



Effect of spray drying condition on physical and antioxidant properties of acerola fruit juice powder

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Introduction

Malpighia glabra L., commonly known as acerola cherry, West Indian cherry or barbados cherry (Family Malpighiaceae), is a fruit native to the West Indies which can be grown in the northeast of South America, Central America as well as Thailand.^{1,2} Acerola fruit is high in vitamin C content which varies from 1,247.10 to 1,845.79 mg/100 mL of pulp.³ Moreover, it is also rich in other nutrients such as thiamin, riboflavin, niacin, carotenes, proteins, and minerals, mainly calcium, iron and phosphorus.⁴ Chemical compositions of acerola fruit varies between cultivars with environmental conditions and the stage of fruit ripeness. Acerola fruit exhibits antioxidant activity due to high contents in vitamin C and polyphenols. These bioactive compounds are known to prevent high blood pressure, and reduce the risk of cardiovascular diseases and cancer.⁵ Hence it is interesting to develop the products from acerola fruit during the upward trend in consuming functional foods and nutraceuticals.

In Thailand, the typical weather is high temperatures and humidity which is not favorable for fruit preservation under natural conditions. Rapid spoilage by many microorganisms is commonly observed in postharvest especially in fruits with high moisture content such as acerola fruit. Drying is an alternative way for the preservation of fruits. As drying helps in reducing wastes and postharvest losses, and further enhances commercialization due to extending the shelf life of the product with minor dependence on seasonal conditions.⁶ From the preliminary study, acerola fruit powder obtained from spray drying showed higher total phenolic contents and antioxidant activity than that obtained from freeze drying. Considering the application in the industry, spray drying technique has high potential productivity and also lower costs than freeze drying technique.^{7,8} The principle of spray drying is the conversion of feed from a liquid or slurry form to a dry powder and it is considered to be one of the most complex methods for fruit juice drying. The feed is atomized into a chamber and then mixed with hot air causing the liquid to evaporate and leaving only the solid particles. The spray drying performance is determined by various factors including yield and physical property of the product. Yield loss in the spray drying system is mostly caused by the attachment of particles to the wall of the apparatus which further affects the quality of the product.⁹ In order to obtain good quality of the product, the optimization of spray drying condition is important.

In this study, the effect of spray drying condition, especially inlet temperature, on physical and antioxidant properties of acerola fruit juice powder was evaluated. Acerola fruit juice powder was determined for yield, moisture content, antioxidant activity by using DPPH assay and total phenolic content by using Folin-Ciocalteu method.

Methods

Materials and chemicals

Ripe acerola fruits were collected from Pathumthani province, Thailand. Maltodextrin (DE10-12) was purchased from Chemipan Corporation Co.,Ltd., Thailand. The reagent and standard used in this study, i.e. Folin-Ciocalteu reagent, gallic acid and 2,2-diphenyl-1-picrylhydrazyl (DPPH) were from Sigma-Aldrich (St. Louis, MO). Ethanol was purchased from Merck (Darmstadt, Germany). All chemicals used in this study were of analytical reagent grade.

Preparation of acerola fruit juice

Acerola fruits were cleaned, air dried, and cut into small pieces after removing the seeds. The fruits were pressed using an electric blender and then were filtered by filter paper No.1 after filtered by gauze.

Preparation of acerola fruit juice powder using spray drying technique

The juice was mixed with maltodextrin (15% w/v) and then was dried by spray drying using a Buchi mini spray dryer B-290 (Switzerland). The sample was dried by using aspirator rate 40 m³/h and feed rate 10 mL/min. The inlet temperature was varied at 120 and 150°C. The percent yield of acerola fruit juice powder was analyzed. The physical characteristics such as color were observed.

Determination of moisture content

The moisture content of acerola fruit juice powder was determined by using moisture analyzer (RADWAG MA 50.R, Poland) at the temperature of 105°C.¹⁰

Determination of antioxidant activity by DPPH assay

This assay is based on the change of color from purple to yellow or colorless, when the DPPH radical reacts with antioxidant substance. DPPH has a strong violet color with maximum absorbance at 517 nm.^{11, 12} Briefly, 0.4 mM of DPPH working solution was prepared in methanol. The DPPH working solution was then added to the sample solution in the same volume. The absorbance was measured at 517 nm after the reaction mixture was incubated in the dark for 30 minutes using an UV spectrophotometer microplate reader (Tecan Infinite M200, Tecan, Austria). The antioxidant activity was calculated using a calibration curve for Trolox (12-50 µg/mL). The result was expressed as Trolox equivalent (TE) in milligram per gram of dry sample. The experiment was performed in triplicated.

Determination of total phenolic content by Folin-Ciocalteu method

The Folin–Ciocalteu reagent is a mixture of phosphotungstate and phosphomolybdate used for the colorimetric *in vitro* assay to determine the total polyphenols.¹³ The assay was performed according to Vongsak et al. with slightly modification.¹⁴ A stock solution of acerola fruit juice powder (0.75 mg/mL) was dissolved in water. Twenty microliters of stock solution was mixed with 50 µL of 10% Folin-Ciocalteu reagent. The mixtures were allowed to react for 3 minutes before adding 80 µL of 7.5% Na₂CO₃ and then incubated at room temperature in the dark for 2 hours. The absorbance of reaction mixtures was measured at 765 nm using an UV spectrophotometer microplate reader (Tecan Infinite M200, Tecan, Austria). Gallic acid at the concentrations of 50-200 µg/mL was used to construct a calibration curve. The result was expressed as gallic acid equivalent (GAE) in milligram per gram of dry sample. The experiment was performed in triplicated.

Results and discussion

Color, moisture content, product yield of acerola fruit juice powder prepared by spray drying using inlet temperatures of 120°C and 150°C were shown in Table 1. It was found that at constant aspirator and feed rate with increasing inlet temperature resulted in a decreasing moisture content and increasing production yield of the acerola fruit juice powder. The similar results were obtained by several studies revealing that moisture content was also decreased with an increasing production yield as the inlet temperature increased.¹⁵⁻²⁰ This may be due to higher temperature during the drying process causing higher rate of heat transfer leading to the enhancement of water evaporation from the droplets and reduction of the powder deposition on the inside wall. The moisture contents of acerola fruit juice powder obtained from both conditions were within the limit (< 6%) according to Bates.²¹

Table 1 Physical properties of acerola fruit juice powder

Inlet temperature (°C)	Color		Moisture content (%)	Product yield (%)
120	Orange		5.87 ± 0.42	15.88 ± 0.13
150	Light pink		4.41 ± 0.26	16.31 ± 0.13

Mean ± SD of two replicate analyses

Antioxidant properties of acerola fruit juice powder were compared with that of its fresh juice in order to observe the retention of antioxidant properties (Table 2). Acerola fruit juice showed the highest DPPH scavenging activity followed by acerola fruit juice powder obtained by spray drying at 120°C (ACP120) and acerola fruit juice powder obtained by spray drying at 150°C (ACP150), respectively. Therefore, increasing the inlet temperature have an effect on DPPH scavenging activity of the samples ($p < 0.05$). Similarly to previous study which reported that increasing in drying temperature decreased the free radical scavenging activity of amla juice powder.²² In addition, the study stated that increasing the drying temperature from 120 to 200°C caused a significant loss of the total antioxidant capacity.²² This information supported our result in which higher drying temperature caused the degradation of some antioxidant compounds in the spray dried acerola fruit juice powder which led to lower DPPH scavenging activity when compared with the juice.

The result of total phenolic content showed significant difference between fresh acerola fruit juice and spray dried powder but did not show significant difference among the two spray dried powder conditions. This result agreed with the study of Marquele et al. which reported that the temperature significantly affected the total phenolic content.²³ The possible explanation may be due to the oxidative condensation phenomena and decomposition of thermolabile compounds that caused degradation of the polyphenols which were induced by in-process factors such as heating.²⁴ However, some studies reported that the temperature above 175°C increased the total phenolic contents.²² Because the polymerization of polyphenols at the temperature above 175°C as well as the synthesis of polyphenols at 200°C increased the total phenolic content of the amla powder. In addition, higher temperature have an effect on the total phenolic content by inactivation of polyphenol oxidase and peroxidase which can cause the oxidative degradation of phenolic compounds.²⁵ Thus, it revealed that total phenolics content is not the only factor contributed to the antioxidant activity of acerola fruit. Other chemical constituents in acerola fruit such as vitamin C, flavonoids, carotenoids have also been reported to possess antioxidant activity.²⁶

Table 2 Antioxidant properties of acerola fruit juice and spray dried acerola fruit juice powder obtained by using two different inlet temperatures

Samples	Antioxidant properties	
	DPPH scavenging activity (mg Trolox/g dried extract)	total phenolic content (mg GAE/g dried extract)
Fresh juice	280.85 ± 2.51 ^a	155.29 ± 1.67 ^a
ACP120	245.87 ± 2.16 ^b	149.89 ± 0.31 ^b
ACP150	224.55 ± 4.66 ^c	149.73 ± 0.24 ^b

ACP120, acerola fruit juice powder obtained by spray drying at inlet temperature of 120°C

ACP150, acerola fruit juice powder obtained by spray drying at inlet temperature of 150°C

Mean ± SD of triplicate analyses

The value in the same column followed by different superscripts (a-c) were significantly different ($p < 0.05$).

Between two conditions investigated in this study, spray drying at inlet temperature of 120°C was more suitable for spray drying of acerola fruit juice in order to obtain good quality of powder which retaining the antioxidant activity.

Conclusion

For spray drying, the temperature had significant impact on the physical properties of the spray dried powder. By increasing the inlet temperature which reduced the stickiness of the products to the inside wall of the spray dryer, the production yield was increased and moisture content was decreased. However, increasing inlet temperature have an effect on DPPH scavenging activity of acerola fruit juice powder. In contrast, increasing inlet temperature did not have an effect on total phenolic content of the spray dried powder. This indicated that the total phenolic contents is not the only factor affecting the antioxidant activity of acerola fruit. Other chemical constituents were also reported to show antioxidant activity. The information obtained from this study will be useful for the scale-up production of acerola fruit juice powder by spray drying.

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