Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
https://www.phytojournal.com
JPP 2023; 12(6): 223-226
Received: 09-08-2023
Accepted: 19-09-2023

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Studies on physicochemical and nutritional properties of dragon fruit (*Hylocereus polyrhizus*)

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DOI: https://doi.org/10.22271/phyto.2023.v12.i6c.14785

Abstract
Physical properties of fruit generally aid in further processing. Several parameters related to the physicochemical and nutritional properties of dragon fruit, such as, fruit weight (394.46 g) length, diameter, pulp weight, edible index (72.45%) and inedible index (27.55) was evaluated. Moisture content (86.32%), total soluble solids (TSS), extract yield, pH, color, antioxidant activity, viscosity, ascorbic acid, titratable acidity, betacyanin and minerals were also measured. Extract yield is an important parameter in economic point of view as it will affect production cost and final product cost which was found (68.15%). Dragon fruit is rich source total phenols, ascorbic acid, bioactive compounds like betacyanin (14.41 mg/100 g) and minerals which act as antioxidant, boost the formation of beneficial gut flora and helps to prevent cardiovascular disease and keeps blood pressure in control. Thus, dragon fruit was found better edible index, extract yield and rich in bioactive compounds.

Keywords: Dragon fruit, antioxidant activity, ascorbic acid, TSS, viscosity, Betacyanin

Introduction
Dragon fruit is part of the Cactaceae family and order of Caryophyllales (Rebecca *et al.*, 2010) [17]. In early 19th century, the French brought it to Southeast Asia. More than 93% of the world's dragon fruit production is produced by three major countries: Vietnam, China, and Indonesia (Chen and Paull, 2018) [2]. *Hylocereus polyrhizus* (red flesh with red peel dragon fruit), *Selenicereus megalathus* (white flesh with yellow peel dragon fruit) and *Hylocereus undatus* (white flesh with red peel dragon fruit) are the three different species of dragon fruit. Pulp (47.40-73.76%), peel (36.70-37.60%), and seed (2.70-14.67%) make up the three main components of dragon fruit (. The fruits of the red dragon (*Hylocereus polyrhizus*) have a huge rectangular form, a dark red peel with enormous scales and a crimson pulp with small black seeds inside (De Mello, 2014) [4].

The color of *H. polyrhizus* is contributed by betacyanin a compound from a set of water-soluble nitrogen containing pigments known as betalains (Rebecca *et al*., 2010) [17]. Betalains play a vital role as the major antioxidant contributor in *H. polyrhizus* whereas non-betalainic phenolic compounds play a minor role (Esquivel *et al*., 2007) [6]. Betacyanin was found to boost the formation of beneficial gut flora in dragon fruit (Liaotrakoon, 2013) [14]. It is low in calories, cholesterol-free and high in antioxidants. It helps to prevent cardiovascular disease and keeps blood pressure in check (Patel and Ishnava, 2019) [22].

Dragon fruit can be used to make a variety of processed products, including RTS (ready to serve) beverage, jam, jelly, juice, nectar, squash, cordial smoothies and more, all of which have delicious flavors and essences. The physicochemical properties of food help in enhancing final products of dragon fruit. Its luscious pulp can also be used to make soft drinks. It encourages the formation of probiotics which aids digestion. It aids in the reduction of blood glucose levels in people with type 2 diabetes (Patel and Ishnava, 2019) [22]. Consumers are demanding nature identical values added food products having increased awareness in health issues leads to increase the consumption of fruit juices and other natural products as an alternate to the traditional caffeine containing beverages such as tea, coffee or other soft drinks. Accompanying the increase in quantity of consumption, there has been a parallel increase in the variety of fruit juices and beverages offered for sale in the market (Gargani *et al*., 1987) [7]

Materials and Methods
The present investigation was carried out in College of Food Processing Technology and Bioenergy, Anand Agricultural University Anand Gujarat, India.

The dragon fruits (*Hylocereus polyrhizus*) uniform, ripened were procured from R K farm and Nursery, Nakhatrana, Dist. Kutch-Bhuj Gujarat. The selected and sorted dragon fruits were washed with tap water to remove soil and dust particles. Ten number of dragon fruits were selected for determining physical properties of fruit. Afterwards, the fruits were cut into half, peel was removed manually and small pieces were made by using stainless steel Kinfe. After cutting operation thick mass of pulp was passed through stainless steel sieve to remove seeds and then proximate composition and nutritional analysis were carried out.

Physical and morphological properties of fruits

Physical and morphological characters of 10 evenly ripened fruit, randomly chosen after harvesting were studied.

Weight of fruit and pulp and peel

Randomly ten fruits from each replication are selected and weighted in electronic balance. The average weight of ten fruits followed by peel weight as well as pulp were calculated and noted.

Length and diameter of fruit

Randomly selected ten fruits were measured individually for length by using vernier caliper at the middle of die fruit. The average length was expressed in millimeters.

Edible index

The per cent yield of pulp is calculated on the basis of weights of pulp after peeling.

$$\text{Pulp } (\%) = \frac{\text{Weight of pulp}}{\text{Weight of fruit}} \times 100$$

Inedible index

Waste index was calculated by given formula:

$$\text{Waste index } (\%) = \frac{\text{Weight of fruit} - \text{weight pf pulp}}{\text{Weight of fruit}} \times 100$$

Biochemical and nutritional properties

Chemical properties namely moisture content, crude fat, crude protein, crude fiber, ash and total carbohydrate were analyzed as per method described in AOAC (2012) [1]. Titratable acidity, pH, total soluble solids were analyzed as per method described in Ranganna (1986) [18]. Nutritional analysis namely ascorbic acid content was analyzed as per method described in Ranganna (1986) [18]. The methods of analysis were briefly explained. Three replications were made and the average values were reported.

Proximate analysis

Moisture content

Gravimetric method was used for determination of moisture (AOAC, 2005) [1]. Moisture was estimated by drying the weighed sample (5 g) to a constant weight in laboratory hot air oven at 105 °C. The dried sample was then cooled to room temperature in desiccators prior to weighing. The per cent moisture content was calculated as follows:

$$\text{Moisture content } (\% \text{ w.b.}) = \frac{w_1 - w_2}{w_1} \times 100$$

Where,
W1= Initial weight of sample (g)
W2= Weight of sample after drying (g)

Titratable acidity as per cent citric acid

Five to ten grams of sample was taken, mixed with 200 ml of distilled water and transferred to a 250 ml volumetric flask. Hundred milliliters of that aliquot were taken in conical flask and titrated with 0.1 N NaOH using phenolphthalein as indicator. The percentage titratable acidity was calculated by formula given (Ranganna, 1986) [18].

$$\text{Titratable acidity } (\%) = \frac{T \times N \times V \times E}{Aliquote\ volume} \times 1000$$

Where,
T = Titre value (ml)
N = Normality of NaOH
V = Volume made up (ml)
E = Equivalent weight of citric acid

Viscosity

The viscosity of juice was determined by Brookfield viscometer by using needle number 63 of DV-11 plus pro model (Plate 3.8) at 60 rpm (25 °C) and measured in cP.

Color value

The color value of dragon fruit pulp was measured by Lovibond colorimeter (Model RT85i) in terms of L*(Lightness), a*(redness and greenness) and b* values (yellowness and blueness). The instrument was calibrated with white and black standard.

Mineral composition

The mineral composition of dragon fruit pulp was estimated using Inductive Coupe Plasma-Optical Emission Spectrometry (ICP-OES) (Make: Perkin Elmer, US, Optima 7000 DV Model). (Ranganna, 2007) [19].

Nutritional analysis

Ascorbic acid

Ascorbic acid of the samples was estimated using 2, 6-dichlorophenol-indophenol by titration method (Ranganna, 1986) [18].

$$\text{Ascorbic acid (mg/ 100 g)} = \frac{T \times D \times V \times 100}{A \times V}$$

Where,
T = Titre value
D = Dye factor
V = Volume made up
A = Aliquot of extract taken for estimation
W = Weight or volume of sample taken for estimation

Total phenol content

The concentration of total phenolic compounds was determined using Folin-Ciocalteu reagent (Kunika and Pranee, 2011) [13] with slight modification.

Antioxidant activity

Antioxidant activity of dragon fruit pulp was determined using the DPPH scavenging effect method as described by Joshi *et al*., (2019). The antioxidant activity of dragon fruit pulp was calculated by the following formula:

$$\text{Antioxidant activity (\%)} = \frac{AB - AA}{AA} \times 100$$

Where,
AB = Absorbance of blank
AA= Absorbance of sample

Total betacyanin content: Total betacyanin content of dragon fruit pulp was obtained from Rebeca *et al*., (2010) [17] with some modifications. Total betacyanin was expressed as mg betanin equivalent per 100 g of sample weight.

$$TBc = \frac{Abs \times D.F. \times MW}{\in \times Lc} \times 100$$

Where.
Abs = Absorbance
D.F. = Dilution factor
M.W. = Betanin (550 g/mol)
∈ =Molar extinction coefficient of batanin water (60000 I/mol. cm)
Lc = Path length of cuvette (1 cm)

Results and Discussion

Physical characteristics of dragon fruit

The findings of the physical characteristics of fresh dragon fruit, including fruit weight, length, diameter, pulp weight, peel weight, pulp to peel ratio, edible index and inedible index are shown in Table 1.

Table 1: Physical characteristics of dragon fruit

Parameters	Mean value ± SD
Fruit weight (g)	394.46 ± 2.25
Length (mm)	121.40 ± 1.63
Diameter (mm)	62.00 ± 0.57
Weight of pulp (g)	285.81 ± 1.79
Weight of peel (g)	109.17 ± 0.72
Pulp to peel ratio	2.61 ± 0.02
Edible index (%)	72.45 ± 0.32
Inedible index (%)	27.55 ± 0.25

Physical properties of fruit could aid in further processing. Data from Table 1 revealed that the mean weight of dragon fruit was 394.46 g, mean length of fruit 121.40 mm, mean diameter of fruit was 62 mm, mean weight of pulp is 285.81 g, mean weight of peel was 109.17 g, pulp to peel ratio was observed 2.61, edible index 72.45% and inedible index was 27.55%. The results obtained were in accordance with physical characteristics of dragon fruit reported independently by Dansena (2023) [3] and Sharma (2016) [20].

Proximate composition of dragon fruit pulp

The perishability and suitability of fruit for product preparation is depend on its chemical properties. The proximate composition of ripe fruits of variety *Hylocereus polyrhizus* was studied and results are depicted in Table 2

Table 2: Proximate composition of dragon fruit pulp

Parameters	Mean value ± SD
Moisture content (%) (wb)	86.32 ± 0.60
Fat (%)	0.27 ± 0.02
Protein (%)	1.17 ± 0.06
Crude fiber (%)	1.24 ± 0.08
Ash (%)	0.45 ± 0.02
Carbohydrate (%)	11.79 ± 0.57

The moisture content, fat, protein, crude fiber, ash and carbohydrate content of dragon fruit pulp was found to be 86.32%, 0.27%, 1.17%, 1.24%, 0.45% and 11.79% respectively. These findings of proximate composition of dragon fruit were in accordance with observations reported independently by Kakde *et al*. (2020) [12] and Madhuri (2017) [15].

Chemical composition of dragon fruit pulp

Chemical composition of fruit indicates the extent of shelf life of fruit and convenience for specific product development and formulation and chemical analysis. The chemical parameters of raw fruit *viz*. TSS, pH, ascorbic acid, betacyanin, titratable acidity, total phenols, antioxidant activity, viscosity, yield and minerals were determined and result obtained were presented in Table 3. The data depicted in Table 3 reveals TSS of any fruit is an important parameter of its quality and denotes the amount of soluble solids in liquids. TSS content of dragon fruit pulp found was 11.43°Bx. Present finding is in close agreement with observation noted independently by Islam *et al*. (2012) [8] and Sharma (2016) [20]. The pH of dragon fruit pulp was 4.58. Similar observation of pH was reported by Mariana *et al*. (2021) [16] i.e. 4.77 for red variety and 4.24 for white variety of dragon fruit.

Table 3: Chemical composition of dragon fruit pulp

Parameters	Mean value ± SD
TSS (°Bx)	11.43 ± 0.03
pH	4.58 ± 0.01
Ascorbic acid (mg/100 g)	21.40 ± 0.32
Betacyanin (mg/100 g)	14.41 ± 0.36
Titratable acidity (%)	0.42 ± 0.01
Total phenolic content (mg GAE/100 g)	19.01 ± 1.45
Antioxidant activity (% DPPH inhibition)	62.37 ± 1.01
Viscosity (cP)	6.41 ± 0.01
Yield (%)	68.15 ± 0.85
Phosphorus (mg/100 g)	22.56 ± 0.80
Calcium (mg/100 g)	8.51 ± 0.10
Iron (mg/100 g)	2.06 ± 0.07
Color L*	21.10 ± 0.18
a*	6.13 ± 0.25
b*	0.66 ± 0.01

The mean ascorbic acid value of dragon fruit pulp observed was 21.4 mg/100 g. Similar results were noted for ascorbic acid independently by Madhuri 2017 [15] and Liaotrakoon *et al*. (2013) [14]. Betacyanin is the important bioactive compound present in flesh and peel of dragon fruit and acts as important coloring factor in the fruit. Its concentration in pulp found to be 14.41 mg/100 g. The results obtained was in accordance with the findings of Kunika and Pranee (2011) [13], who reported betacyanin in dragon fruit flesh 15.53 and peel 14.27 mg/100 g, respectively. The titratable acidity measures the total concentrations total acids in food. Titratable acidity of dragon fruit pulp observed was 0.42%. The reported findings are more or less similar to independent findings reported by Sharma (2016) [20] and Islam *et al*. (2012) [8].

Fruits are the main source of the photochemical polyphenols, which are the most prevalent in our diets (Jimenez *et al*., 2001) [10]. Total phenolic content (TPC) and antioxidant activity of dragon fruit pulp found were 19.01 mg GAE/100 g and 62.37%, respectively. Woo *et al*. (2011) [21] reported higher TPC i.e. 24.22 ± 0.95 mg GAE/100 g for pulp. This difference in TPC may most likely due to variations in growth due to environmental conditions as well as difference in maturation stage dragon fruit. Results for TPC and antioxidant activity of dragon fruit pulp in present studies are in close agreement with results concluded by Ezzah *et al*. (2019) [5].

Viscosity of dragon fruit pulp found was 6.41 cP. Jiang *et al*. (2020) [9] reported viscosity of red dragon fruit pulp 9.4 cP. Different varieties, geographic conditions and cultivation techniques could account for the viscosity difference. The pulp yield obtained was 68.15%.

Minerals are the vital components of food substances. They are the integral parts of the hormones and enzymes and other bioactive compounds. The phosphorus, calcium and iron content of dragon fruit pulp was 22.56 mg/100 g, 8.51 mg/100 g and 2.06 mg/100 g, respectively. The present findings are also in close agreement with findings independently reported by Kakde *et al*. (2020) [12] and Madhuri (2017) [15].

The appearance of fruit is the deciding factor in the consumer acceptability. The color values L*, a* and b* of dragon fruit pulp was found to be 21.10, 6.13 and 0.66, respectively. Similar results for color analysis were reported independently by Mariana *et al.* (2021) [16] and Wu *et al*. (2019) [23].

Conclusion

The result showed that dragon fruit weight was 394.46 g, edible index (72.45%) and inedible index was observed 27.55%. Moisture content, extract yield and betacyanin were found 86.32%, 68.15% and 14.41 mg/100 g respectively. Thus dragon fruit has potential to process into value added products as it has more edible index, extract yield and also rich in bioactive compounds.

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