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Effect of rotation speed and steam pressure on physico-chemical properties of drum dried pitaya *(Hylocereus polyrhizus)* peel

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Abstract

Red pitaya *(Hylocereus polyrhizus)* peel is a rich source of fibre, antioxidant and betacyanin; however, it is discarded during processing, so it is able to cause environmental problems. In order to convert the fruit waste to potential by-product ingredients, drum drying is used as pre-treatment to create an ingredient which is shelf-stable. In this study, the effects of rotation speed and steam pressure of drums on the physico-chemical properties of pitaya peel that had undergone drum drying are investigated. Pitaya peel was dried in a laboratory scale double drum dryer at rotation speed of 1, 2, and 3 rpm at steam pressure of 1, 2, and 3 bar. The drum dried pitaya peel was then further analyzed based on percentage yield, moisture content, water activity, betacyanin retention and color change. Interaction of steam pressure and rotation speed gives significant effect ($p < 0.05$) on percentage yield, moisture content, water activity, betacyanin retention and Hunter L value, whereas it has no significant on Hunter a and b values. The best combination parameters (1 rpm and 2 bar) yield the highest betacyanin retention (80.21 mg/g of dry solid), acceptable moisture content (10.66% wet basis), water activity (a_w = 0.42) and with 7.61% of yield.

Introduction

Pitaya or in another name, dragon fruit, is a worldwide recognized fruit crop (Gunasena *et al*., 2011). Pitaya is now grown in Israel, Vietnam, Taiwan, Nicaragua, Australia, and the United States commercially (Wall and Khan, 2008). On average, annual production of this fruit worldwide is generally 4 to 20 tons fresh mass/hectare (Nobel, 2008). While red pitaya peel comprises about 22% of the whole fruit weight (Bakar *et al*., 2013), the peel discarded worldwide is estimated to be 0.8 to 4 tons fresh mass/hectare which is a huge source of agricultural waste, as it is only used as fertilizer in the industry nowadays.

There are several studies which have been conducted on the red pitaya *(Hylocereus polyrhizus)* peel. Total phenolic content (TPC) assessment and 2,2, diphenyl-1-picrylhydrazyl test demonstrates that peels of the pitaya contain higher phenolic content and radical scavenging activities than the pitaya pulps (Nurliyana *et al*., 2010). Furthermore, the red pitaya peel contain a considerable amount of peptin (10.79 %), betacyanin pigment (150.46 mg/100g of the dry matter) and total dietary fibre, where the percentage of insoluble and soluble dietary fibre is as high as 56.50% and 14.82%, respectively. Glucose, fructose and maltose are also detected in the pitaya peel (Jamilah *et al*., 2011). In short, pitaya peel can be a good source of antioxidant, natural colouring, thickening agent and fibre content. Thus, converting pitaya peel into powder form can be a potential application in various foods and beverages as a natural colorant and adding nutritional values to the foods.

In converting fruit waste to a potential useful by-products, pre-treatment is a vital step to create a microbially stable ingredient (O'Shea *et al*., 2012). Drying is probably the oldest food preservation process. Among all, drum drying is widely used in the food industry due to its high efficiency involving -fewer labour, economical, user friendly with different product, and high production rates (Gavrielidou *et al*., 2002; Daud, 2006). It had been used to dry purees, soup mixture, premix breakfast cereals and even heat sensitive product due to the short exposure towards high (Baker, 1997; Daud, 2006; Pua *et al.*, 2010).

Therefore, the objective of this study is to convert the pitaya peel into powder or flakes form by using drum dryer and to investigate the effects of processing variables of drum dryer such as steam pressure and drum rotation speed on severals characteristics that

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include the moisture content, betacyanin retention, and water activity of pitaya peel powder. Lastly, the suitable drying conditions for drum dried pitaya peel will also be determined.

Materials and Methods

Preparation of pitaya peel

Commercially matured red pitaya fruits *(Hylocereus polyrhizus)* obtained from Madam Sun Dragon Fruit Farm in Tangkak, Johor was used to obtain pitaya peel. The fruits were washed and peeled manually, followed by cutting the peel into smaller size. The peel was ground using an ultra-fine friction grinder (Masuko's Supermasscolloider, Motor: 15kW 2 P, MK ZA 10-20J, Japan) at 2000 rpm and stored in chiller in a light impermeable container. Exposure to light was avoided to reduce possible loss of nutrients.

Drum drying of pitaya peel slurry

400 g of pitaya peel slurry was poured on the drum of the heated double drum dryer (R.Simon Nip Feed Test Machine, Model 4766, England) at 0.1 mm drum gap size. The drum drying was run until the pitaya peel puree was fully dried, at rotation speed of 1 rpm and steam pressure of 1 bar, continued at others conditions up to of 3 rpm and 3 bar. Each combination of parameters was repeated three times. The dried pitaya peel was removed in powder form from the drum surface by two blades that are located on each drum. The dried powder collected were immediately stored in amber bottles with cotton inside to avoid moisture absorption. Then, aluminium foil was used to cover the outside of the bottle to prevent light penetration. The samples were stored in chiller (4^{o}C) prior to analysis.

Determination of color

The color of pitaya powder was measured using calibrated Hunter Lab UltraScan Pro Spectrocolorimeter (Hunter Associate Laboratory Inc., Reston, USA). The results were expressed as L (lightness: 0 = black, 100 = white), a (-a = greenness, +a = redness) and b (-b = blueness, +b = yellowness) values (Sagrin and Chong, 2013).

Determination of betacyanin retention

Determination of betacyanin retention was carried out with slight modification (Lim *et al*., 2011). Betacyanin was extracted using the solvent (distilled water) extraction method. 1 g of the dried peel powder was mixed with 25 g of distilled water then shaken and centrifuged at 3500 rpm (2380 ×g) (Kubota 5800, Japan) for 10 minutes at 24^{o}C. The centrifuged solution was then filtered and the clear solution was kept in test tubes wrapped with aluminium foil to prevent light penetration and stored at 4^{o}C for further analysis. The concentration of betacyanin was determined by using the spectrophotometer (Genesys 20, Thermo Electron Corporation, Model 4001/4), and absorption spectrum of betacyanin was determined at a wavelength of 538 nm. The betacyanin content was calculated using the formula below:

$$\text{Betacyanin content}\left(mg/\text{dry solid weight}\right) = \frac{A \times DF \times MW \times V \times 100}{\varepsilon \times L \times W} \text{ ------ } (1)$$

Where

A is the absorption value at the absorption maximum (538nm) corrected by the absorption at 600nm

DF is the dilution factor

MW is the molecular weights of betacyanin (550 g/mol)

V is the Volume extract (mL)

W is the dry solid weight of extracting material (g)

ε is the molar extinction coefficient of betacyanin (65,000 L mol^{-1} cm^{-1}) and

L is the path length of the cuvette (1 cm)

Moisture content

Moisture content was determined by the method outlined in AOAC (2000). Pitaya peel powder of 3 g was heated under 105^{o}C overnight and the difference in weight was determined.

Water activity

A pre-calibrated water activity meter (Aqua lab, Model CX2, Decagon Devices, Pullman, WA) was used to measure the water activity (aw) of the dried pitaya powder. Triplication of the reading were determined (Sagrin and Chong, 2013).

Statistical analysis

The data were analyzed and presented as mean values with standard deviations of triplication data. A statistical program Minitab 16 (Minitab Inc. USA) was used to perform the Two Way ANOVA and follow-up post hoc comparison (Tukey's test). Values were considered at 95% significant ($p < 0.05$).

Results and Discussion

The interaction effects of parameters were analyzed using Two Way ANOVA. The interaction of rotation speed and steam pressure gave a significant interaction effect on percentage yield, moisture content, water activity, betacyanin retention with p value ≤ 0.001 and Hunter L value ($p = 0.01$).

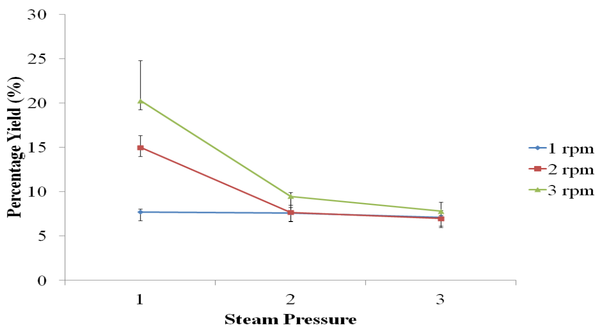

Figure 1. Interaction plot of rotation speed (rpm) and steam pressure (bar) for percentage of yield of drum dried pitaya peel

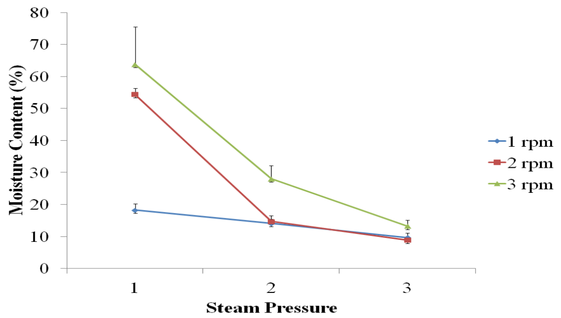

Figure 2. Interaction plot of rotation speed (rpm) and steam pressure (bar) for moisture content of drum dried pitaya peel

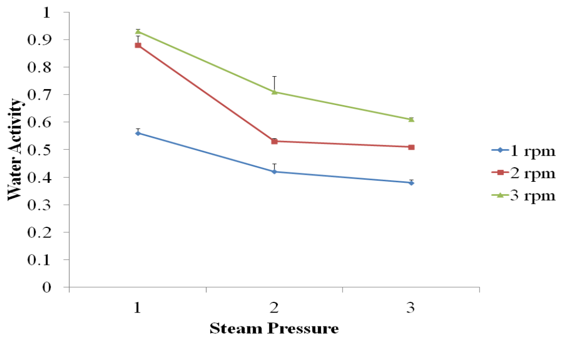

Figure 3. Interaction plot of rotation speed (rpm) and steam pressure (bar) for water activity of drum dried pitaya peel

However, Hunter a value ($p = 0.199$) and Hunter b value ($p = 0.105$) were not affected by the interaction effect of rotation speed and steam pressure.

Percentage of yield

Percentage yield was found to be increased when the rotation speed of drum dryer increased. Meanwhile, the percentage of yield decreased when steam pressure increased, as shown in Figure 1. Percentage of yield was calculated by dividing dried powder over the sample weight, where the higher the weight of dried powder, the higher the percentage yield. Based on the result, higher dried powder weight contains had higher moisture content, which reflects that the mass of dried product was influenced by moisture content. On the other hand, higher dry solid output rate was achieved during the higher drum speed which increases the movement of feed liquid in the drums (R.H.Kakade *et al*., 2011) Hence, increasing of moisture content and dry solid weight gave an increment in percentage of yield of dried pitaya peel.

Moisture content and water activity

The moisture content and water activity increase when the rotation speed of drum dryer was increasing. On the other hand, both of the responses decreased when the steam pressure was increased. The interaction effects of steam pressure and rotation speed on moisture content and water activity are shown in Figure 2 and Figure 3, respectively. The relationship of moisture content and water activity can be explained by the sorption isotherm (Belitz *et al*., 2009). Although the sorption isotherm is not in linear regression, high moisture content usually incorporated with high water activity. Drum surface temperature was increased by higher steam pressure, which increases moisture removal rate from the pitaya peel puree and thus reduces the product moisture content (Kakade *et al*., 2011). Hence, increase of steam pressure will decrease the percentage of yield and water activity as well.

Increasing of rotation speed increases moisture content and water activity of pitaya peel powder. Residence time of feed on the drum surface decreases with increasing rotation speed, thereby the shorter drying time gives higher moisture content end product. (Kakade *et al*., 2011). This result shown agreement with previous study where higher rotation speed causes the end product wetter (Kalogianni *et al*., 2002). Drum drying of starch sheet gives similar result where the moisture content increased continuously when the drum rotation speed increased at a steam pressure below 800 kPa (Vallous *et al*., 2002). Besides, Pua *et al.* (2010) also reported that the moisture content of jackfruit *(Artocarpus heterophyllus)* powder increase rapidly with the increasing of drum rotation speed.

Betacyanin retention

The interaction effect of rotation speed and steam pressure on betacyanin content is shown at Figure 4. From the figure, higher rotation speed gave lower percentage of betacyanin retention. Meanwhile, percentage of betacyanin retention of pitaya peel powder increased when steam pressure increased from 1 bar to 2 bar, but it dropped when steam pressure increased from 2 bar to 3 bar.

The betacyanin retention is higher at low rotation

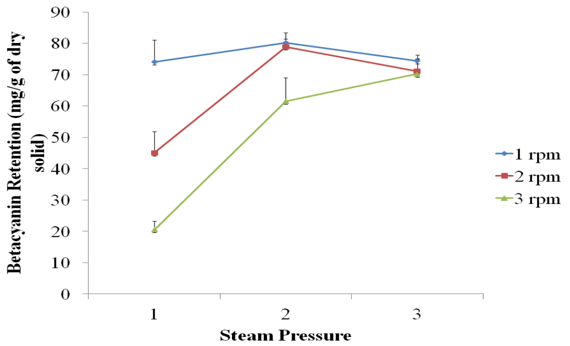

Figure 4. Interaction plot of rotation speed (rpm) and steam pressure (bar) for betacyanin retention of drum dried pitaya peel

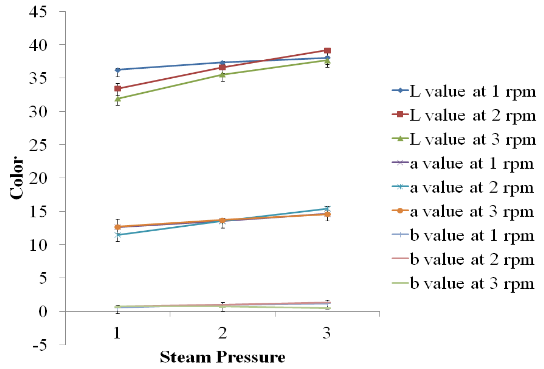

Figure 5. Interaction plot of rotation speed (rpm) and steam pressure (bar) for Hunter L,a, b value of drum dried pitaya peel

speed of drums. When the rotation speed is decreased, the retention time of pitaya peel slurry on drum dryer is longer. The pitaya peel experience higher heat fluxes, thus degradation of betacyanin occur at higher rate and experience fluctuating chromatic stability, which causes the formation of the isomer of betacyanin, isobetanin (Herbach *et al*., 2006). Isobetanin gives a different pigment configuration but all betacyanins still give a same wavelength color that is able to be detected at wavelength of 538nm using spectrophotometer (Harivaindaran *et al*., 2008), which causes high percentage of betacyanin retention. The highest percentage of betacyanin retention was determined at rotation speed of 1 rpm and steam pressure of 2 bar, which gave an average of 80.21 mg/g of dry solid. Since betacyanin is a very heat sensitive pigment (Cheryan and Alvarez, 1995), it will be destroyed at high heat temperature. This explains the drop of betacyanin content at a steam pressure of 3 bar. At 1 rpm and 2 bar, the formation of isobetanin occurs at the highest rate, and yet the interactive effect of rotation speed and steam pressure had not destroyed the betacyanin compound, thus the betacyanin retention-occur at the highest percentage.

Color analysis

The Hunter L value was significantly affected by rotation speed and steam pressure at all combinations. Even Hunter a value and Hunter b value are not affected by the interaction effect, however, statistical analysis showed that Hunter a value was affected by steam pressure ($p \leq 0.001$). Figure 5 shows the color analysis of drum dried pitaya peel. The Hunter L values decreased as the rotation speed of drums were increased. On the other hand, Hunter L values increased when steam pressure increased. Meanwhile, the interaction of rotation speed and steam pressure did not give significant effect on Hunter a ($p = 0.199$) and b ($p = 0.105$) values. Color changes that were observed during drying is due to the complex reactions of food components in the pitaya peels (R.H.Kakade *et al*., 2011).

Decrease of Hunter L value indicates the brightness of pitaya peel powder decreasing, which means that color of the powder becomes darker. The darker color of the drum dried pitaya peel color can be attributed to high drying temperature. Drum drying of mango powder possess a darker color compared to the sprayed dried, freeze dried and air dried mango powder, mainly due to the chemical reactions between sugar and proteins which is formerly known as Maillard reaction or browning reaction (Caparino *et al*., 2012). Since the pitaya peel consists of protein and sugar as well, thus there is a possibility that Maillard reaction had occurred that makes the drum dried pitaya peel darker. Previous study on drying of strawberry puree also shown that the high processing temperature greatly influences the color degradation (Abonyi *et al*., 2002).

Conclusion

Steam pressure and rotation speed of drums have shown interactive relationship during drum drying process of pitaya peel slurry. The result had indicated that both independent variables significantly ($p \leq 0.05$) affected the drum drying temperature and therefore influencing the quality and color stability of pitaya peel powder. The best drying condition for pitaya peel is at 1 rpm of rotation speed and 2 bar of steam pressure which produce the highest betacyanin content and shelf life stable powder.

References

Abonyi, B. I., Feng, H., Tang, J., Edwards, C. G., Chew, B. P., Mattinson, D. S. and Fellman, J. K. 2002. Quality retention in strawberry and carrot purees dried with Refractance WindowTM system. Journal of Food Science 67(3): 1051-1056.

Bakar, J., Ee, S. C., Muhammad, K., Hashim, D. and

Adzahan, N. 2013. Spray-drying pptimization for red pitaya peel *(Hylocereus polyrhizus)*. Food and Bioprocess Technology 6(5): 1332-1342.

Baker, C. G. J. 1997. Contact dryer. In D.Oakley (Ed.). Industrial Drying of Foods, p. 122-124. London: Blackie Academic & Professional.

Belitz, H.-D., Grosch, W. and Schieberle, P. 2009. Water. In H.-D. Belitz, W. Grosch & P. Schieberle (Eds.). Food Chemistry, p. 3. Heidelberg: Springer.

Caparino, O. A., Tang, J., Nindo, C. I., Sablani, S. S., Powers, J. R. and Fellman, J. K. 2012. Effect of drying methods on the physical properties and microstructures of mango (Philippine 'Carabao' var.) powder. Journal of Food Engineering 111(1): 135-148.

Cheryan, M. and Alvarez, J. R. 1995. Food and beverage industry. In R. D. Noble & S. S. Stern (Eds.). Membrane Separation Technology: Principles and Applications, p. 459. Amsterdam: Elsevier Science.

Daud, W. R. W. 2006. Drum dryers. In A. S. Mujumdar (Ed.). Handbook of Industrial Drying, Third Edition ed., p. 203-211. Boca Radon: CRC Press.

Gavrielidou, M. A., Vallous, N. A., Karapantsios, T. D. and Raphaelides, S. N. 2002. Heat transport to a starch slurry gelatinizing between the drums of a double drum dryer. Journal of Food Engineering 54: 45-58.

Gunasena, H. P. M., Pushpakumara, D. K. N. G. and Kariyawasam, M. 2011. Dragon fruit *Hylocerus undatus* (Haw.) Britton and Rose. In D. K. N. G. Pushpakumara, H. P. M. Gunasena & V. P. Singh (Eds.). Underutilized Fruit Trees in Sri Lanka, Vol. 2, p. 110-136. New Delhi: World Agroforestry Centre.

Harivaindaran, K. V., Rebecca, O. P. S. and S.Chandran. 2008. Study of optimal temperature, pH and stability of dragon fruit *(Hylocereus polyrhizus)* peel for use as potential natural colorant. Pakistan Journal of Biological Sciences 11(18): 2259-2263.

Herbach, K. M., Rohe, M., Stintzing, F. C. and R.Carle. 2006. Structural and chromatic stability of purple pitaya (*Hylocereus polyrhizus* [Weber] Britton and Rose) betacyanin as affected by the juice metrix and selected additives. Food Research International 39: 667-677.

Jamilah, B., Shu, C. E., Kharidah, M., Dzulkifly, M. A. and Noranizan, A. 2011. Physico-chemical characteristics of red pitaya *(Hylocereus polyrhizus)* peel. International Food Research Journal 18: 279-286.

Kalogianni, E. P., Xynogalos, V. A., Karapantsios, T. D. and Kostoglou, M. 2002. Effect of feed concentration on the production of pregelatinized starch in a double drum dryer. LWT - Food Science and Technology 35(8): 703-714.

Lim, S. D., Yusof, Y. A., Chin, N. L., Talib, R. A., Endan, J. and Aziz, M. G. 2011. Effect of extraction parameters on the yield of betacyanins from pitaya fruit *(Hylocereus polyrhizus)* pulps. Journal of Food, Agriculture & Environment 9(2): 158-162.

Nobel, P. S. 2008. Cactaceae. In J. Janick & R. E.Paull (Eds.). The Encyclopedia of Fruit & Nuts, p. 215. Wallingford: CAB International.

Nurliyana, R., Syed Zahir, I., Mustapha Suleiman, K., Aisyah, M. R. and Kamarul Rahim, K. 2010. Antioxidant study of pulps and peels of dragon fruits: a comparative study. International Food Research Journal 17: 367-375.

O'Shea, N., Arendt, E. K. and Gallagher, E. 2012. Dietary fibre and phytochemical characteristics of fruit and vegetable by-products and their recent applications as novel ingredients in food products. Innovative Food Science & Emerging Technologies 16(0): 1-10.

Pua, C. K., Hamid, N. S. A., Tan, C. P., Mirhosseini, H., Rahman, R. B. A. and Rusul, G. 2010. Optimization of drum drying processing parameters for production of jackfruit *(Artocarpus heterophyllus)* powder using response surface methodology. LWT-Food Science and Technology 43: 343-349.

Kakade, R. H., Das, H. and Ali, S. 2011. Performance evaluation of a double drum dryer for potato flake production. Journal of Food Science Technology 48(4): 432-439.

Sagrin, M. S. and Chong, G. H. 2013. Effects of drying temperature on the chemical and physical properties of Musa acuminata Colla (AAA Group) leaves. Industrial Crops and Products 45(0): 430-434.

Vallous, N. A., Gavrielidou, M. A., Karapantsios, T. D. and Kostoglou, M. 2002. Performance of a double drum dryer for producing pregelatinized maize starches. Journal of Food Engineering 51(3): 171-183.

Wall, M. M. and Khan, S. A. 2008. Postharvest quality of dragon fruit (*Hylocereus* spp.) after X-ray irradiation quarantine treatment. Hort Science 43(7): 2115-2119.