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Development of dragon fruit leather

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Abstract
The present investigation was carried out to preparation of fruit leather from red flesh dragon fruit (*Hylocereus polyrhizus*). The leather was prepared by using red flesh dragon fruit pulp and sugar as 60:40. The prepared homogeneous mixture of 78° Brix consisted of pectin (4g), potassium metabisulphite (0.1g), citric acid (1g). The development dragon fruit leather dried at different temperature (55 °C, 65 °C and 75 °C) with different thickness (2, 3 and 4 mm) in mechanical tray drier. The result showed that after optimization process the best treatment obtained was 60:40 of dragon fruit pulp and sugar at drying temperature of 55 °C with 2 mm of pulp thickness and the final moisture content was 16 per cent (wb), TSS 78.1, Total sugar 68.8. The mean score as per 9 point hedonic scale of fresh dragon fruit leather for colour and appearance was 8.1, texture 8.1, flavour 8.2, taste 8.1 and overall acceptability 8.1 on point hedonic scale.

Keywords: Development, dragon, leather, colour

Introduction
Dragon fruit is one of the newly introduced and emerging super exotic fruit crop in India. It is originated principally from tropical and subtropical forest regions of Mexico and Central South America (Britton and Rose, 1963; Mirzahi *et al*., 1996) [4]. It belongs to the family *Cactaceae* and genus *Hylocereus*. Dragon fruit have the flesh or pulp filled with lots of tiny black seeds which are edible with the fruit. There are different species found in the global market. Dragon fruit received worldwide recognition and recently drawn much more attention from growers and consumers due to its attractive color, medicinal benefits, high nutritional and economic value, unique shape. Dragon fruit pH is ranging between 4.7 to 5.1 and TSS ranging from 11 to 19^0 Brix (Gunasena *et al.,* 2007). Dragon fruit species *Hylocereus polyehizus* (Red flesh) is great source of vitamin C and water soluble fiber (Mizrahi and Nerd, 1999) [7]. Also it is a good source of proline (1.1 -1.6 g/L) and the seeds of red flesh dragon fruit also contains some amount of essential fatty acids (linoleic acid, 51%) (Ariffin *et al.,* 2009) [2].
The flesh of dragon fruit is used to develop various types of products such as jellies, jam and juices, ice creams and soft drinks, marmalades and also to produce products such as sherbet, yoghurt, syrup, candy, pastry, ketch, wine, spreads (Anonymous, 2006). The peel and red flesh of dragon fruit also used as a food coloring agent and as a raw material for the food coloring industries (Wybraniec and Mizrahi, 2002) [9]. It significantly improves the appearance of the food products and also increases the nutritional quality of the end products.
Fruit leathers are dehydrated fruit based products which are tasty, soft with chewy, rubbery texture and sweet in taste. Fruit leathers, dehydrated sugar-acid-pectin gels are restructured from fresh fruit pulp with combination of others ingredients after a simplest operations of dehydrations (Huang and Hsieh, 2005) [10]. It is made by pouring fruit onto a flat surface for drying. Fruit leather do not require refrigeration and pulp based fruit leathers are nutritious and organoleptically acceptable to customers. They contains substantial quantities of dietary fibers, carbohydrates, minerals, vitamins and antioxidents (Ayotte, 1980; Gujral and Brar, 2003) [3, 5]. The consumption of processed fruit products is gradually becoming popular, so the scope of utilizing dragon fruit remains bright in India. Therefore, development of process for preparation of dragon fruit leather considered in this study.
For dragon fruit, drying seems to be simplest technology for preserving when they are abundantly available. Fruit leathers are often considered as a health food and health food marketing images such as “pure” or “rich in vitamins” (Vatthanakul *et al*., 2010) [8].

From dragon fruit if quality products are developed from dragon fruit it might be accepted by the consumers which will explore its nutrients to maximum extent. The nutrient rich dragon fruit having leading capacity for the development of new, safe, nutritious and acceptable food to consumers throughout the year. Hence the present study was conducted to study the drying characteristics of dragon fruit leather.

Materials and Method

Selection of Raw Materials

Uniform-sized, healthy, matured, well-ripened, dragon fruits *hylocereus polyrhizus* (Red skin with red flesh) was procured from Rukmini farm, sangola, Maharashtra

Preparation of Sample

The procured dragon fruit were be washed, peeled manually to extract the pulp. The extracted pulp were homogenized and heated up to desired TSS and pectin (4g), citric acid (1g), potassium metabisulphate (0.1g) etc. were added of appropriate quantity. The prepared thick solution were smeared on plastic sheet in stainless steel trays. Drying was done in tray dryer to optimize the time temperature combination. The prepared leather was packed and stored at room temperature.

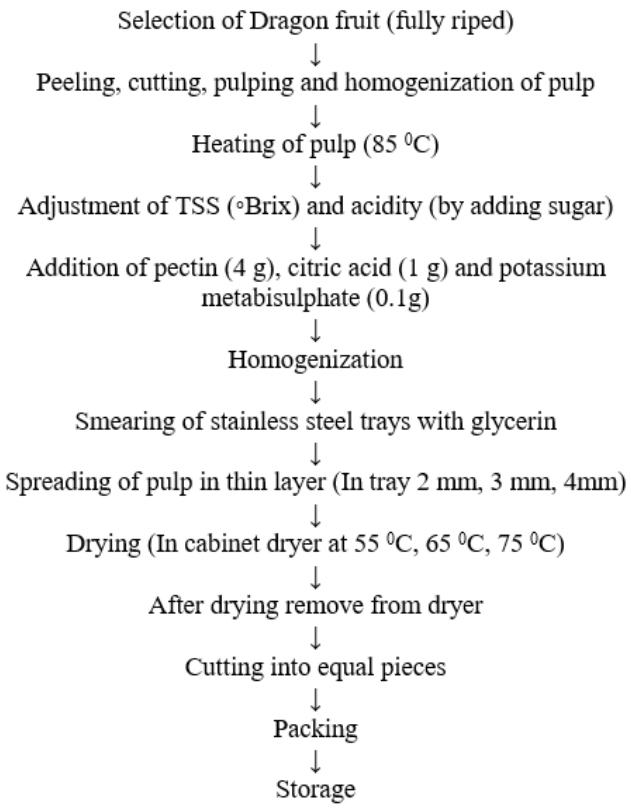

Fig 1: Flow chart for preparation of dragon fruit leather

Experimental Plan

Experiments were planned to study Development of process for value added product from dragon fruit. Variables selected in this study have been classified in two major categories as independent variables, dependent variables.

Experimental Plan

Experiments were planned to study Development of process for value added product from dragon fruit. Variables selected in this study have been classified in two major categories as independent variables, dependent variables. The details of the variables of present experiment are as follows:

Independent variables

Pulp: sugar concentration (%) - 60:40
Temperature - 55 (R1), 65 (R2), 75 (R3)
Thickness - 2 mm, 3 mm, 4 mm

Dependent variables

- Moisture content
- Total soluble solids (TSS)
- Total sugar

Experimental set-up

Dragon fruit leather was dried in mechanical tray dryer at three different air temperature 55, 65 and 75^{o}C. A mechanical tray dryer was used in the dehydration experiment in this study. The velocity of drying air measured by an anemometer was kept constant for all the experiments and it was found to be 2 (±0.1) m/s.

Experimental procedure for tray drying dragon fruit leather

The sample for dragon fruit leather was prepared with procedure. Before beginning an experiment, the initial moisture content of sample was determined. The instrumentation was checked deliberately and dryer was started one hour before experiments keeping in mind the end goal to achieve enduring condition of temperature. The prepared thick sample was spread in aluminum trays having perforated surface and inserted into the mechanical tray dryer. The drying temperature was taken as 55, 65 and 75^{o}C simultaneously at constant drying air velocity of 2 m/s in drying chamber. During drying, the samples were weighed at an interim until the point that the sample attained constant equilibrium moisture content (EMC).

Three replication were carried out and average values were used for calculation. At the completion of each experiment, the final moisture content of each sample was considered as EMC. The data were used to analyze the drying characteristics *viz.* moisture content, drying rate, moisture ratio and determined the quality on the basis of several parameters *viz.* TSS, pH, titrable acidity, reducing sugar, non-reducing sugar, total sugar, and texture analysis i.e. hardness and stickiness.

Drying characteristics

Estimation of Moisture content

The moisture content of leather was determined by standard oven method (Ranganna, 2000). The sample was dried in oven at 105 °C temperature until the material became completely dry. Then sample were removed from oven and cooled in desiccators for 10 min. Then the weight of the dry sample was taken. The per cent moisture content was calculated by using equation.

$$\text{Moisture content (\%) (wb)} = \frac{\text{mass of fresh sample(g)} - \text{mass of dried sample(g)}}{\text{mass of fresh sample (g)}} \times 100$$

Drying rate

The moisture content data recorded during experiments were analyzed to determine the moisture lost from the samples in particular time interval. The drying rate of sample was calculated by following mass balance equation (Brooker *et al.*, 1997).

$$R = \frac{WML\ (g)}{Time\ interval\ (min) \times DM\ (g)}$$

Where

R = Drying rate at time θ, g water/ g-min

WML = Initial weight of sample – Weight of sample after time θ

DM = Dry matter, g

Quality analysis of dragon fruit leather

Chemical constituents like TSS, total sugar,acidity of dragon fruit leather were determined.

Total soluble solid (TSS)

The TSS content of pulp was determined with the help of Erma hand refractometer of 0-80 °Brix range in duplicate (A.O.A.C., 1990). The prism of refractometer was washed with distilled water and wiped to dry after each reading.

Estimation of total sugars

Total sugars were determined by volumetric method of Lane and Eynon (1923) as reported by Ranganna (2000). In a 100 ml volumetric flask 10 g of sample was taken. Then 2 ml concentrated HCl was added and the flask was kept in hot water bath at 70-80°C for 30 min. after cooling the hydrolysate was neutralized by adding pinch of sodium carbonate till formation of effervescence stopped. The volume of the neutralized hydrolysate was made to 100 ml with distilled water. The total sugars in the neutralized hydrosulfate were determined in same way as described under reducing sugars.

$$\text{Total sugar (\%)} = \frac{\text{Factor x Volume made up}}{\text{Titre x Weight of sample taken}} x100$$

Sensory evaluation of dragon fruit leather

The dragon fruit leather was evaluated for the sensory attributes using 9 point hedonic scale by a panel consumer. The leather was evaluated for color, flavor, taste, texture and overall acceptability using a 9 point hedonic scale ranging from like extremely (9) to dislike extremely (1) for different parameters. The mean values of score for color, flavor, taste, texture and overall acceptability were calculated.

Results and Discussion

Initial moisture content

The initial moisture content of dragon fruit leather was found in the range of 41 - 45 per cent, wb.

Drying kinetics

The dragon fruit leather of pulp to sugar ratio as 60:40 was prepared and dried at 55˚C, 65˚C, 75°C and thickness of 2 mm, 3 mm, 4 mm were dried in tray dryer. The air velocity of dryer was kept constant as 2 m/s. The variation in moisture content of dragon fruit leather with drying time, drying rate and moisture ratio were calculated. The range of final moisture content of dragon fruit leather samples was 15 - 22 per cent, db.

Moisture reduction was higher at initial stages and then started to decrease with the increasing drying time. It was observed that drying occurred completely in falling rate period and no constant rate period was observed at all drying temperatures.

Effect of drying time on moisture content

The typical curves showing variation in moisture content with time for drying of dragon fruit leather at temperatures of 55 ^{0}C, 65 ^{0}C and 75 ^{0}C are shown in fig. 1 to 3.

From these curves it was observed that the moisture content of dragon fruit leather decreased exponentially with the drying time for all drying conditions. The drying time for dragon fruit leather in tray dryer presented in table 1. The moisture content and duration of drying were statistically analyzed and regression equation were predicted. The equation of moisture content and duration of drying were presented in Table 1 along with coefficient of determination. The moisture content of dragon fruit leather decreased exponentially with drying time under all drying conditions. As the drying air temperature increased, the drying curves exhibited steeper slope indicating that the rate of moisture loss increased with increase in drying air temperature. This resulted into substantial decrease of drying time.

For the ratio of pulp: sugar as 60:40, the moisture content was decreased for 2, 3 and 4 mm thickness as 72.41 to 21.13 per cent, db at 55 ^{0}C, 72.41 to 22.10 per cent, db at 65 ^{0}C and 72.41 to 21.62 per cent, db at 75 ^{0}C with drying time 480, 405 and 330 min. For 3 mm thickness its decreased from 72.41 to 20.93 per cent, db at 55 ^{0}C, 72.41 to 21.39 per cent, db at 65 ^{0}C, 72.41 to 21.79 per cent, db at 75 ^{0}C with drying time 525, 465 and 390 min. similarly for 4 mm at 55 ^{0}C decreased from 72.41 to 19.94 per cent, db, at 65 ^{0}C 72.41 to 20.10 per cent, db, at 75 ^{0}C 72.41 to19.78 per cent with drying time 600, 540 and 480 min respectively.

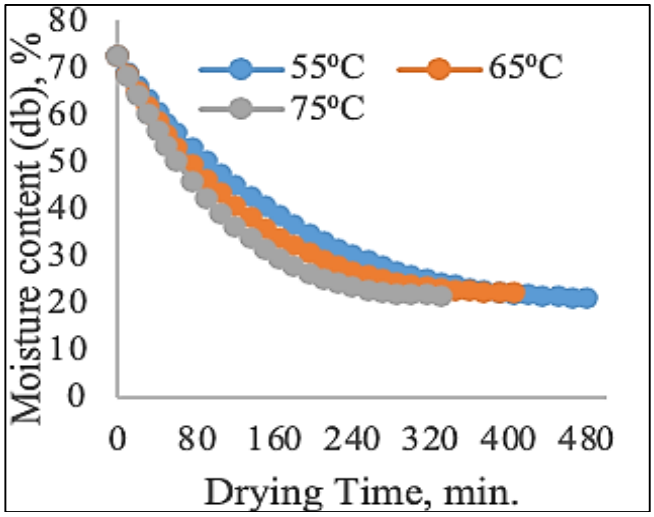

Fig 1: Variation in moisture content of dragon fruit leather with time for 2 mm of thickness at 55 ^{0}C, 65 ^{0}C and 75 ^{0}C temperature

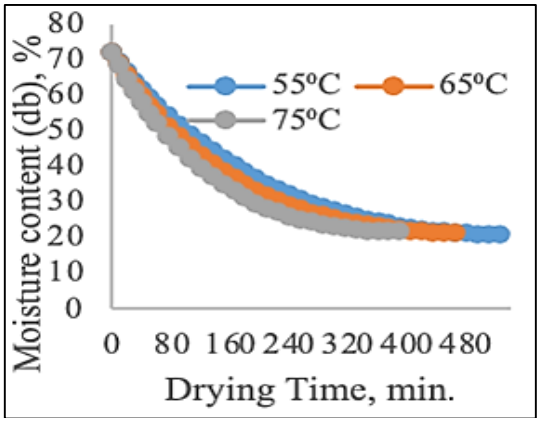

Fig 2: Variation in moisture content of dragon fruit leather with time for 3 mm of thickness at 55 ^{0}C, 65 ^{0}C and 75 ^{0}C temperature

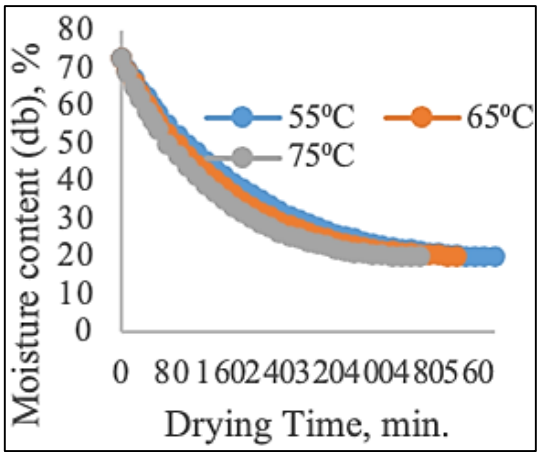

Fig 3: Variation in moisture content of dragon fruit leather with time for 4 mm of thickness at 55 ^{0}C, 65 ^{0}C and 75 ^{0}C temperature

It can be seen that there was a wide variation in drying time for the range of drying temperatures 55 to 75 ^{0}C of leather 480 to 600 min for thickness 2 mm, 525 to 645 min for 3 mm thickness, 600 to 720 min for 4 mm thickness.

Moisture reduction found to be temperatures dependent, which was slow at lower temperature and took more time as compared to drying at higher temperatures. It can also be observed from these curves that the drying time decreased with increase in drying temperatures. Hence, experimental results showed that the drying air temperatures has effect on the removal of moisture content. It can also be seen that minimum time for drying of dragon fruit leather was observed for higher temperatures (75 ^{0}C) and maximum time was recorded for low temperatures (55 ^{0}C) for the samples. The drying time observed under various drying conditions is presented in Table 1.

Effect of temperature on drying rate of dragon fruit leather

The drying rate for the dragon fruit leather was estimated from the moisture loss in known time interval and expressed as g of moisture evaporated per g of dry matter-min. The drying rate as function of moisture content at different drying air temperature for dragon fruit leather with treatment in tray dryer is shown in fig. 4 to 7.

The drying rate was found to be varying for 60:40 ratio of pulp:sugar from 0.000022, 0.000022 and 0.000036 g-water/ g-dm-min at 55, 65 and 70 ^{0}C of drying temperature for 2 mm of thickness, for 3 mm thickness 0.00002, 0.000034 and 0.000034 g-water / g-dm-min at 55, 65 and 70 ^{0}C, for 4 mm thickness it continuously decreased from 0.000011, 0.000032 and 0.000022 g-water / g-dm-min at 55, 65 and 70 ^{0}C (Fig 4 to 6)

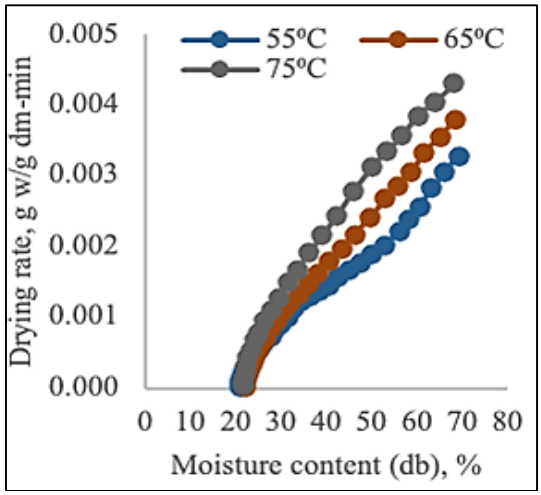

Fig 4: Variation in drying rate of dragon fruit leather with moisture content for 2 mm thickness at 55 ˚C, 65 ˚C and 75 ˚C temperature

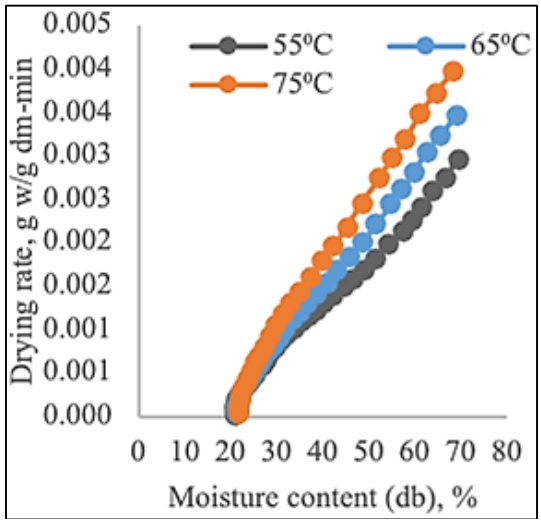

Fig 5: Variation in drying rate of dragon fruit leather with moisture content for 3 mm thickness at 55 ˚C, 65 ˚C and 75 ˚C temperature

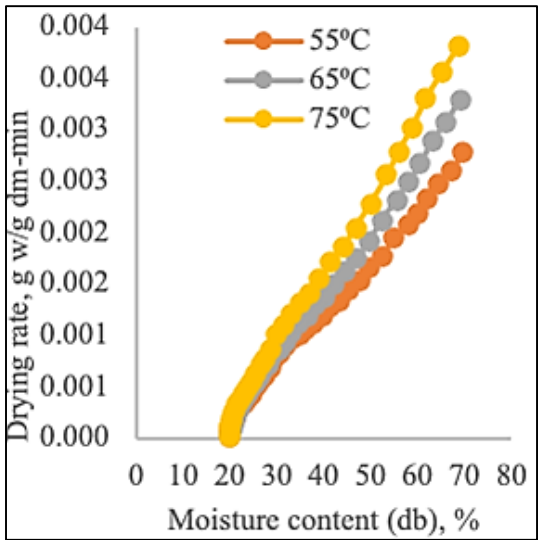

Fig 6: Variation in drying rate of dragon fruit leather with moisture content for 4 mm thickness at 55 ˚C, 65 ˚C and 75 ˚C temperature

Further, the drying rates continuously decreased with respect to time for the ratio of 65:35 (Fig. 2 to 6). The drying rate was found to be varying from 0.000031, 0.000024 and 0.000039 g-water/ g-dm-min at 55, 65 and 70 ^{0}C of drying temperature for 2 mm of thickness, for 3 mm thickness 0.000010, 0.000037 and 0.000031 g-water / g-dm-min at 55, 65 and 70 ^{0}C, for 4 mm thickness it continuously decreased from 0.000012, 0.000020 and 0.000039 g-water / g-dm-min at 55, 65 and 70 ^{0}C (Fig 2 to 6).

From the observations it can be seen that, a constant rate-drying period was not found in drying curves. The entire drying process took place in the falling rate period; the curves typically demonstrated smooth diffusion controlled drying behaviour under all drying temperatures. Moreover, an important influence of air drying temperature on drying rate could be observed in these curves. It is obvious from these curves that the higher the drying temperature, the greater the drying rate, so the highest values of drying rate were obtained during the experiment at 75 ^{0}C. It can be seen that initially the drying rate was more and subsequently it reduced with drying time. It can also be seen that they follow typical drying rate curves.

Table 1: Quality

Parameter	Temperature (°C)								
	55			65			75		
	2 mm	3 mm	4 mm	2 mm	3 mm	4 mm	2 mm	3 mm	4 mm
TSS	78.1	76.89	75.74	77.5	75.89	74.74	76	74.4	74.9
Total sugar	68.8	66.6	65.98	69.8	65.5	64.4	60.3	59.09	59.7
Overall acceptability	8.1	7	8	7	6	7	8	8	6

Conclusion

It can be concluded from experimental observations and analysis that highly acceptable fruit leather can be prepared from 60:40 of red flesh dragon fruit pulp and sugar. The significant result found out of drying rate, TSS, acidity and total sugar. As per the sensory evaluation study of dragon fruit leather, the best treatment obtained was 60:40 of dragon fruit pulp and sugar at drying temperature of 55°C with 2 mm of pulp thickness.

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