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Effect of Blanching and Drying Temperatures on Physicochemical Properties of Red Dragon Fruit (*Hylocereus polyrhizus*) Peel Powder

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ABSTRACT

Large production of red dragon fruit by-products, which are frequently discarded from food industry has become a major waste problem. Converting this waste into useful products with good physicochemical properties could solve the pollution issues. Thus, a study was carried out to investigate the effect of blanching and drying temperatures on physicochemical properties of red dragon fruit peel powder. Dragon fruit peel was pre-treated with hot water at 90 °C for 2 minutes before being dried in hot air oven dryer at 50 °C, 60 °C and 70 °C. Results showed that the powdered sample of blanched and dried at 50 °C had significantly higher fiber, water activity and moisture content than those of unblanched/blanched and dried at 60 °C and 70 °C. Result also showed that the colour of this powder was similar to the fresh dragon fruit peel. When dried at 50 °C, the unblanched and blanched powders exhibited a slightly higher water solubility index compared to those dried at 60 °C and 70 °C. Based on the evaluation of bulk and tapped densities, all powders having the Carr Index in the range of values between 20 and 28 thus can be categorised as slightly poor flowing. For all conditions studied, powder that was blanched and dried at 50 °C was the best condition as it contained the highest amount of fiber with good physicochemical properties.

Keywords: Red dragon fruit, peel, dietary fiber powder, blanching, drying.

INTRODUCTION

Dragon fruit, or also known as pitaya or pitahaya, is a member of the tropical fruit in the Cactaceae family (Nurliyana et al., 2010). Generally, the fruit comes in three varieties, which are red-flesh with red-skin (*Hylocereus polyrhizus*), white-flesh with pink-skin (*Hylocereus undatus*) and white-flesh with yellow-skin (*Hylocereus megalanthus*) (Hernawati et al., 2018). However, there are only two varieties of the fruit are commonly found in the Malaysian market; *Hylocereus polyrhizus* and *Hylocereus undatus*.

Red dragon fruit flesh has been reported to contain high amount of dietary fiber (10.1 g/100 g dry weight), vitamin A (102.13 μg/100 g dry weight), vitamin C (540.27 mg/100 g dry weight) and vitamin E (105.67 μg/100 g dry weight) (Norhayati et al., 2012). Apart from that, red dragon fruit is also rich in phosphorus and calcium. Typically, in the beverage industry of producing red dragon fruit juice, the peel is the main by-product, which is widely discarded as a waste during processing and not consumed efficiently, resulting in nutritional waste (Ding et al., 2009). The peels' nutritional content could not be disregarded as they contain considerable amount of betacyanin, polyphenols, antioxidants, pectin and dietary fibre, which could be utilised for commercial purposes (Hernawati et al., 2018). Harivaindaran et al. (2008) and Ding et al. (2009) reported that red dragon fruit peel has great potential as thickening agent and natural colorant. A study by Wu et al. (2006) found that red dragon fruit peel was efficient in inhibiting melanoma cells growth due to its strong anti-proliferative effect.

Due to functional ingredients and health benefits provided by red dragon fruit peel, several studies have been conducted to convert the peel into a shelf-stable powder, as well as to produce a non-perishable product that is easy to use. One of the preservation techniques that can be used to achieve this is the drying process. However, the application of heat during drying might cause degradation to the product (Heras-Ramírez et al., 2012; Chantaro et al., 2008). Therefore, pre-treatments such as blanching can be applied to reduce the thermal degradation. Blanching is a common technique used to inactivate enzymatic reactions in fruit and vegetables, thus minimising deterioration (Sanjuán et al., 2001). The studies also reported that blanching at the optimal temperature helps in preserving the nutritional, structural and organoleptic properties of fruit and vegetables.

The aim of this study was to assess the effect of blanching and drying temperatures on the physicochemical properties of red dragon fruit peel powder in order to find the best preservation techniques to achieve the highest fiber content and good physical properties.

MATERIALS AND METHODS

Sample collection and preparation

Red-flesh dragon fruits (*Hylocereus polyrhizus*) were bought from a local market at Pulau Kerengga, Marang, Terengganu, and selected based on size and skin colour uniformity. Samples were prepared according to the method described by Akter et al. (2010) with slight modifications. The fruits were peeled and the peels were collected. The peels were pre-washed with tap water to remove unwanted residue. Then, the peels were sliced into small pieces of 3 cm (length) x 3 cm (width) using a sharp knife. 500 g of the peels were blanched in water at 90 °C for 2 minutes, with ratio of peels to water about 1:2. Another 500 g of the peels were used as unblanched samples. Both blanched and unblanched peels were weighed for their wet weight and proceeded to drying processes. About one-third of the blanched and unblanched samples were dried in hot air oven dryer (Model FDD-720, PROTECH, Selangor, Malaysia) at different temperatures of 50°C, 60°C and 70°C. Every two hours, the samples weight were recorded. The drying process was stopped when the weight of dried samples reached constant values. After that, the dried peels were grounded using blender and sieved through 150 µm to 250 µm mesh screen to obtain a uniform particle size range. The powder was packed in a sealed zipped bag and stored at room temperature, 37 °C until further analysis.

Determination of drying curve

Drying curve was determined from the mass loss in the sample using method according to Roongruangsri & Bronlund (2016). During the drying process, the weight of sample was recorded for every two hours until constant weight. Moisture content in the sample at each time intervals was calculated using Eqn. 1:

$$MC_{db}\ (\%\ db) = \frac{(W0 - Wf)}{Wf} \times 100 \qquad \textbf{Eqn. 1}$$

Where;
Wo = initial weight of sample at each interval time (g)
Wf = final weight of sample (g)

Moisture content of dried powder was determined by oven drying at 105°C (AOAC 1995).

Determination of water activity (a_w)

Water activity of the powder was measured using water activity meter (Aqua Lab, Malaysia). The powder was spread evenly in the Retronic cup before placed in the water activity meter. Triplicate samples were analyzed and the means were reported.

Determination of crude fiber content

Crude fiber content for fresh and dried powders were analyzed according to AOAC methods (1995).

Colour analysis

The colour changes of peel powder was analyzed according to the method proposed by Sugumaran et al. (2019) using chroma meter (Minolta Chroma Meter CR-400, Osaka, Japan). The colour was expressed in term of L*, a* and *b. For this scale, the L* parameter indicates the colour variation from black to white; the a* axis shows the variation from red to green; and the b* axis shows the variation from yellow to blue. Prior to measurement, the Chroma Meter was calibrated with a white standard tile. Hunter values for each powder was measured in triplicate.

Determination of water solubility index

Water solubility index of powder was determined using method described by Hsu et al. (2003). 2 g of powder was vigorously mixed with 25 ml distilled water in a 50 ml of centrifuge tube. Then, the mixture was placed in a water bath at 37°C for 35 minutes. The mixture was centrifuged at 4000 × g and 4°C for 10 minutes. The pellet was filtered and the residue was placed into a pre-weighed petri dish and oven-dried at 105°C overnight. Water solubility index was calculated by following Eqn. 2:

$$\%\ \text{WSI} = \frac{Weight\ of\ dried\ residue}{Weight\ of\ original\ powder} \times 100 \quad \textbf{Eqn. 2}$$

Determination of bulk and tapped densities

The bulk and tapped density of powder was measured according to the method of Saifullah et al. (2016). For bulk density, 5 g of powder was taken into 25 ml granulated cylinder and the volume was recorded. Bulk density was calculated from the ratio of the mass of the powder to its occupied volume (Eqn. 3):

$$\text{Bulk density, } \rho_\beta\ (\text{g/cm}^3) = \frac{Mass\ of\ red\ dragon\ fruit\ peel\ powder}{Volume\ occupied\ by\ the\ powder} \quad \textbf{Eqn. 3}$$

The tapped density was measured by tapping the powder in the graduated cylinder for 100 times from a height of 15 cm. The tapped density was calculated by dividing the mass of the powder with the volume of powder after being tapped (Eqn. 4):

$$\text{Tapped density, } \rho_t\ (\text{g/cm}^3) = \frac{Mass\ red\ dragon\ fruit\ peel\ powder}{Volume\ occupied\ by\ the\ powder} \quad \textbf{Eqn. 4}$$

Determination of flowability

The flowability powder was evaluated in terms of the Carr Index (CI) (Table 1), as described by Jinapong et al. (2008). It was calculated from the bulk and tapped densities of the powder, as shown in Eqn. 5:

Table 1. The Carr's Index and powder compressibility, correlated to the flowability.

% Compressibility	Relative flowability
5-15	Excellent
12-16	Good
18-21	Fair
23-28	Slightly poor
28-35	Poor
35-38	Very poor
>40	Extremely poor

$$\text{Carr Index (CI)} = \frac{\rho_t - \rho_\beta}{\rho_t} \times 100 \qquad \textbf{Eqn. 5}$$

Where;
ρ_β = bulk density
ρ_t = tapped density

Statistical analysis

The results were presented as mean values with standard deviations. Different mean values were analyzed by analysis of variance (ANOVA), least significant different (LSD) and Tukey's test at significant level of 95% (α= 0.05) using statistical software SPSS 20 (SPSS Inc., USA).

RESULTS AND DISCUSSION

Drying Curve of Dragon Fruit Peel

Drying curves of dragon fruit peels that were dried at 50, 60 and 70 °C are shown in Fig.1. Both unblanched and blanched peels shows similar drying trend, where the moisture contents decreased in time until they reached the equilibrium values. The drying process can be divided into two periods; falling rate (from initial time of drying to about 10 hours) and diffusion period (from about 10 hours to about 18 hours). A similar finding was also observed by Roongruangsri and Bronlund (2016) for pumpkin slices.

For the falling rate period, the moisture content began to decrease or fall until it levels off at about 10 hours drying time. This behaviour corresponds to drying period where the evaporating water occur vigorously. During the first falling rate period, the moisture content decreased until it reached moisture content of approximately 40 to 50% after 6 hours. Then, second falling rate period took place where moisture content decreased slower and non-linear compared in the first falling period. During falling rate period, water is brought to the surface through the pores and capillaries in the product. Some of the water was physically trapped in peel capillaries while other water loosely bound. Hence, it took time for the water to move to the surface of the peel, where it can be removed by the drying air (Mercer, 2014). Moisture content of the peels became constant after 10 hours drying at drying temperatures of 50 °C, 60 °C and 70 °C.

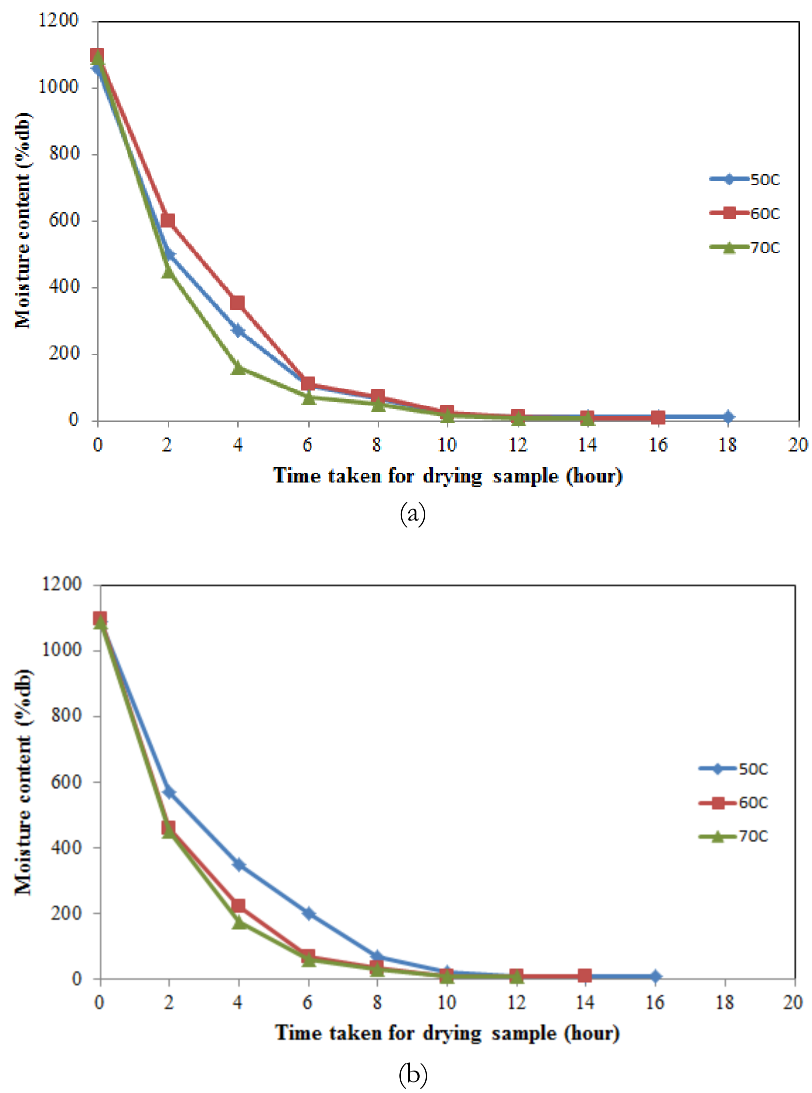

Fig. 1. Moisture profile of dragon fruit peel slices for a) unblanched and b) blanched samples during drying at 50°C, 60°C and 70°C

As can be seen in Fig. 1, the drying curve for blanched samples were steeper than the unblanched samples, hence they reached the equilibrium moisture content faster. The blanched peels that were dried at 70°C was the quickest to dry. This occurs due to the blanching process, which softened the texture of the peels and thus enhanced water removal from the samples. Severini et al. (2005) also observed similar behaviour when blanching potato cubes.

As expected, the drying time for both unblanched and blanched samples decreased as the drying temperature increased (Table 2). A high drying temperature caused a lower air relative humidity in the oven, resulting in a greater driving force for the heat to transfer to the samples and consequently a shorter drying time (Akter et al., 2010). Moreover, moisture diffusivity is higher at high temperature (Chantaro et al., 2008). These results were in line with previous studies of cabbage outer leaves (Nilnakara et al. (2009)) and carrot peels (Chantaro et al. (2008)).

Table 2. Drying time of both unblanched and blanched samples subjected to different temperatures.

Treatment		Drying time (hour)
Unblanched		
	50°C	18
	60°C	16
	70°C	14
Blanched		
	50°C	16
	60°C	14
	70°C	12

Physicochemical Properties

The moisture content, crude fiber content and water activity of the fresh, blanched and powdered red dragon fruit peels are summarised in Table 3. Blanching seemed to had no influence on moisture content as both fresh and blanched peels had the same value 90% wet basis. In fact, the blanched and unblanched powders that dried at the same drying temperature were similar to each other. However, drying temperature had a significant effect on the moisture content. The moisture content decreased with an increase in the drying temperature. Both blanched and unblanched powders at 50°C exhibited the highest moisture content, approximately 9% dry matter. Despite of lower drying force at lower temperature, this behaviour could be associated with higher degree of starch gelatinization, which might affect the cell structure and thus increase internal resistance for the movement of moisture (Leeratanarak et al., 2006). These results were consistent with previous studies of potato chips (Leeratanarak et al., 2006), white pitaya peel (Sengkhamparn et al., 2013) and persimmon peel (Akter et al., 2010).

Table 3. Moisture, crude fiber content and water activity of fresh, blanched and powdered red dragon fruit peels

Treatment	Moisture content (%)	Water activity, (a_w)	Crude Fiber (%)
Fresh	90.09 ±0.08^{a}	0.98±0.001^{a}	3.36±0.10^{c}
Blanched	90.32 ±0.11^{a}	0.99±0.002^{a}	3.58±0.01^{c}
Unblanched			
50°C	9.15±0.09^{b}	0.56±0.0003^{b}	28.58±0.18^{ab}
60°C	8.41±0.28^{c}	0.42±0.003^{d}	27.99±0.43^{b}
70°C	8.40±0.20^{c}	0.42±0.01^{d}	27.81±0.16^{b}
Blanched			
50°C	9.08±0.03^{b}	0.55±0.001^{c}	30.76±1.66^{a}
60°C	8.19±0.01^{c}	0.42±0.0001^{d}	30.08±0.33^{ab}
70°C	8.17±0.06^{c}	0.42±0.003^{d}	27.77±0.18^{b}

Mean within a column with different letters are significantly different ($p<0.05$), n=3.

Water activity is one of the important factors that influences the shelf life of powder. High water activity indicates high amount of free water available for biochemical degradations, thus shortens the shelf-life. Besides, it indicates the quantity of water content in the food product as its availability to cooperate in microbial, chemical and physical reactions (Koirala, 2018). As can be seen in Table 3, water activity for fresh and blanched peels were the same (near to 1), meanwhile the dried powders were in the range 0.42 to 0.56. It was found that the water activity of red dragon fruit peel powders decreased when the drying temperature increased, which was similar to the trend observed in the moisture content. The unblanched powder dried at 50°C had the highest water activity (0.56). According to Fontana (2000), food products with water activity lower than 0.59 can be regarded as microbiologically and chemically safe. When comparing between the blanched and unblanched powders, only powders dried at 50°C exhibited a significant difference. This behaviour is probably due to relatable content of moisture available in powder which also high after dried at lower drying force at lower temperature, 50°C compared to powder at temperatures 60°C and 70°C.

For the effect of blanching and different drying temperatures on the crude fiber content of red dragon fruit peel was analysed using acid and alkali digestion. It can be seen that there were significant different among controls and peel samples subjected to unblanched and blanched with various drying temperatures. However, there was no significant difference of the crude fiber content fresh sample and blanched sample without drying. Besides, at the same drying temperature, the unblanched and blanched peel powder had the same crude fiber content. Overall, there are no significant difference between unblanched and blanched sample. Even so, Table 3 shows that the crude fiber content of blanched powder subjected to various drying temperatures with range from 27.77% to 30.76% was higher than that of the unblanched powder ranging from 27.81% to 28.58%. As compared to other studies on white cabbage (Wennberg et al., 2006), cabbage outer leaves (Nilnakara et al., 2009), carrot peels (Chantaro et al., 2008), persimmon peels (Akter et al., 2010) and white dragon fruit peel (Sengkhamparn et al., 2013), finding from this present study was in contrast to previous studies where blanching treatment shown significant effect in crude fiber content due to the loss of minerals, vitamins and sugars from plant cells to the hot water. The changes in amount of total solids then resulted to relative increase in the other contents on dry basis (Nilnakara et al., 2009). The impact of drying temperature on crude fiber can be observed in the blanched powders. Powder that has been dried at 50°C had higher crude fiber than the one dried at 70°C. According to Sengkhamparn et al. (2013), some pectin and other fibers such as cellulose or hemicellulose were degraded at high temperature, thus resulted in lesser amount of crude fiber.

Table 4 summarizes the colour values of red dragon fruit peel powders. For L* value, the peels and dried powders produced darker colour after blanching. This happens due to leaching out of some soluble pigments from the plant cells such as betacyanin and betaxanthins during blanching process (Nilnakara et al., 2009; Wolfe & Liu, 2003). The drying temperature had no impact on unblanched powders, but an increase in the drying temperature resulted in a lighter colour for the blanched samples. Similar observation was reported by Sengkhamparn et al. (2013) for pitaya (*hylocereus undatus*) peel.

Table 4. Colour of fresh, blanched and powdered red dragon fruit peel.

Treatment	L*	a*	b*
Fresh	32.66 ± 1.16^{c}	24.31 ± 0.39^{c}	5.23 ± 0.54^{b}
Blanched	26.55 ± 0.37^{d}	13.72 ± 0.17^{d}	5.23 ± 0.54^{b}
Unblanched			
50°C	53.01 ± 0.78^{a}	29.49 ± 0.29^{a}	7.24 ± 0.06^{a}
60°C	53.25 ± 0.10^{a}	27.42 ± 0.52^{b}	3.42 ± 0.31^{cd}
70°C	53.41 ± 0.29^{a}	27.03 ± 0.21^{b}	2.16 ± 0.06^{e}
Blanched			
50°C	49.40 ± 0.03^{b}	27.69 ± 0.22^{b}	6.51 ± 0.18^{a}
60°C	50.20 ± 0.14^{b}	27.15 ± 0.03^{b}	4.23 ± 0.14^{c}
70°C	52.42 ± 0.20^{a}	24.42 ± 0.26^{c}	3.34 ± 0.07^{d}

Means within a column with different letters are significantly different ($p<0.05$), n = 3.

For a* values of redness, the result shows that there were significantly different in all values of red dragon fruit peel powder. The blanched without drying sample shows significantly lower in redness compared to fresh peel sample. Similarly, blanched sample subjected to drying process resulted in lower redness values than those of unblanched dried sample. According to Akter et al. (2010) and Nilnakara et al., (2009), the blanching pre-treatment process might inhibit the enzymatic browning of the peels' plant cells hence reduce the red colour pigments. As increased in drying temperature for both pre-treated and non-pre-treated samples, the a*, redness values were decreased in values which may cause by damage of betacyanin pigments when subjected to heat process. The unblanched dried sample at 50°C shows higher in retaining redness value probably due to no blanching treatment and low drying temperature. However, blanched dried sample at 50°C was significantly lower in redness value or higher loss of red colour which might be due to the higher in drying temperature. This observation might be due to damage of betacyanin which can be caused by blanching pre-treatment and higher temperature during drying process.

For b* values of yellowness, there was no significant different between fresh peel and blanched without drying samples. However, b* values of yellowness for unblanched and blanched samples subjected to various drying temperature were significantly different to each other. This means that, there was no effect of blanching treatment on those samples since it did not give any significant different among fresh and blanched peel samples. Moreover, as increased in the drying temperature for both unblanched and blanched samples, b* or yellowness was decreased in value. This means that, higher in drying temperature caused higher loss of yellow colour. Akter et al. (2010) has mentioned that, betaxanthin which gave the yellow colour pigment probably was damage during the drying process hence resulted lower in yellowness. Besides, betaxanthin pigment was sensitive to heat, light, moisture, pH and oxygen (Woo et al., 2011).

The water solubility index, bulk density, tapped density and flowability of red dragon fruit peel powders are listed in Table 5. Blanching process was found to have no impact on the water solubility index. However, the water solubility index decreased as the drying temperature increased. Powders dried at a higher temperature were less soluble in water probably due to higher in drying temperature caused some pectin or other fibers such as cellulose or hemicellulose degraded (Sengkhamparn et al., 2013). Besides, according to Fellows (1988), increased protein denaturation occurred as increased in drying temperature which then decreases the water solubility index of powder. Both unblanched and blanched powder dried at 50°C obtained slightly higher water solubility index compared to unblanched and blanched powder dried at 60°C and 70°C which might due to high availability of soluble component and less starch degradation. The result of this study is in agreement with water solubility index on pumpkin powder (Roongruangsri & Bronlund, 2016).The unblanched and blanched powder dried at 50°C indicate they can be soluble in water and very appreciable since solid-water interactions constitute to a limiting factor in utilization of food powder which then may become high potential for use in baking (Tedom et al., 2020).

Table 5. Water solubility index, bulk density, tapped density and flowability of unblanched and blanched red dragon fruit peel powder drying at different temperatures.

Treatment	Water solubility index (%)	Bulk density (g/cm³)	Tapped density (g/cm³)	Flowability (%)
Unblanched				
50°C	85.34±0.11[a]	0.53±0.00[b]	0.71±0.00[b]	29.58±0.00[a]
60°C	83.39±0.06[b]	0.57±0.02[a]	0.77±0.00[a]	25.97±2.25[b]
70°C	83.17±0.45[b]	0.53±0.00[b]	0.67±0.00[c]	25.37±0.00[b]
Blanched				
50°C	84.85±0.007[a]	0.53±0.00[b]	0.71±0.00[b]	25.35±0.001[b]
60°C	83.20±0.17[b]	0.53±0.00[b]	0.70±0.00[bc]	24.29±0.00[b]
70°C	82.05±0.73[b]	0.56±0.00[a]	0.75±0.04[a]	21.13±0.00[c]

Means within a same column with different letters are significantly different ($p<0.05$). n = 2 for water solubility index, while n = 3 for bulk density, tapped density and flowability.

Bulk and tapped densities are among physical properties to measure and define the volume of the solid and liquid materials and all closed and opened pores (Ezzat et al., 2020). Different markets perceived different characteristics which mean in order to reduce storing and shipping costs, high density products are desired in military uses and re-manufacturers' markets meanwhile as psychological characteristics like having bulky and light products are preferred in retail market (Yang & Atallah, 1985). The bulk density of the powders was in the range of 0.53 g/cm^3 to 0.57 g/cm^3, while the tapped density ranged from 0.67 g/cm^3 to 0.77 g/cm^3. No trend could be observed for both densities because the powders were sieved using 150 μm to 250 μm mesh screen, thus having a narrow particle size distribution. According to Singh et al. (2010), the bulk density of powder is primarily influenced by the particle size distribution, particle size and particle shape. Lee et al. (2012) found that the bulk density of hallabong powders was affected by the drying technique, in which powder produced by hot air-oven drying was denser than freeze drying due to smaller in porosities for hot-air oven drying powder as caused by surface hardening and shrinkage meanwhile larger porosities for freeze dried powder because of the particle shape was preserved.

Flowability is one of the attributes or properties of defining the powder itself which can be ranked from good free-flowing to bad-flowing on its sliding scale. According to Çalışkan Koç, (2020), this flow characteristic is important attribute of quality especially in order for measuring, handling, packaging, filling into bag, transportation, mixing and dosing (Ezzat et al., 2020). The classification of powder flowability based on the Carr Index (CI) are very good (<15), good (15-20), fair (20-35), bad (35-45) and very bad (>45) (Jinapong et al., 2008). From the result shows in Table 5, all powders had Carr Index (CI) values between 20 and 35 and thus indicated that the powder showed fair ability to flow. A fair flowability implies that there is greater interaction between particles, which is related to their bulk and tapped densities. A study by Tze et al. (2012) found that, particle size and particle distribution play important factor in flowability where a decrease in particle size of spray-dried pitaya powder caused poor flowing properties.

CONCLUSION

Blanching and drying treatments of red dragon fruit peel in order to obtain fiber powder were successfully conducted in this study. The effect of blanching and drying with different temperatures of 50°C, 60°C and 70°C on physicochemical properties of the powder were determined. Based on the result, both process blanching pre-treatment with hot-water and drying with hot-air oven dryer have physically altered the product hence producing the best properties of powder. Besides that, technique of blanching using hot water at 90°C for 2 minutes as a pre-treatment method before drying in order to achieve desired powder with high fiber was obtained. The result shows higher fiber content was produced for blanched and dried powder compared to unblanched and also fresh peel itself. As subjected to drying process, low moisture content of powder was obtained at high temperature, 70°C. In accordance to moisture content, lower water activity values (<0.60) were achieved in order to prolong the shelf life of powder by reducing the growth rate of microorganisms. Moreover due to blanching and drying process, colour of red dragon fruit peel powder significantly different compared to the fresh peel and blanched without drying peel samples. Dried blanched sample at 50°C exhibited a suitable drying temperature in order to achieve good quality dietary fiber powder. However, for physical properties of powder the findings show no significant different for powder subjected with unblanched or blanched at various drying temperatures. Hence, blanching and drying treatment at 50°C can be described as the suitable process combination to achieve high fiber powder with good physical properties.

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