Physicochemical and Antioxidant Activities of Spray-dried Pitaya Fruit Powder

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Abstract. Pitaya commonly known as dragon fruit is very popular in China due to its intense color, constituent minerals, vitamins, and antioxidant properties. In the present study, physiochemical properties and antioxidant activities of fruit powder from two pitaya cultivars (namely red flesh and white flesh) and fruit peel were observed. Compared with the fruit powder of fruit flesh, the fruit powder made from fruit peel showed a higher antioxidant activity. The current study provides insights to produce spray-dried pitaya fruit powders that could potentially be used as functional food ingredients in various food fields.

1. Introduction
Pitaya (Hylocereus undatus (Haw.)), also as known as dragon fruit, is of a member of the cactus family. The fruit described associated with the green color of the immature fruit, and the ‘dragon-like’ appearance of the ‘scales’ or bracts on the fruit surface. Besides of its special appearance, pitaya also known to be rich in nutritional value, especially rich in betalains which meet the increasing trade interest for antioxidant products and natural food colorants [1]. According to the color of pitaya fruit flesh, three types of fruit, namely white-fleshed, red-fleshed and yellow-fleshed, exists in production and market [2]. But the white- and red- fleshed fruit is very usual in market. It is difficult to have a long-time shelf time because it ripe in hot season.

Spray drying is a well-known technique used in food industries since 1940s. It transforms a material from liquid to a dried powder state by spraying into a hot drying gas medium. A appropriate hot temperature is important to this technique. The product can be made in the form of powder, granules and agglomerates [3]. For most fruit or fruit juice, various antioxidants exist inside that is sensitive to high temperature. So the quality and sensory of product may lose especially vitamin C, β-carotene, flavors and aroma. A lot of studies were reported that compared the influence of different drying methods on different quality attributes of fruits and vegetables. However, no studies have been conducted to evaluate the effect of drying methods on the color, and antioxidant. Thus, the objective of the present work was to investigate the influence of spray-drying method on the color change and the antioxidant activity of pitaya fruit.
2. Materials and Methods

2.1. Plant Materials and Sampling
Fruits of pitaya were purchased from a local supermarket in Zhanjiang city, Guangdong Province. Uniform fruit without visible defects were selected as the experimental materials. Two cultivars were chosen in our study, namely red-fleshed and white fleshed. The flesh and peel were separated by hand. The puree of pitaya fruit was extracted by a juicer. The puree was kept in fridge at 4°C for further use.

2.2. Drying Experiment
The puree was blend for 5 min to a uniform consistency. The spry-dryer used in our study is DFRP-sprying tower (Dafeng, Wuxi). The dryer conditioned for 1 h before starting the experiment. The tap-water was pumped through the atomizer with the dryer inlet and outlet temperature set at 180 and 80°C, respectively. The puree was pumped into the dryer chamber by a pump at a flow rate of 0.5 ml/s. The air temperature of dryer inlet and outlet were 180°C and 90°C, respectively. These temperatures were determined by our previous work.

2.3. Determination of powder color
Pitaya fruit powder color was measured by a colorimeter (MiniScan XE Plus, HunterLab, VA, USA), which provided CIE L*, a*, and b* values. L* represents the relative lightness of color with a range from 0 to 100, being small for dark color and large for light color. Both a* and b* scales extend from -60 to 60. Negative a* values indicates greenness and positive for redness, while b* is negative for blueness and positive for yellowness. These values were then converted to a hue angle \( h° = \arctan\left[\frac{b*}{a*}\right] \) and a chroma value \( C= \sqrt{(a*)^2+(b*)^2} \) which quantified the intensity or purity of the hue [4]. The values of hue angle 0°, 90°, 180°, and 270° represent red purple, yellow, bluish green, and blue, respectively. Chroma value indicates the intensity or color saturation.

2.4. Antioxidant activity measurement of pitaya fruit-powder
Two methods to measure antioxidant activity were applied in our study, namely DPPH free radical scavenging assay and Ferric reducing/antioxidant power assay (FRAP assay).

The free radical scavenging activity of fruit extracts was measured according to DPPH method [5]. A 100 µl aliquot of fruit extract was mixed with 3.9ml of 60 µM DPPH methanolic solution. The reaction for scavenging DPPH radicals was kept in the dark at room temperature for 6 h. The absorbance was measured by a UV-visible spectrophotometer (SP-752N, Shanghai Spectrum Instrument Co., LTD, China) at 515 nm, against a blank of methanol without DPPH. Results were expressed as percentage of inhibition of the DPPH radical. Percentage of inhibition of the DPPH radical was calculated according to the equation \([(\text{Abs control}-\text{Abs sample})\times100/\text{Abs control}]\). Trolox was used as the standard. Results were expressed as mmol Trolox equivalents/100 g fresh weight.

The FRAP assay was performed according to the method described by Guo[6], with some modification. FRAP reagent was made from 1mM TPTZ and 2 mM ferric chloride in 300 mM sodium acetate buffer (pH 3.6). A 200µl aliquot of fruit extract was mixed with 1.8ml FRAP reagent, the absorbance was measured after a 10 mins reaction using a UV-visible spectrophotometer (SP-752N, Shanghai Spectrum Instrument Co., LTD, China) at 595 nm, against a blank of methanol. The antioxidant capacity of the fruit extract was determined by its ability to reduce ferric to ferrous ions in the FRAP reagent. The standard curve was constructed using concentration of Trolox from 0 to 1 000 µM and the linear range was used for calculation. FRAP assay results were expressed on a fresh weight basis as mmol Trolox equivalents/100 g fresh weight.

2.5. Particle shape
SEM (Philips XL-30 ESEM; MEMS and Nanotechnology Exchange, VA, USA) was used to analyze the particle shape of the fruit powder.
2.6. Statistical Analysis
Data were analysed using Data Processing System (DPS) version 3.01 (Zhejiang University, Hangzhou, China). The correlation was calculated by Statistical Product and Service Solutions (SPSS, USA).

2.7. Maintaining the Integrity of the Specifications
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3. Results and Discussion

3.1. The Color of Pitaya Fruit Powder
From the table 1, we noted that different cultivars of pitaya fruit-powder showed different color. The white-fleshed fruit-powder had the highest lightness (92.84). The value of a* indicated that the red-fleshed powder and peel powder were red (49.52 and 27.09, respectively), while white-fleshed was yellow (a*=-0.61). That was also indicated by the value of h0. It was red when h0 equal to 0, and the values of red-fleshed and peel sample were 342.32 and 1.81, respectively, in our study. It was yellow when h0 equal to 90. The value of the white-fleshed sample was 96.16.

Table 1. The color index and antioxidant activity of pitaya fruit-powder.

|                  | DPPH | FRAP | L*   | a*   | b*   | C      | h0     |
|------------------|------|------|------|------|------|--------|--------|
| red-fleshed powder | 2.88 | 2.05 | 44.67 | 49.52 | -15.78 | 51.98  | 342.32 |
| white-fleshed powder | 0.63 | 0.48 | 92.84 | -0.61 | 5.68  | 5.71   | 96.16  |
| pitaya peel powder   | 5.25 | 1.90 | 64.05 | 27.09 | 0.85  | 27.11  | 1.81   |

3.2. The Antioxidant Activity of Different Powder
DPPH free radical scavenging assay and Ferric reducing/antioxidant power assay were used in our study to determine the antioxidant activity. The white-fleshed sample showed a lower antioxidant activity by both methods. The peel powder had the highest antioxidant activity by DPPH method (5.25), while the peel sample showed a lower antioxidant activity by FRAP method (1.90). In summary, the red samples of fruit powder showed a higher antioxidant activity than white sample, regardless of measurement method (Table 1).

3.3. The Correlation Between fruit Color and Antioxidant Activity in Pitaya Fruit Powder
Different correlations were detected in our study, as shown in table 2. Interestingly, the different antioxidant activity measurement method showed the similar antioxidant activities to the pitaya fruit powder. Both of DPPH and FRAP showed a negative correlation with lightness (-0.582, and -0.947). However, positive correlations between antioxidant activities and a*values, and chroma (C) were detected in our study. The finding of the present study may be attributed to the different contents of total phenolic compounds in red-fleshed fruit, white-fleshed fruit, and peel. Similar results were also report by Lee [7]. Tenore pointed out that the loss of phenolic compounds including gallic acid, caffeic acid and p-coumaric acid during spray drying result in the reduction in radical scavenging activity of fruit [8].
Table 2. The effect of different extract temperature on the volatile compound

|        | DPPH | FRAP | L*   | a*   | b*   | C    | ho   |
|--------|------|------|------|------|------|------|------|
| DPPH   | 1    |      |      |      |      |      |      |
| FRAP   | 0.812| 1    |      |      |      |      |      |
| L*     | -0.582| -0.947| 1    |      |      |      |      |
| a*     | 0.540| 0.929| -0.999*| 1    |      |      |      |
| b*     | -0.201| -0.734| 0.913| -0.933| 1    |      |      |
| C      | 0.449| 0.886| -0.988| 0.995| -0.965| 1    |      |
| ho     | -0.282| 0.331| -0.616| 0.656| -0.883| 0.730| 1    |

3.4. The Powder Morphology

Both red and white flesh fruit powders in the present study showed spherical particle morphology with smooth surfaces and no surface cracks. Powders of fruit peel showed an irregular shape (Figure 1). Agglomerate is a particle composed of individual grains of material bound together by sub-micron dust. And agglomerate was observed in both red and white flesh fruit powders. Similar particle morphology has been reported for spray-dried blackberry [9] and cactus pear powders [10].

Figure 1. Scanning electron microscope images showing particle morphology of: (A) red flesh fruit powder; (B) white flesh fruit powder; and (C) fruit peel powder.
4. Conclusion
In conclusion, pitaya fruit powder made by spray drying can be used as an excellent food resource. In spite of the different antioxidant activity of fruit powder, the higher antioxidant activity was observed in fruit powder from fruit peel. The current study provides insights to produce spray-dried pitaya fruit powders that could potentially be used as functional food ingredients or coloring agents in various food applications.

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References
[1] Le Bellec, F., Vaillant, F. and Imbert, E. Pitahaya (Hylocereus spp.): a new fruit crop, a market with a future. Fruits, 61(2006) 237-250.
[2] Grimaldo-Juárez, O., Terrazas, T., García-Velásquez, A., Cruz-Villagas, M., and Ponce-Medina, J.F. Morphometric analysis of 21 pitahaya (Hylocereus undatus) genotypes. J. Prof. Assoc. Cactus. 9(2007) 99-117.
[3] Nindo, CI. and Tang, J. Refractance window dehydration technology: a novel contact drying method. Dry. Technol. 25 (2007) 37-48.
[4] McGuire, RG. Reporting of objective color measurements. HortScience. 27(1992) 1254-1255.
[5] Zhang, W., Li, X., Zheng, J., Wang, G., Sun, C., Ferguson, I. B. and Chen, K. Bioactive components and antioxidant capacity of Chinese bayberry (Myrica rubra Sieb. and Zucc.) fruit in relation to fruit maturity and postharvest storage. Eur. Food Res. Technol. 227 (2008) 1091-1097.
[6] Guo, C., Yang, J., Wei, J., Li, Y., Xu, J. and Jiang, Y. Antioxidant activities of peel, pulp and seed fractions of common fruits as determined by FRAP assay. Nutr. Res. 23 (2008) 1719-1726.
[7] Lee, KH., Wu, TY. and Siow, I.F. Spray drying of red (Hylocereus polyrhizus) and white (Hylocereus undatus) dragon fruit juices: Physicochemical and antioxidant properties of the powder. Int. J. Food Sci. Tech. 48 (2013) 2391-2399.
[8] Tenore, G.C., Novellino, E. and Basile, A. Nutraceutical potential and antioxidant benefits of red pitaya (Hylocereus polyrhizus) extracts. J. Funct. Foods. 4(2012) 129-136.
[9] Ferrari, C.C., Germer, S.P.M. and de Aguirre, J.M. Effects of spray-drying conditions on the physicochemical properties of blackberry powder. Dry. Technol. 30(2012) 154-163.
[10] Obon, J.M., Castellar, M.R., Alacid, M. and Fern andez-Lopez, J.A. Production of a red–purple food colorant from Opuntia stricta fruits by spray drying and its application in food model systems. J. Food Eng. 90(2009) 471-479.