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Optimization of process variables for development of dragon fruit leather by using fruit peel as by-product utilization

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Abstract
Dragon fruit is one of the newly introduced and emerging super-exotic fruit crops in India. It is a good source of Vitamin-C, water-soluble fibres and antioxidants. Dragon fruit peel is the major by-product left over from either fresh consumption or food processing. The dragon fruit peel may contain some natural pigment like pectin. It is a good food supplement for making fruit leather. Hence, dragon fruit pulp heated with extracted peel water increases the stability of the dragon fruit leather. The leather was prepared by using white flesh dragon fruit pulp and sugar in different combinations as (10, 20, 30, 40 and 50%) as per the statistical design of RSM. The prepared homogeneous mixture was dried in a mechanical dryer at different temperatures (55, 60, 65, 70 & 75 ºC) and thicknesses (2, 3, 4, 5 & 6 mm). It may be concluded that the optimized dragon fruit leather having the formulation of peel: Sugar: Temperature: Thickness was found as 20%: 40%: 60 ºC: 5 mm, respectively, which is extremely useful for satisfying consumer tastes and preference and optimized sample having Vitamin C of 21.1 mg/100g and Overall acceptability of 7.59.

Keywords: Dragon fruit, drying, physico-chemical, organoleptic, etc.

Introduction
Dragon fruit is one of the newly introduced and emerging super-exotic fruit crops in India. It originated principally from tropical and subtropical forest regions of Mexico and Central South America. It belongs to the family Cactaceae and the genus Hylocereus. Dragon fruit has flesh or pulp filled with lots of tiny black seeds which are edible with the fruit. Dragon fruit received worldwide recognition and recently drawn much more attention from growers and consumers due to its attractive colour, medicinal benefits, high nutritional and economic value, and unique shape. The dragon fruit helps the method (biological process) process prevent colon cancer and diabetes, neutralize toxic substances such as heavy metals, and reduce cholesterol levels and high blood pressure and consumed regularly the dragon fruit will facilitate against respiratory illness and cough (Britton and Rose, 1963) [8].
Dragon fruit is great source of vitamin C and water-soluble fiber (Mizrahi and Nerd, 1999) [7]. Seeds of dragon fruit also contain 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, and marmalades and also to produce products such as sherbet, yoghurt, syrup, candy, pastry, ketch, wine, spreads.
Fruit leathers are dehydrated fruit based products which are tasty, soft with chewy, rubbery texture and sweet in taste. Fruit leather does not require refrigeration and pulp-based fruit leathers are nutritious and organoleptically acceptable to customers. They contain substantial quantities of dietary fibers, carbohydrates, minerals, vitamins and antioxidants (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 a process for the preparation of dragon fruit leather considered in this study.
Dragon fruit skin has bigger potency than the flesh from the production number of dragon fruit every year. Until today dragon fruit skin has not widely used. In this modern era, people want everything instantly, including for their health. Therefore, we tried to processed red dragon fruit skin waste to become an instant, health and easily-consumed product in the form of fruit leather. Therefore, this study will be carry out the most appropriate filler ingredient and ratio of sugar and dragon fruit peel used to produce the desired fruit leather texture.

2. Materials and Methods

2.1. Preparation of sample

The dragon fruit leather was prepared as per the standard process mentioned below. The procured dragon fruit was being washed and peeled manually to extract the pulp. The extracted pulp was homogenized and heated up to desired TSS and citric acid (1 g), potassium metabisulphate (0.1 g) etc. were added in appropriate quantities. The prepared thick solution was smeared on plastic sheets in stainless steel trays. Drying was done in a tray dryer to optimize the time-temperature combination. The prepared leather was packed and stored at room temperature.

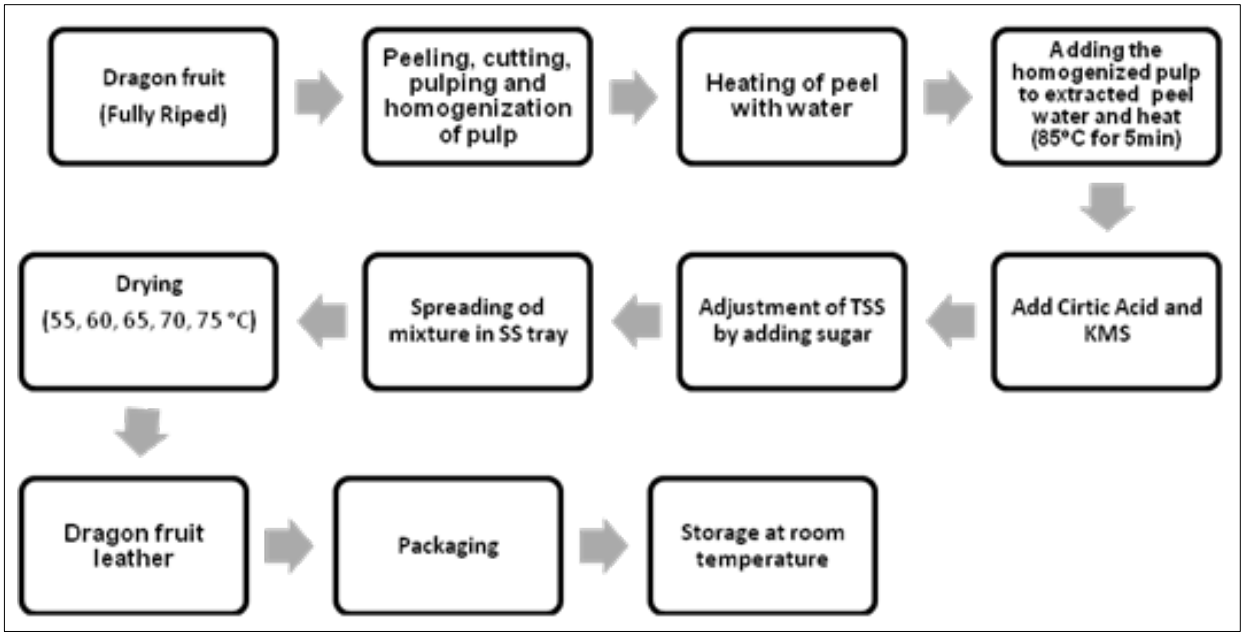

Fig 1: Process flowchart for preparation of dragon fruit leather

2.2. Experiment plan

Dragon fruit leather with various process formulations was prepared by using the tray drying technique. Four process variables with five levels each were considered by using a central composite rotatable design (CCRD). Thirty experiments were conducted and their interactions were also studied by using RSM as an experimental statistical design to see the effect of different independent variables on various physical chemicals, sensory and colour value of the dried product.

Table 1: Experimental plan for the development of dragon fruit leather

Independent Variables	Dependent Variables	
Peel crush (g/100 g of pulp)	10, 20, 30, 40, 50	Ascorbic acid, pH, TSS, Color value (L*, a*, b*), organoleptic evaluation Colour, texture, flavour and overall acceptability
Sugar (g/100 g of pulp)	10, 20, 30, 40, 50	
Temperature (°C)	55, 60, 65, 70, 75	
Thickness (mm)	2, 3, 4, 5, 6	

2.3. Physico-chemical analysis of dragon fruit leather:

The proximate composition represents the gross content of important chemical constituents such as ascorbic acid, pH, and TSS. The study of the proximate composition serves as an important base to study the nutritive quality of dragon fruit leather. The standard methods have been used for the proximate analysis.

Table 2: Actual and coded values of different parameters for experimentation

Sr. No.	Coded Value				Actual Value			
	Peel (g/100g)	Sugar (g/100g)	Temperature (°C)	Thickness(mm)	Peel (g/100g)	Sugar (g/100g)	Temperature (°C)	Thickness(mm)
1	-1	-1	-1	-1	20	20	60	3
2	1	-1	-1	-1	40	20	60	3
3	-1	1	-1	-1	20	40	60	3
4	1	1	-1	-1	40	40	60	3
5	-1	-1	1	-1	20	20	70	3
6	1	-1	1	-1	40	20	70	3
7	-1	1	1	-1	20	40	70	3
8	1	1	1	-1	40	40	70	3
9	-1	-1	-1	1	20	20	60	5
10	1	-1	-1	1	40	20	60	5
11	-1	1	-1	1	20	40	60	5
12	1	1	-1	1	40	40	60	5

13	-1	-1	1	1	20	20	70	5
14	1	-1	1	1	40	20	70	5
15	-1	1	1	1	20	40	70	5
16	1	1	1	1	40	40	70	5
17	-2	0	0	0	10	30	65	4
18	2	0	0	0	50	30	65	4
19	0	-2	0	0	30	10	65	4
20	0	2	0	0	30	50	65	4
21	0	0	-2	0	30	30	55	4
22	0	0	2	0	30	30	75	4
23	0	0	0	-2	30	30	65	2
24	0	0	0	2	30	30	65	6
25	0	0	0	0	30	30	65	4
26	0	0	0	0	30	30	65	4
27	0	0	0	0	30	30	65	4
28	0	0	0	0	30	30	65	4
29	0	0	0	0	30	30	65	4
30	0	0	0	0	30	30	65	4

2.3.1. Determination of Total Soluble Solid (TSS)
The Total Soluble Solid (TSS) of dragon fruit leather was determined by using Digital Refractometer.

2.3.2. Determination of pH
The pH of the dragon fruit leather was measured by using a Digital pH meter.

2.3.3. Determination of Vitamin-C
Vitamin-C of dragon fruit was determined by Titrimetric (Volumetric) Method.

$$Ascorbic\ acid\left(\frac{mg}{100g}\right) = \frac{0.5mg \times V_2 ml \times 50ml \times 100}{V_1 ml \times 5ml(aliquote) \times Wt.of\ sample(5g)}$$

2.3.4. Determination of color value (L*, a* and b*)
The colour of the dragon fruit leather was measured in terms of L*, a* and b* values. All the colour measurements were done using a Digital photoelectric colourimeter.

2.3.5. Organoleptic evaluation of dragon fruit leather
The dragon fruit leather samples were evaluated for their sensory attributes namely colour texture, flavour and overall acceptability by a panelist drawn from faculty members and postgraduate students of CAET, AAU, Godhra. The panellist were asked to record their observations on a sensory sheet based on 9 points hedonic rating scale where 9 and 1 represent liked extremely and disliked extremely, respectively. The overall final rating was obtained by averaging the marks, a score of rating i.e. like moderately was considered as the acceptability of the products.

3. Results and Discussions
3.1. Effect of process variables on the quality of dragon fruit leather
The table shows the experimental design and responses (Vitamin-C, overall acceptability, pH, TSS and colour value L*, a*, b*) collected for optimization of different process variables (peel, sugar, temperature and thickness) for production of dragon fruit leather by using Response Surface Methodology techniques. To visualize the combined effects of two factors on the response, three-dimensional response graphs surfaces (Fig. 2-6) were also generated for each of the fitted models as a function of two variables, while keeping the third variable at the central value. The quadratic models were fitted to the experimental data and statistical analysis was carried out for each response by using Design Expert Software 8.0.7.1 (Stat Ease Inc).

3.2. Analysis of responses
Various responses (Vitamin C, sensory evaluation in terms of overall acceptability, pH, TSS, colour values in terms of L*, a*, b*) of dragon fruit leather were discussed and results are presented here.

3.2.1. Effect on Vitamin-C
The model F-value of 2.92 implies the model is significant. R^2 and adjusted R^2 values of the model are 0.73 and 0.48 respectively. The adequate precision value of 6.39 indicates that the model can be used to predict the response within the design space as it is greater than 4.0.
Analysis of variance show that F-values for linear terms of temperature and thickness are 6.37, 6.20 and 20.26 at P Value of 0.0233, 0.0250 and 0.0004 respectively, showing that the term C and square term of C and D are significant terms (p<0.05). It may be seen from Fig. 2 that the increase in sugar and peel content in dragon fruit leather may increase in Vitamin C of the product due to a better sugar-peel blend ratio.

3.2.2. Effect on overall acceptability
Overall Acceptability of the Dragon fruit leather ranged from 6.25 to 8.17 with an average value of 6.97. The model F-value of 3.33 implies the model is significant. Values of “Prob > F” less than 0.0500 indicate model terms are significant. Analysis of variance show that F-values for linear terms of temperature and thickness are 13.53 and 27.21 at P-Value of 0.0022 and 0.0001 respectively, showing that the square term of C and D are the significant terms (p<0.05). It may be seen from Fig. 3 that the increase in sugar content in dragon fruit leather may increase in overall acceptability of the product.

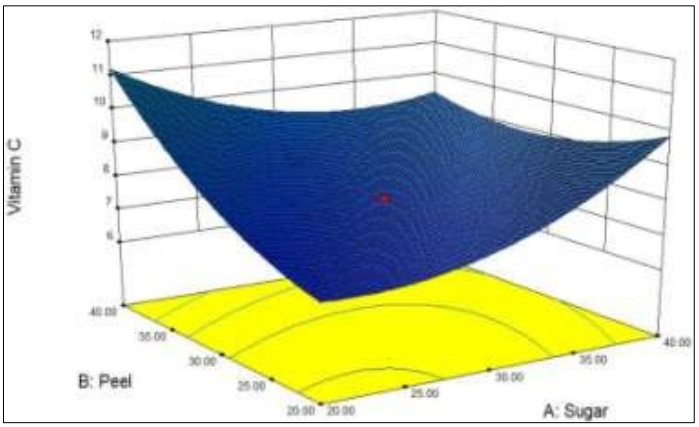

Fig 2: Variation of vitamin-C with respect to sugar and peel in dragon fruit leather

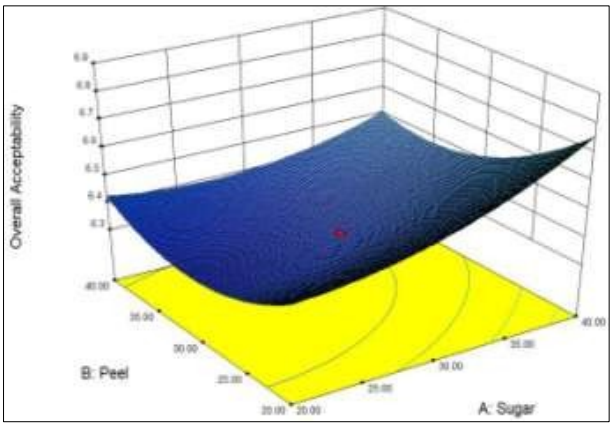

Fig 3: Variation of overall acceptability with respect to sugar and peel in dragon fruit leathe

Table 3: ANOVA effect on different process variables on Vitamin-C of dragon fruit leather

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	1427.71	14.00	101.98	**2.92**	0.0240	**Significant**
A-Sugar	2.46	1.00	2.46	0.07	0.7942	
B-Peel	23.62	1.00	23.62	0.68	0.4238	
C-Temperature	222.83	1.00	222.83	6.38	0.0233	
D-Thickness	114.63	1.00	114.63	3.28	0.0901	
AB	23.11	1.00	23.11	0.66	0.4287	
AC	31.16	1.00	31.16	0.89	0.3599	
AD	103.99	1.00	103.99	2.98	0.1050	
BC	26.91	1.00	26.91	0.77	0.3940	
BD	1.80	1.00	1.80	0.05	0.8234	
CD	45.26	1.00	45.26	1.30	0.2729	
A^2	23.98	1.00	23.98	0.69	0.4203	
B^2	13.25	1.00	13.25	0.38	0.5472	
C^2	216.59	1.00	216.59	6.20	0.0250	
D^2	707.86	1.00	707.86	20.26	0.0004	
Complete Model						
Residual	524.02	15.00	34.93			
Lack of Fit	524.02	10.00	52.40			
Pure Error	0.00	5.00	0.00			
Total	1951.732	29				
R2	0.73	Adeq. Precision			6.39	
Adj R^2	0.48					

3.2.3. Effect on pH: pH of the Dragon fruit leather ranged from 3.10 to 4.90 with an average value of 3.82. The model F-value 3.07 implies the model is significant. Values of "Prob > F" less than 0.0500 indicate model terms are significant. Analysis of variance show that F-values for linear terms are 4.57, 10.38, 7.95 and 10.29 at P-Value of 0.0494, 0.0057, 0.0129 and 0.0059 respectively, showing that the term B, BD, CD and B^2 are significant model terms (p<0.05). It may be seen from Fig. 4 that the increase or decrease in peel content may increase or decrease in pH of the product.

3.2.4. Effect on colour value (b*)

The colour value b* of the dragon fruit leather ranged from 2.65 to 0.11 with an average value of 1.01. The model F-value of 2.62 implies the model is significant. Values of "Prob > F less than 0.0500 indicate model terms are significant. Analysis of variance showed that F-values for linear terms is 6.52, 13.20 and 9.48 at P Value of 0.0220, 0.0024 and 0.0076 respectively, showing that the CD and square term of D are the significant terms (p<0.05).

Table 4: ANOVA effect on different process variables on overall acceptability of dragon fruit leather

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	5.67	14.0	0.40	**3.32**	0.01	**Significant**
A-Sugar	0.21	1.0	0.21	1.76	0.20	
B-Peel	0.11	1.0	0.11	0.95	0.33	
C-Temperature	0.11	1.0	0.11	0.93	0.35	
D-Thickness	0.38	1.0	0.38	3.13	0.09	
AB	0.04	1.0	0.04	0.38	0.54	
AC	6.25	1.0	6.25	5.13	0.99	
AD	0.007	1.0	0.007	0.06	0.80	
BC	0.001	1.0	0.001	0.008	0.92	
BD	0.33	1.0	0.33	2.78	0.11	
CD	0.001	1.0	0.001	0.008	0.92	
A^2	0.12	1.0	0.12	0.99	0.33	
B^2	0.39	1.0	0.39	3.25	0.09	
C^2	1.65	1.0	1.65	13.53	0.002	
D^2	3.31	1.0	3.31	27.21	0.0001	
Complete Model						
Residual	1.82	15	0.12			
Lack of Fit	1.82	10	0.18			
Pure Error	0	5	0			
Total	7.50	29				
R2	0.75	Adeq. Precision			6.65	
Adj R^2	0.52					

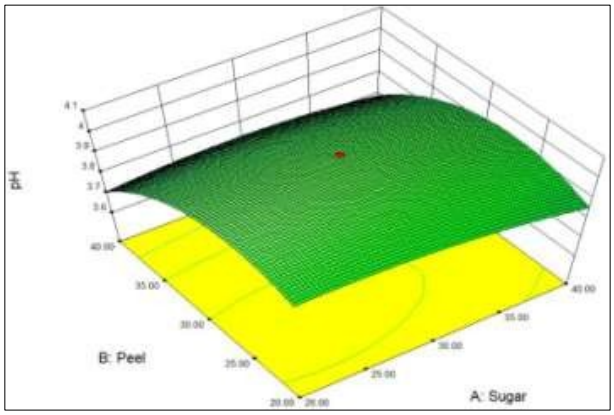

Fig 4: Variation of pH with respect to sugar and peel in dragon fruit leather

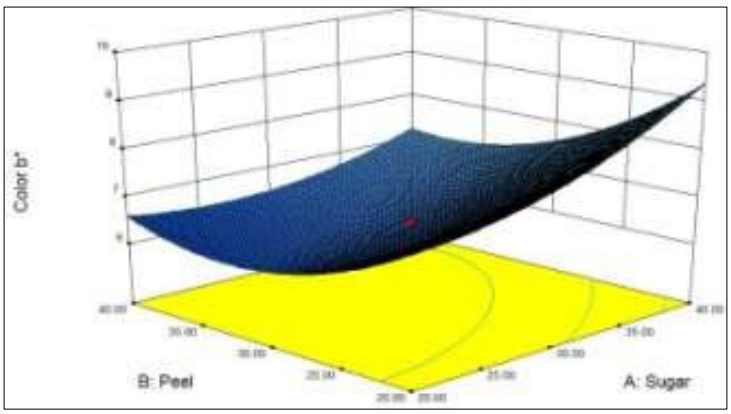

Fig 5: Variation of color value (b*) with respect to sugar and peel in dragon fruit leather

It may be seen from Fig. 5 that the increase in sugar content may increase in color value b* and the increase in peel in dragon fruit leather may decrease in color value b* of the product.

Table 5: ANOVA effect on different process variables on pH of dragon fruit leather

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	2.64	14.0	0.18	**3.07**	0.01	**Significant**
A-Sugar	0.02	1.0	0.02	0.43	0.52	
B-Peel	0.28	1.0	0.28	4.57	0.04	
C-Temperature	0.16	1.0	0.16	2.70	0.12	
D-Thickness	0.16	1.0	0.16	2.70	0.12	
AB	0.01	1.0	0.01	0.16	0.69	
AC	0.01	1.0	0.01	0.16	0.69	
AD	0.16	1.0	0.16	2.59	0.12	
BC	0.01	1.0	0.01	0.16	0.69	
BD	0.64	1.0	0.64	10.38	0.005	
CD	0.49	1.0	0.49	7.95	0.01	
A^2	0.04	1.0	0.04	0.69	0.41	
B^2	0.63	1.0	0.63	10.29	0.005	
C^2	0.04	1.0	0.04	0.69	0.41	
D^2	0.002	1.0	0.002	0.04	0.82	
Complete Model						
Residual	0.92	15	0.06			
Lack of Fit	0.92	10	0.09			
Pure Error	0	5	0			
Total	3.57	29				
R2	0.74	Adeq. Precision			7.97	
Adj R^2	0.50					

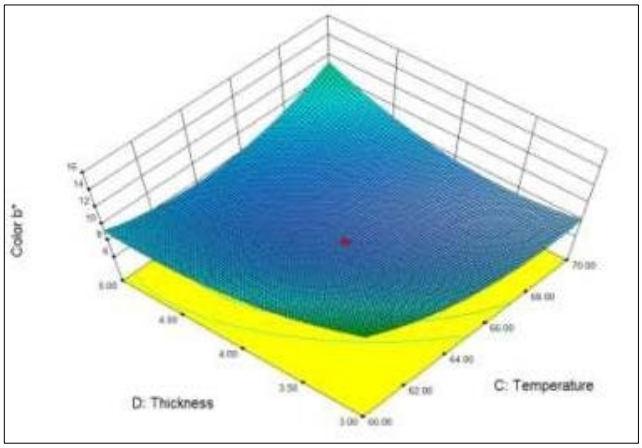

Fig 6: Variation of color value b* with respect to temperature and thickness in dragon fruit leather

It may be seen from Fig. 6 that the increase in temperature and thickness in dragon fruit leather may increase in color value b* of the product.

Table 6: ANOVA effect on different process variables on color value (b*) of dragon fruit leather

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	
Model	446.07	14.0	31.86	2.62	0.03	**Significant**
A-Sugar	10.68	1.0	10.68	0.87	0.36	
B-Peel	12.57	1.0	12.57	1.03	0.32	
C-Temperature	33.39	1.0	33.39	2.74	0.11	
D-Thickness	6.64	1.0	6.64	0.54	0.47	
AB	1.91	1.0	1.91	0.15	0.69	
AC	14.76	1.0	14.76	1.21	0.28	
AD	8.39	1.0	8.39	0.69	0.41	
BC	23.25	1.0	23.25	1.91	0.18	
BD	11.20	1.0	11.20	0.92	0.35	
CD	79.34	1.0	79.34	6.52	0.02	
A^2	4.61	1.0	4.61	0.38	0.54	
B^2	15.96	1.0	15.96	1.31	0.26	
C^2	160.50	1.0	160.50	13.20	0.002	
D^2	115.30	1.0	115.30	9.48	0.007	
Complete Model						
Residual	182.27	15	12.15			
Lack of Fit	182.27	10	18.22			
Pure Error	0	5	0			
Total	628.34	29				
R2	0.70	Adeq. Precision			6.10	
Adj R^2	0.43					

3.3. Optimization for prediction of process parameters for developed dragon fruit leather

Optimization of process parameters was done using Design Expert 8.0.7.1 software. Numerical optimization was carried out by putting the values of process parameters within the experimental range and by setting desirable goals for the responses. Optimization of process parameters for the preparation of dragon fruit leather by tray drying techniques was performed on the basis of its dominant quality attributes such as overall acceptability and vitamin C.

The optimum range of process parameters for tray-dried dragon fruit leather was found as: Sugar-40.0 g/100g, peel-20.0 g/100g, temperature-60.0 °C and thickness-5mm. Corresponding to optimum values of process parameters, predicted values of responses were found as organoleptic

scores in terms of overall acceptability (7.59) and Vitamin-C (21.10 mg/100 g) having desirability (0.62).

4. Conclusions

On the basis of the results obtained, it may be concluded that the prepared dragon fruit leather having the formulation of peel: sugar: temperature: thickness was found as 20%: 40%: 60 ºC: 5 mm, respectively, which is extremely useful for satisfying consumer tastes and preference and optimized sample having Vitamin C of 21.1 mg/100 g and Overall acceptability of 7.59.

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