Evaluation of Physicochemical Properties of Refractance Window Dried Indian Jujube Pulp

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Abstract—*Refractance Window (RW) drying process was classified in the fourth generation of drying methods. This process uses hot water as the source of heat and the temperature of water can be controlled as per requirement. RW drying process uses 50–70 % less cost and more than 50 % less energy than the freeze-drying process when the drying capacity is kept the same. RW drying system utilizes circulating water at 95 to 97 °C as a means to carry thermal energy to materials to be dehydrated. The present study was focused on the evaluation of physicochemical properties such as moisture, density, solubility, Browning Index, color, Ascorbic acid content and total antioxidant activity of the RW dried Indian Jujube powder. The results were also compared with the physicochemical properties of Jujube powder dried by other techniques available on literature. The study revealed that the properties of RW dried powder are better than other drying methods, The RW dried Jujube powder can be used to enrich the Anganwadi food.*

1. INTRODUCTION

Refractance Window (RW) is a novel film drying technique and it is characterized by maintaining a relatively low temperature inside the food and by requiring shorter process times [1]. To dry a similar amount of product, the cost of the RW equipment is about one-third of the cost of a freeze-dryer (FD); while energy consumption of RW is less than half of the energy consumption for a FD [2]. RW drying system uses circulating water at 95 to 97°C as a means to convey thermal energy to materials to be dehydrated. As the product does not have direct contact with the heat transfer medium during RW drying, no cross-contamination occurs [3]. A RW dryer can preserve color [4], heat sensitive vitamins and phytochemicals. RW has been used for processing fruit and vegetable pulps in order to obtain dried powders, with results that indicate good retention of natural compounds [5]. The Indian jujube commonly known as Ber, Desert apple and Indian pulm in India. Jujube is generally recognized as an outstanding source of biologically active compounds related to both nutritional and nutraceutical values. Dried jujube fruits have been commonly utilized as food, food additive, and flavouring for thousands of years due to their high nutritional value. The nutritional composition of Indian jujube is shown in table 1.

Table 1: Nutritional composition of Indian jujube fruit (on fresh weight basis)

Constituents	Amount per (100 g)
Moisture	81.6-83.0
Protein (g)	0.8
Fat (g)	0.07
Fiber (g)	0.60
Carbohydrate (g)	17.0
Total Sugar (g)	5.4-10.5
Reducing Sugar (g)	1.4-6.2
Non-Reducing Sugar (g)	3.2-8.0
Ash (g)	0.3-0.59
Calcium (mg)	25.6
Phosphorus (mg)	26.8
Iron (mg)	0.76-1.8
Carotene (mg)	0.0021
Thiamine (mg)	0.02-0.024
Riboflavin (mg)	0.02-0.038
Niacin (mg)	0.7-0.873
Citric acid (mg)	0.2-1.1
Ascorbic acid (mg)	65.8-76.0
Fluoride (ppm)	0.1-0.2
Pectin (% dry basis)	2.2-3.4

Source: (Morton, 1987; Pareek and Dhaka, 2008; Pareek et al., 2009)

2. MATERIALS AND METHODS

Raw materials

Indian jujube fruits will be collected from the local market of Kanpur Uttar Pradesh in March 2019. Dried the jujube pulp by using RW drying technique at different temperature and different pulp thickness. The chemicals used for the analysis were of analytical grade.

Determination of drying time

Moisture content of the dried jujube powder samples was determined using oven method (103±1°C) according to the approved method of Association of Official Analytical Chemists (AOAC, 2002).

Determination of Bulk density, Tapped density and True density of Powder

Bulk density

Pass a quantity of powder sufficient to complete the test through a sieve with apertures greater than or equal to 1.0 mm, if necessary, to break up agglomerates that may have formed during storage; this must be done gently to avoid changing the nature of the material. Into a dry graduated cylinder of 25 ml, gently introduce, without compacting, approximately 16 g of the test sample (m) weighed with 0.1% accuracy. Carefully level the powder without compacting, if necessary, and read the unsettled apparent volume ($V0$) to the nearest graduated unit. Calculate the bulk density in (g/ml) using the formula $m/V0$. Generally, replicate determinations are desirable for the determination of this property.

Tapped density

A 25 ml graduated cylinder with a mass of 15 ± 5 g; and settling apparatus capable of producing, in 1 minute, either nominally 250 ± 15 taps from a height of 3 ± 0.2 mm, or nominally 300 ± 15 taps from a height of 14 ± 2 mm. Calculate the tapped density (g/ml) using the formula m/Vf in which Vf is the final tapped volume. Generally, replicate determinations are desirable for the determination of this property. Specify the drop height with the results.

True density

Take 10ml petroleum ether in 25ml measuring cylinder and added 1gm of optimized sample, freeze dried and tray dried sample separately, volume increases and note down the reading. Performed the experiment in triplicate and calculate the true density (g/ml) using the formula m/V in which V is the final true volume.

Determination of Powder Solubility

In conformity with Estman and Moore's method, the optimized powder sample (1g db) was mixed into 100mL distilled water and milk in a digital stirrer at high velocity (1,000 rpm) for 5 min. The moisture content of the powder samples was about 4 - 5% (db); as a result, 1.04 g powder was added to 100mL distilled water and milk separately. This solution was transferred to some experimental centrifuge tubes and centrifuged at 3,000 rpm for 5 min and was allowed to settle completely for 30 min. An aliquot of 25mL of the supernatant was transferred to pre-weighed Petri dishes and immediately oven-dried at 105°C for 5 hours. The solubility was calculated by the difference in weight in accordance with the following equation:

$$\text{Solubility} = \frac{(m_{sp} - m_p)\times(100/25)}{m_{i,db}}$$

Where:

- m_{sp} Mass of Petri dishes and initial samples (g)
- m_p Mass of Petri dishes (g)
- $m_{i,db}$ Dry mass of sample (g)

Determination of Browning Index

Colour change was measured by using Hunter lab colorimeter (Minolta, Japan) as L, a, b[7]Browning index is calculated as:

$$\boldsymbol{BI} = \frac{[\mathbf{100}(\boldsymbol{x} - \mathbf{0.31})]}{\mathbf{0.172}}$$

Where

$$x = (a + 1.75L)/(5.645L + a - 0.3012b).$$

Colour Analysis

Colour changes in dried jujube powder were analysed 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. Calibration against a standard white tile occurred immediately prior to each set of three readings. In addition, total colour change index (ΔE) was calculated as described by [8]:

$$\Delta E = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2}$$

Where: L_o, a_o and b_o are initial values of fresh samples and L, a and b are color values of dried samples.

Estimation of Total Antioxidant Activity:-

Total antioxidant activity of the dehydrated jujube pulp was measured by the DPPH method. The antioxidant activity is measured according to [9] as the percentage inhibition of DPPH and then calculated according to the following equation:

$$\%\text{inhibition of DPPH} = \frac{(A_c - A_s)}{A_c} * 100$$

3. RESULTS AND DISCUSSION

Moisture Content

Moisture content of the RW dried jujube powder is displayed in Table 2. The moisture percentage is relatively low as compared to Hot-air dried Chinese jujube [10].

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Table 2: Moisture content of RW dried Indian Jujube powder

Sample	Moisture content (in %)
S1	4.23±0.11
S2	5.55±0.12
S3	5.49±0.08
S4	5.84±0.10
S5	5.45±0.15
S6	4.63±0.16
S7	4.65±0.07
S8	5.59±0.64
S9	5.33±0.05
S10	5.33±0.05
S11	5.33±0.05
S12	5.33±0.05
S13	5.33±0.05

Density

Bulk, Tapped and True density of the RW dried jujube powder is shown in Table 3. The density of RW dried jujube powder is relatively more as compared to Hot-air dried Chinese jujube [10].

Bulk, Tapped and True density

Table 3: Bulk, Tapped and True Density of RW dried Indian Jujube powder

S. No.	Bulk density	Tapped Density	True density
1	617.2	626.2	2000
2	615.1	618.4	2000
3	599.6	622.5	2000
4	607.2	628.8	
5	611.2	628.6	
6	596.4	624.4	
7	598.4	619.6	
8	612.8	620.8	
9	615.2	625.2	
10	604.4	618.4	
Average	607.75	623.29	2000
Standard deviation	7.676985809	3.946432989	0

Solubility

The solubility of RW dried jujube powder in milk is more as compared to water and the solubility of RW dried Indian Jujube powder in Milk and Water is shown in Table 4.

Table 4. Solubility of RW dried Indian Jujube powder in Milk and Water

RW dried powder	Solubility (in %)
In Milk	16.08
In Water	0.76

Browning Index

The browning index of the RW dried jujube pulp is presented in the Table 5. The browning index of the RW dried jujube pulp is relatively low as compared to Air-drying, Vacuum drying and Freeze drying [11].

Table 5: Browning Index of RW dried Indian Jujube powder

Sample	Browning index
S1	25.73777
S2	20.29964
S3	13.83933
S4	10.81723
S5	18.38744
S6	6.093093
S7	9.082934
S8	10.60258
S9	9.635931
S10	9.635931
S11	9.635931
S12	9.635931
S13	9.635931

Color

The value of Hunter L, a and b of RW dried jujube powder is shown in Table 6. and result revealed the better color property as compared to Air-drying, Vacuum drying and Freeze drying [11].

Table 6. Color (L^*, a^*, b^* value) of RW dried Indian Jujube powder

Sample	L^*	a^*	b^*
S1	40.25432	11.9313509	22.051564
S2	48.04082	11.4539158	18.895552
S3	49.76767	7.16502795	19.01258
S4	49.35783	5.26229503	16.655066
S5	53.93303	11.7211713	18.553462
S6	55.67888	3.13102939	12.054426
S7	53.76566	4.82542036	15.138455
S8	50.93866	5.16792905	17.900111
S9	60.12508	5.67677087	18.292824
S10	60.12508	5.67677087	18.292824
S11	60.12508	5.67677087	18.292824
S12	60.12508	5.67677087	18.292824
S13	60.12508	5.67677087	18.292824

Ascorbic Acid Content

In this study, the content of vitamin C in fresh jujube is about 2,019.89 mg/100 g dry basis (d.b.) under the condition of the water content of fresh jujube is 79.71 %.While the vitamin C content of jujube powder made by short- and medium-wave infrared drying was about 450 mg/100 g d.b [12]. Infrared dried jujube powder has high retention of vitamin C as compared to RW dried jujube powder but in Hot – air dried jujube powder has less vitamin C than RW died powder. Ascorbic acid content of RW dried Indian Jujube powder is shown in Table 7.

Table 7: Ascorbic Acid Content of RW dried Indian Jujube powder

Sample	Vitamin C (mg/100g)
S1	343
S2	215.6
S3	127.4
S4	117.6
S5	156.8

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S6	156.8
S7	176.4
S8	166.6
S9	107.8
S10	107.8
S11	107.8
S12	107.8
S13	107.8

Total Antioxidant Activity

RW dried jujube powder has a more Total antioxidant activity as compared to Freeze, Microwave, Oven and Sun drying [13]. Total Antioxidant Activity of RW dried Indian Jujube powder is shown in Table 8.

Table 8. Total Antioxidant Activity of RW dried Indian Jujube powder

Sample	TPC (mg/100g)
S1	0.0637
S2	0.0637
S3	0.0641
S4	0.0665
S5	0.0647
S6	0.0662
S7	0.0528
S8	0.0518
S9	0.0517
S10	0.0517
S11	0.0517
S12	0.0517
S13	0.0517

Conclusion

The present work conclude that the physicochemical properties such as Moisture, Density, Solubility, Browning index, Color, Ascorbic acid content and Total antioxidant activity of the RW dried Indian Jujube powder has better retention as compared with the physicochemical properties of Jujube powder dried by other techniques available on literature. The study revealed that the properties of RW dried powder are better than other drying methods, The RW dried Jujube powder can be used to enrich the Anganwadi food.

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