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Comparative study of different drying techniques of dragon fruit peel

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Abstract
Dragon fruit (*Hylocereus polyrhizus*) peel is the major by-product left over from either fresh consumption or fruit processing. The peel is accounted for about one-fourth of the whole fruit. Dragon fruit peel contains some valuable components such as antioxidants, vitamin C betalain compound and pectin. Its properties are needed to be exploited and understood for its better utilization. The aim of this work is to investigate the drying of dragon fruit peel pulp by Refractance Window Drying (RWD) and the effects of process conditions on the drying rates and color difference on the Characteristic of the final dried powder and to compare the RWD with hot air drying and freeze drying for the production of dried dragon fruit peel powder. The heating water temperature of 95°C and pulp thickness of 3.5 mm were selected for RW drying of dragon fruit peel pulp. The powder characteristics were assessed from its drying time, and colour difference. The shorter drying time of 42 min was observed in RWD of the peel. The drying time of RWD dried peel powder was very less as comparison to hot air drying and freeze drying. The colour analysis of the dried samples yields that the colour of the freeze-dried sample was good but the colour of RWD sample was far better than the hot air-dried sample. In conclusion the RWD time of dragon fruit peel was very short and the colour of the sample was better and can be used as a natural colorant. However, the properties of RWD dragon fruit peel powder need to be evaluated to check the suitability as natural colorant.

Keywords: Dragon fruit peel, hot air drying, refractance window drying, freeze drying

Introduction
Dragon fruit peel is the major by-product left over from either fresh consumption or fruit processing. The peel is accounted for about one-fourth of the whole fruit. The dragon fruit peel may contain some valuable components; thus, its properties are needed to be exploited and understood. The pH value (4.7) and dry matter (7-9 g/100 g fresh weight) of both dragon fruit peels were comparable values. Vitamin C content of the red-flesh dragon fruit peel (13 mg/100 g) is greater than the white-flesh dragon fruit (5 mg/100 g). Dragon fruit peel may be a possible natural source of betacyanin (red/purple pigment), Total betacyanin content in the red-flesh dragon fruit peel (20 mg/100 g) is double than the white-flesh peel (10 mg/100 g). The betacyanin pigment in dragon fruit has also been identified that it consists of betanin, phyllocactin, hylocerenin and their derivatives (Kim *et al*., 2011) [11] This natural color of dragon fruit peel can be used in food industry as a promising food colouring agent. The peel is also a good source of dietary fiber, accounting to 69 g/100 g of dried peel (Jamilah *et al*., 2011) [6] The peel of both dragon fruit species also shows remarkable Antioxidative potential (Choo and Yong, 2011; Kim *et al*., 2011) [3, 11]. It is suggested that the Antioxidative properties can be contributed to betacyanin (dragon fruit's pigment). Besides its color function, betacyanin has other health benefits (Delgado-Vargas *et al*., 2000) [5]. Based on above considerations, preserving nutritional value of fruit peel is of outmost important while converting them into powders by using any drying technique. Drying is a suitable option for the production of food powders, which is easy to use, transport and storage. The main drying process used to produce powdered foods are spray drying (SD), drum drying (DD), and freeze-drying. To be more competitive, powdered foods should maintain their nutritional, physical and chemical characteristics, and be produced at low cost. However, producing high-quality powdered foods at low-cost is not always possible from the above-mentioned processes (Ochoa-Martínez, Quintero, Ayala, &Ortiz, 2012) [9].
An alternative drying process for producing powdered foods is the Refractance Window Drying (RWD). RWD is a method for concentrating and drying solutions and purees that allows obtaining films and flakes at relatively low processing temperatures, with reasonable costs (Nindo *et al*., 2003) [7]. According to Nindo and Tang (2007) [8], for the same drying capacity, the RWD equipment requires 50–70% less capital expenditure and 50% less energy

than the freeze drier process. In the RWD process, a solution or puree is spread onto a transparent polyester mat, which has its lower surface in contact with hot water circulating in a reservoir. A polyester film, used as the mat in which the drying solution or suspension is spread, is partially transparent to infrared radiation and commercially known as Mylar sheet (Nindo & Tang, 2007) [8]. The heat required by the drying process is supplied by the hot water circulating in the reservoir. One advantage of this drying method is the possibility of using a relatively low drying temperature and controlling the residence time of the drying solution, which enables obtaining flocculated or powdered products with good sensory properties and less nutritional losses (Abonyi*et al*., 2002; Nindo & Tang, 2007) [1, 8]. Hence, the present study was focused on RWD of dragon fruit peel and compare freeze drying and hot air drying with RWD for the production of dragon fruit peel powder.

2. Material and Methods

2.1 Raw materials

The fresh Dragon fruits were purchased from the Chakarpur market of Kanpur,

2.2. RWD of dragon fruit peel

2.2.1 Preperation of dragon fruit peel pulp

First dragon fruit was washed under the tap water properly then it cut into two half sections and removed the pulp completely from the peel with the help of spoon and transfered into a lab grinder to obtain smooth pulp (Fig.1).

Fig 1: dragon fruit peel pulp

2.2.2 Lab scale RWD setup

A laboratory scale RW dryer (Fig.2) was set up for drying of dragon fruit peel, the set up consists of thermostatic water bath filled with distilled water. A mylar sheet (thickness 0.15 mm) was placed on the top of the water bath. After this. drgaon fruit peel pulp was uniformily spread on to the mylar sheet.

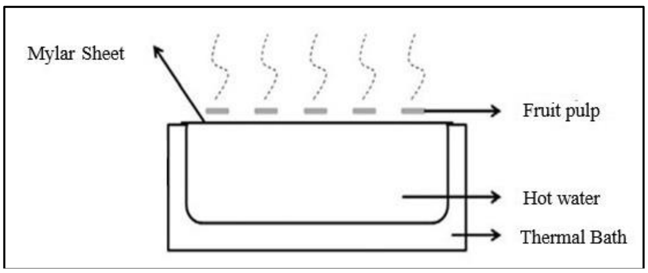

Fig 2: Schematic sketch of batch RW dryer

2.2.3 RWD process

The RWD of dragon fruit peel was conducted at 95 ºC (temperature of water bath) and a pulp (peel) thickness of 3.5mm. In this method thermal energy from hot water is transferred to wet food material deposited as thin film on a mylar sheet. The plastic sheet is directly contact with the hot water and results in very rapid drying. The dry product is then scraped off from the plastic sheet after completion of drying and grinded inthe laboratory grinder and packed into the aluminum pouches untill the further analysis.

2.3 Hot air drying of dragon fruit peel pulp

The hot air drying of the peel pulp was carried out in a lab scale automatic hot air dryer (Model ArmfeildUP08MICII). The pulp was dried at a temperature of 70 °C and at an air velocity of 1 m/s. the operating condition were selected on the basis of previously reported results (Singh, A., *et al* 2015; Upadhyay, A., *et al* 2015) [12].

2.4 Freeze drying of dragon fruit peel pulp

The dragon fruit peel pulp was poured into Schott bottle and frozen in ultra-low temperature freezer (Model: shivam instruments) at –40 °C for overnight. Then the pulp was freeze dried using freeze dryer (Model: labconco free air 2.5) at –50 °C under pressure below
0.110 mBar for 72 hours. The dried pitaya peel powder was ground using laboratory grinder (Antal, T. 2015) [2]. The powder obtained was stored in aluminum pouch at room temperature until further analysis.

2.5 Determination of drying time

Drying time was noted from the start of experiment up to the moisture content ranges between of 5-6 %.

2.6 Color analysis of the dried samples

Colour changes in dried powder were analyzed in an author made box at stable statuses of monitoring and using Image analysis software MATLAB R 2015a. Fluorescent lamps were used to create the required wavelength. A special surrounded chamber, in which the whole walls were covered with black colour, was used to avoid reflection of the wavelength in space and any type of fluctuation when capturing. Images were captured using a Lenovo K3 note mobile phone with 13 MP camera. The camera was located in 20 cm distance (in parallel and constant) of samples, and the captured photographs were saved in jpg format. Three colour indices of L* (lightness–darkness), a* (redness–greenness) and b* (yellowness–blueness) values were obtained.

2.7 Total color difference (ΔE)

The total color difference between (ΔE) the fresh peel and dried samples was determined using the below equation as described by Diamante *et al*. (2010)

$$\Delta E^* = (L^* - L_I) \quad + (a \ - a_I) \ + (b \ - b_I)$$

where Lo*, ao* and bo* are initial values of fresh samples and L*, a* and b* are color values of dried samples.

3. Results and Discussion

3.1 RWD of Dragon fruit peel

The RWD of Dragon fruit peel was successfully carried out at 95C and 3.5mm thickness. The drying time taken to dry the peel was around 42 min, the image of the RWD dragon fruit peel powder is shown below (Fig. 3)

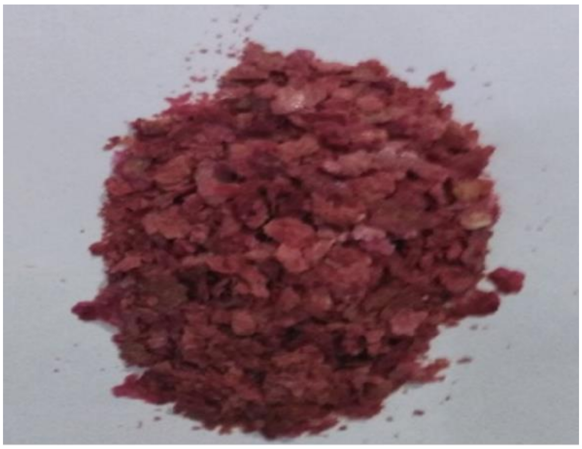

Fig 3: RWD Dragon fruit peel at 95C amd 3.5mm thickness

The color analysis of the fresh and dried sample yields that the fresh sample has a* value of 37.39 where as RWD sample has 19.02. There is a loss of around 49% in the redness of the dried sample compared to fresh sample.

3.2 Comparison of RWD, Freeze drying and hot air drying for the Production of dragon fruit peel powder

3.2.1 Drying time

The drying time was significantly reduced in RWD when compared to Hot air drying Freeze drying. The time taken to dry the dragon fruit peel at selected conditions in RWD was around 42 min where as in hot air drying and freeze drying the time was 480 min and 72 hrs respectively. The significant decrease in drying time in RWD can be attributed to rapid unique heat transfer mechanism of RWD. The drying time of the dried samples was shown in fig.4.

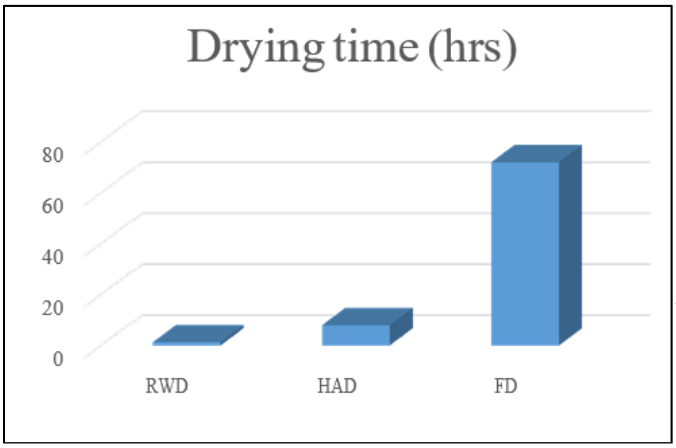

Fig 4: Drying time of dried samples (HAD-Hot air drying, FD-Freeze drying)

3.2.2 Color of the dried samples

The images of the hot air dried and freeze-dried samples were shown in fig. 5 & 6. The L*, a* and b* of fresh, RWD, hot air dried, freeze dried samples were shown in Table 1

Table 1: L*, a*and b* values of fresh and dried samples

Sample	L*	a*	b*
Fresh	47.34	37.39	-0.90
RWD	27.43	19.02	6.94
FD	32.48	22.48	4.86
HAD	27.97	12.56	11.26

Fig 5: Hot air dried dragon fruit peel powder

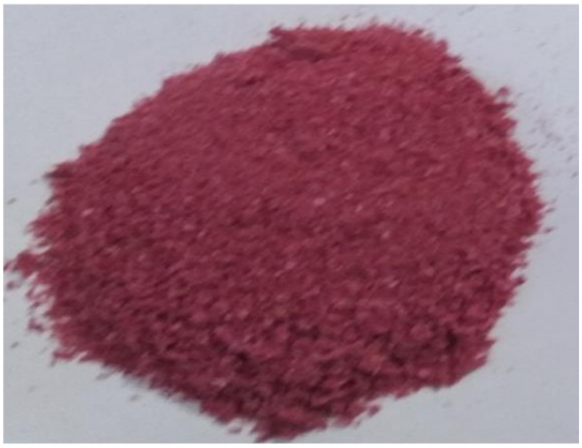

Fig 6: Freeze dried dragon fruit peel powder

From table 1 it is observed that there is a reduction in lightness of the fresh sample compared to all the dried samples. The a* values indicates that there is a reduction in redness of the dried samples compared with the fresh sample. The % reduction of redness in RWD, hot air drying and freeze drying were 49.13%, 66.40% and 39,87% respectively. The % reduction was very high in hot air drying when compared to both freeze drying and RWD. However, the % reduction was less in freeze drying compared to RWD.

Total color difference (ΔE) of the dried samples

The total color difference (ΔE) of the dried samples compared with fresh samples was shown in fig.7. The ΔE of the freeze-dried sample was (21.82) very less compared to hot air drying and RWD. The total color difference of RWD was (28.21) better in comparison with hot air drying (33.76).

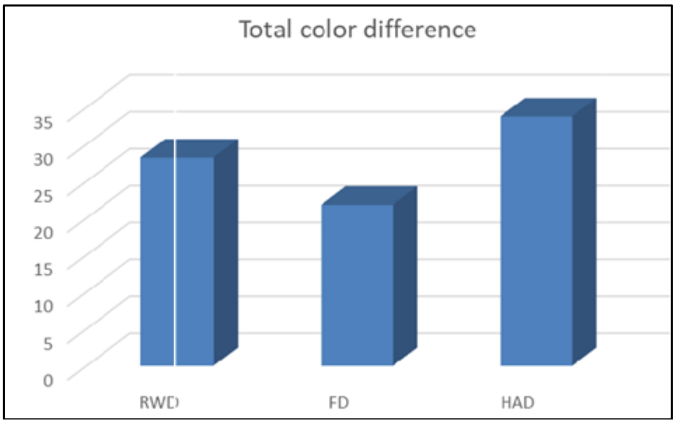

Fig 7: Total color difference of dried samples

Conclusion

From the above experimental study, it can be concluded that the RWD can be used for the drying of dragon fruit pe the study indicated that RW l pulp. The operation of the RWD drying is simple. The results of can be used to produce dragon fruit peel powder with minimum drying time and better color retention compared to hot air drying and freeze drying. RWD peel powder was compared with hot air dried and freeze-dried sample and the results showed that RWD took less time when compared to hot air drying and freeze drying. RWD took 42 min as hot air drying took 400 min which was very high and the color appearance of hot air dried is poor as compared to RWD. RWD took less time when compared to freeze drying. RWD took 42 min whereas freeze drying took 72 hrs, which was very high and the color appearance of freeze dried sample was good but the energy costs to operate freeze dryers is very high as compared to RWD. However, optimization of RWD processing conditions may further improve the color of the dried sample. Further physicochemical and microbiological analysis of the samples is required to check the suitability of RWD sample as natural food colorant

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