity (a_w) content of all samples showed between 0.43-0.54. Karanda tea production with roasting-rolling 70-80 ℃ 10 min, dried at 60 ℃ 3 hr. was found to have the highest level of water activity and significantly different (p≤0.05) from other treatments.

Table 2. Color and Water activity (a_w) of karanda tea

temperatures for roasting and rolling, rolling time and drying temperature	Color			Water activity (a_w)
	L*	a*	b*	
40-50 ℃ 10 min. dried at 60 ℃ 3 hr.	-22.65^{a} ±0.54	52.57^{bc} ±4.45	-2.01^{a} ±9.61	0.49^{b} ±0.04
40-50 ℃ 20 min. dried at 80 ℃ 3 hr.	- 27.95^{b} ±1.48	55.26^{a} ±0.12	-5.76^{abc} ±2.89	0.43^{c} ±0.02
50-60 ℃ 10 min. dried at 60 ℃ 3 hr.	- 26.54^{b} ±0.52	52.84^{bc} ±0.72	-2.36^{a} ±1.28	0.49^{b} ±0.01
50-60 ℃ 20 min. dried at 80 ℃ 3 hr.	- 28.03^{b} ±0.30	51.50^{bc} ±1.44	-4.36^{ab} - ±2.68	0.48^{b} ±0.01
70-80 ℃ 10 min. dried at 60 ℃ 3 hr.	-31.44^{c} ±2.78	45.51^{c} ±1.32	-8.90^{c} - ±1.43	0.54^{a} ±0.01
70-80 ℃ 20 min. dried at 80 ℃ 3 hr.	-33.34^{c} ±2.92	- 49.98^{b} ±1.09	-7.86^{bc} - ±3.36	0.49^{b} ±0.02

$^{a-e}$ values with different letters in the same column are significantly different (*p*≤0.05)

The total soluble solid (°brix), total acidity (%) and pH are shown in Table 3. The total soluble solid and pH ware found to vary among 3.0-3.1 and 3.2-3.4, respectively and non-significantly for all treatments. Total acidity (%) varied between 9.62-12.65 and Karanda tea production with roasting-rolling 70-80 ℃ 10 min, dried at 60 ℃ 3 hr. was found to have the highest total acidity and significantly different (p≤0.05) from other treatments.

Proximate analysis of Karanda tea shown in Table 4, roasting and rolling temperature, rolling time and different drying temperature in all six formulas affected the moisture content of Karanda tea (p≤0.05) but did not affect ash, crude fat, crude protein, crude fiber and carbohydrate contents (p>0.05).

Table 3. Total soluble solid total acidity and pH of karanda tea

temperatures for roasting and rolling, rolling time and drying temperature	Total soluble solid ^{ns} (°brix)	Total acidity (%)	pH^{ns}
40-50 ℃ 10 min. dried at 60 ℃ 3 hr.	3.1±0.04	11.00^{c} ±0.22	3.3±0.09
40-50 ℃ 20 min. dried at 80 ℃ 3 hr.	3.0±0.04	11.90^{b} ±0.34	3.4±0.10
50-60 ℃ 10 min. dried at 60 ℃ 3 hr.	3.0±0.04	9.62^{e} ±0.03	3.3±0.15
50-60 ℃ 20 min. dried at 80 ℃ 3 hr.	3.1±0.04	10.95^{c} ±0.05	3.3±0.06
70-80 ℃ 10 min. dried at 60 ℃ 3 hr.	3.1±0.04	12.65^{a} ±0.22	3.2±0.05
70-80 ℃ 20 min. dried at 80 ℃ 3 hr.	3.0±0.04	10.47^{d} ±0.12	3.2±0.09

$^{a-e}$ Values with different letters in the same column are significantly different (*p*≤0.05)
^{ns} = not significantly different (*p*>0.05)

Table 4. Chemical properties of karanda tea

Temperatures for roasting and rolling, rolling time and drying temperature	Chemical properties					
	Moisture (%)	Ash^{ns} (%)	Crude Protein^{ns} (%)	Crude Fat^{ns} (%)	Crude fiber^{ns} (%)	*Carbohydrate^{ns} (%)
40-50 ℃ 10 min. dried at 60 ℃ 3 hr.	10.29^{ab} ±0.76	4.44±0.19	1.70±0.19	3.50±1.72	51.94±2.01	28.13±0.75
40-50 ℃ 20 min. dried at 80 ℃ 3 hr.	11.66^{a} ±0.14	3.93±0.20	1.65±0.19	3.44±1.96	52.20±2.94	27.12±4.91
50-60 ℃ 10 min. dried at 60 ℃ 3 hr.	9.98^{ab} ±13.21	4.85±0.78	1.73±0.19	4.66±0.53	51.22±8.03	27.56±4.93
50-60 ℃ 20 min. dried at 80 ℃ 3 hr.	9.28^{c} ±0.14	4.53±0.34	1.69±0.19	5.53±0.78	52.26±1.26	26.40±1.35
70-80 ℃ 10 min. dried at 60 ℃ 3 hr.	9.42^{c} ±0.21	3.62±0.42	1.69±0.19	3.73±1.60	52.72±4.33	28.82±5.81
70-80 ℃ 20 min. dried at 80 ℃ 3 hr.	9.97^{ab} ±0.22	4.83±3.73	1.61±0.19	4.24±0.45	53.05±9.82	26.30±10.22

$^{a-c}$ Values with different letters in the same column are significantly different ($p \leq 0.05$)
^{ns} = not significantly different ($p > 0.05$) *Carbohydrate= 100-Moisture-Lipid-Protein-Ash-Crude fiber

The temperatures for roasting and rolling, rolling time and different drying temperature in all six formulas affected bioactive compound content, free radical scavenging capacity (DPPH) and ferric reducing capacity, anthocyanin content are shown in Table 5. It was observed that an increase in roasting and rolling temperature and time or drying temperature significantly increased in total phenolic content ($p \leq 0.05$).

Table 5. Bioactive compounds of karanda (*Carissa carandas*) tea

Temperatures for roasting and rolling, rolling time and drying temperature	Bioactive Compounds			
	Total phenolic (mg GAE/g)	Antioxidant activity (% DPPH)	FRAP mg Trolox eq. (mgTE/g)	Total anthocyanins (mg/g)
40-50 ℃ 10 min. dried at 60 ℃ 3 hr.	128.72^{e}±0.16	53.65^{b}±0.71	3.15^{d}±0.67	433.23^{d}±0.28
40-50 ℃ 20 min. dried at 80 ℃ 3 hr.	137.61^{e}±0.72	57.47^{a}±0.43	3.41^{c}±0.51	420.40^{e}±0.32
50-60 ℃ 10 min. dried at 60 ℃ 3 hr.	151.57^{d}±0.59	56.98^{b}±0.80	3.89^{a}±0.48	455.33^{b}±0.13
50-60 ℃ 20 min. dried at 80 ℃ 3 hr.	197.23^{c}±0.21	58.56^{a}±0.33	3.76^{b}±0.43	446.35^{c}±0.31
70-80 ℃ 10 min. dried at 60 ℃ 3 hr.	221.76^{b}±0.15	57.83^{a}±0.85	3.70^{b}±0.63	459.54^{b}±0.99
70-80 ℃ 20 min. dried at 80 ℃ 3 hr.	245.96^{a}±0.55	51.51^{b}±0.80	3.96^{a}±0.38	480.40^{a}±0.76

$^{a-d}$ Values with different letters in the same column are significantly different ($p \leq 0.05$)

Roasting and rolling temperature at 70-80 ℃, rolling time 10 min, oven drying temperature at 80 ℃ were selected for further study the appropriate amount of water and temperature for Karanda tea making due to its high bioactive compound content. Tea making conditions were investigated in six formulas. The water content (ml) to temperature (℃) for tea making was 80:70, 90:70, 80:80, 90:80, 80:90 and 90:90. The experiment indicated that the amount of water and water temperature in tea making did not affect the content of all bioactive compounds in Karanda tea (p>0.05) (Table 6).

Table 6. Bioactive compounds of karanda tea

Sample (water: temperature)	Bioactive Compounds			
	Total phenolics^{ns} (mg GAE/g)	**Antioxidant activity^{ns} (% DPPH)**	**FRAP^{ns} mg Trolox eq. (mgTE/g)**	**Total anthocyanins^{ns} (mg/g)**
80 ml : 70 °C	98.03±0.50	23.27±0.48	2.23±0.34	189.79±0.50
90 ml : 70 °C	97.96±0.43	23.79±0.53	2.25±0.40	190.40±0.65
80 ml : 80 °C	96.06±0.71	23.58±0.65	2.20±0.60	193.33±0.94
90 ml : 80 °C	97.58±0.60	24.34±0.43	2.31±0.71	188.48±0.86
80 ml : 90 °C	97.58±0.91	23.79±0.76	2.39±0.22	189.38±0.37
90 ml : 90 °C	97.89±0.98	23.57±0.48	2.35±0.14	190.14±0.58

^{ns} = not significantly different (p>0.05)

Table 7. Hedonic score of sensory evaluation of Karanda tea brewing

Sample (water:temp)	Hedonic score				
	appearance	**color**	**flavor^{ns}**	**taste^{ns}**	**overall liking^{ns}**
80 ml : 70 °C	7.62^{b} ±1.23	7.46^{a} ±1.23	6.60±1.34	6.50±1.97	7.02±1.24
90 ml : 70 °C	7.84^{a} ±1.11	7.30^{d} ±1.11	6.56±1.34	6.58±1.75	7.06±1.11
80 ml : 80 °C	7.58^{c} ±1.20	7.50^{b} ±1.20	6.56±1.39	6.50±1.75	7.08±1.35
90 ml : 80 °C	7.28^{d} ±1.12	7.40^{c} ±1.12	6.62±1.46	6.60±1.65	6.88±1.14
80 ml : 90 °C	7.26^{d} ±1.14	7.28^{d} ±1.14	6.62±1.51	6.74±1.72	6.96±1.11
90 ml : 90 °C	7.24^{d} ±1.06	7.22^{d} ±1.06	6.44±1.51	7.60±1.55	6.86±1.28

$^{a-d}$ Values with different letters in the same column are significantly different (p≤0.05)
^{ns} = not significantly different (p>0.05)

Sensory evaluation of Karanda tea brewing was shown in Table 7. The amount of water and water temperature in all six formulas for making Karanda tea had no effect on the flavor, taste and overall liking but affect the appearance and color. Karanda tea brewing at water content 90 ml and water temperature 70 ℃ showed the highest appearance score (7.84±1.11), while the highest color score was observed in tea brewing at water content 80 ml and water temperature 70 ℃.

Discussion

Karanda fruit is high in water content, dietary fiber and a rich source of bioactive compounds. In this experiment, ripe Karanda fruits selected because, at this stage, total phenolic content, total anthocyanin content, total tannin content and antioxidant property are at the highest level, followed by semi-ripe fruits while unripe fruits have a low level of those compounds. Moreover, it found that anthocyanin content increases by stages of ripening (Pewlong *et al*., 2013). The consistent with the experiment performed by Buachun (2018) that found that the extract from Karanda flesh had total phenolic content and total tannin content higher than the extract from Karanda seeds. Vitamin C content found in fruit flesh was low. The reason is reasonable that the fruit flesh at the ripe stage selected in the experiment had vitamin C content two times lower than the fruit flesh at the unripe stage as the immature stage with 307.20 mg/100g of vitamin C content was found while the ripe stage with 180.40 mg/100g vitamin C content, the lowest level was found respectively (Pewlong *et al*., 2013).

Karanda fruit flesh was roasted, rolled and oven-dried in a hot air oven at a determined temperature to gain Karanda tea product. The roasting and rolling contributed to bruising and fruit cell breaking. When they were oven-dried, they became darker. The roasting, rolling, and oven drying can stimulate a darker color with the involvement of enzyme, namely, polyphenol oxidase enzyme. When shook vegetable and fruit cells, enzyme reactants and oxygen were exposed to one another. Monophenol shall be oxidized to be diphenol, which is colorless and diphenol shall be further oxidized to be O-quinone having a dark brown color. The concentration of fruit flesh depends on temperature and stress. High temperatures in the roasting, rolling and oven drying and high pressure affect the color at a higher concentration (Nanthachai *et al*., 2013).

All Karanda tea formulas had aw values ranging between 0.43-0.54 compliant with product standard requirements of dried mixed herb powder or dried food products as they are specified to have water activity (a_w) value equal to 0.6 or lower. Water activity (a_w) is a factor in controlling and preventing the deterioration of food products, which has a direct effect on the shelf life of products since aw value is a factor indicating levels of independent water content microorganisms use to support their growth (Thai Industrial Standards Institute, 2013).

The roasting, rolling and oven drying at different temperatures in all six formulas affected the moisture content of Karanda tea. It did not affect ash, fat, protein, dietary fiber and carbohydrate contents. The reason is probably that the moisture content rate shall rapidly decrease when temperature and drying rates are high. It is consistent with the experiment performed by Phosee *et al*. (2013) on temperature, moisture content and color changes of mint leaves during the drying process.

The higher temperature in the roasting, rolling and oven drying contributed to the entire phenolic content, total anthocyanin content tends to increase and give different bioactive compound content with statistical significance. It is reasonable that the process of roasting and rolling using heat produced stress that could break down cell walls. The rising heat inhibited oxidative reaction and the hydrolytic enzyme activation, bringing the degradation of phenolic compounds to an end. The temperature in this process induced the Maillard reaction and the occurrence of various phenolic compounds. The group of these compounds is known as melanoidin or Maillard reaction product (MRPs), having an antioxidant property, which can increase radical scavenging capacity (Vashisth et *al*., 2011; Arslan and Ozcan, 2010; Othong, 2015).

The experiment indicated that bioactive compounds tended to increase when water temperature for tea making was higher. The consistent with the experiment performed by Noosing *et al*. (2014) that revealed that temperature and time spent on making instant germinated purple rice tea affected anthocyanin content as when the temperature in soaking the germinated purple rice was higher, the tea contained greater anthocyanin content and 65 ℃ was the optimum condition for tea made with the highest anthocyanin. Luemchan *et al*. (2008) found that high temperatures used to extract anthocyanin in black glutinous rice affected gaining greater anthocyanin content.

About the consideration of antioxidant efficiency triggered by phenolic compound, anthocyanin, tannin and vitamin C contents in Karanda fruit, the antioxidant activity of Karanda fruit is relatively high. When it developed to Karanda fruit tea, it is also rich in bioactive compounds. Though it is processed by roasting, rolling, oven drying and high water temperature for tea making, there is no effect on bioactive compound content in Karanda tea, which can see only a small effect on the destruction of bioactive compounds during the production process. Consequently, Karanda fruit tea was categorized in a healthy drink group, which may give another choice to consumers who like to drink various kinds of tea and those who care about their health.

In the study on the tea production process, it found that Karanda flesh controlled by the temperature for roasting-rolling at 70-80 ℃, 10 min of roasting-rolling and oven drying at 80 ℃ is a tea production process appropriate to give high nutrient Karanda fruit tea product. The method of roasting-rolling and oven drying using heat enables bioactive compounds to increase by stimulating enzymes in Karanda flesh and tea, making the condition to gain tea rich in antioxidants and bioactive compounds beneficial to consumers. While its appearance, color, flavor and taste can meet consumers' satisfaction, namely, 1 gram of Karanda tea powder moistened with 80-90 ml water at 70-90 ℃. The development of imitation tea drink products from the fruit is another approach to increasing the nutritional value of drink products and promoting food products made from plants, vegetables and local herbs to be more widely known.

Acknowledgments

The authors gratefully thank Division of Food Science and Technology, Faculty of Agricultural Technology, Rajamangala Technology University of Thanyaburi for their financial support.

References

AOAC (2000). Official methods of analysis. Association of Official Analytical Chemists, Washington, DC.

Arslan, D. and Ozcan, M. M. (2010). Study the effect of sun, oven and microwave drying on quality of onion slices. LWT - Food Science and Technology, 43:1121-1127.

Buachun, N. (2018). Antioxidant activity and total phenolic from seeds and fruits of Carissa carandas. Journal of Research and Development, Valaya Alongkorn Rajabhat University under the Royal Patronage, 13:53-63.

Burits, M. and Bucar, F. (2000). Antioxidant activity of Nigella sativa essential oil. Phytotherapy Research, 14:323-328.

Fakngoen, S. and Meerod, S. (2017). Extraction and separation of anthocyanins from *Carissa carandas* L. The Vth Kamphaeng Phet Rajabhat University National Conference, 1011 p.

Gupta, P., Bhatnagar, I., Kim, S. K., Verma, A. K. and Sharma, A. (2014). In-vitro cancer cell cytotoxicity and alpha amylase inhibition effect of seven tropical fruit residues. Asian Pac Journal of Trop Biomed, 4:S665-S671.

Hsu, L. C., Hurang, L. S., Chen, W., Weng, M. Y. and Tseng, Y. C. (2004). Qualities and antioxidant properties of bread as affected by the incorporation of yam flour in the formulation. International Journal of Food Science & Technology, 39:231-238.

Itankar, P. R., Lokhande, S. J., Verma, P. R., Arora, S. K., Sahu, R. A. and Patil A. T. (2011). Antidiabetic potential of unripe Carissa carandas Linn. Fruit extract. Journal of Ethnopharmacology, 135:430-433.

Khonsarn, N., Chaiyabot, A., Chairak, N. and Lawan, S. (2018). Effect of drying on total phenolic contents and antioxidant activities in herbal infusions. Journal of Khon Kaen AGR, 46:1395-1400.

Kubola, J., Siriamornpun S. and Meeso, N. (2011). Phytochemicals, vitamin C and sugar content of Thai wild fruits. Journal of Food Chemistry, 126:972-981.

Langley-Evans, S. C. (2000). Antioxidant Potential of Green and Black Tea Determined using the Ferric Reducing Power (FRAP) assay. International Journal of Food Science and Nutrition, 51:181-188.

Luemchan, D., Chantrapornchai, W. and Haruathaithanasan, V. (2008). Extraction of anthocyanin from black glutinous rice. 46th Kasetsart University Annual Conference: Agro-Industry, 677 p.

Maheshwari, R., Sharma, A. and Verma, D. (2012). Phyto-therapeutic Significance of Karaunda. Bulletin of Environment, Pharmacology and Life Sciences, 1:34-36.

Nanthachai, N., Monnamorn, S. and Panate, K. (2013). Effect of processing on antioxidant activity and total phenolic content of pummel peel tea. The Journal of Agricultural Science, 44:221-224.

Noosing, S., Mundee, P. and Leelawat, B. (2014). Development of instant germinated purple rice tea. Journal of Science and Technology, Thammasat University, 22:337-346.

Othong, J., Thongtun, J. and Limsuwan, T. (2015). Development of Yanang herbal tea and its physicochemical properties, antioxidant activity and total phenolic compound. 53rd Kasetsart University Annual Conference: Plants, Animals, Veterinary Medicine, Fisheries, Agricultural Extension and Home Economics, 1595 p.

Pewlong, W., Sajjabut, S., Singphet, S. and Eamsiri, J. (2013). Influence of fruit ripening stages on the bioactive compounds of *Carissa carandas* L. The Journal of Agricultural Science, 44:334-340.

Phosee, N., Khongbutr, P., Uttamating, K. and Rittichai Assawarachan, R. (2013). Effect of temperature on moisture ratio and color changes on mint leaves during hot air drying process. Journal of Rajamangala University of Technology Suvarnabhumi, 1:103-114.

Simla, S. (2016). *Carissa carandas* L.: The fruit mentioned in Thai literature that has many health benefits. Journal of Khon Kaen AGR, 44:557-566.

Simla, S., Boontang, S. and Siritrakulsak, P. (2013). The evaluation of some phytochemical content and antioxidant activity in Carissa carandas L. Journal of Khon Kaen AGR, 41:602-606.

Thai Industrial Standards Institute (2013). Community product standard, mulberry leaf tea 1446/2556. Ministry of Industry. Bangkok.

Theppakorn, T. (2012). Tea (*Camellia sinensis* L.): Manufacturing and chemical compositions from fermentation. Burapha Science Journal, 17:189-196.

Wrolstad, E. R., Dust, W. R. and Lee, J. (2005). Tracking color and pigment changes in anthocyanin products. Trends in Food Science & Technology, 16:423-428.

Vashisth, T., Vashisth, R. K. and Pegg, R. B. (2011). Effects of drying on the phenolics content and antioxidant activity of muscadine pomace. LWT - Food Science and Technology, 44: 1649-1657.

(Received: 13 August 2020, accepted: 21 April 2021)