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A comparative analysis of red and white dragon fruit pulp and juice characteristics

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Abstract

To ascertain their potential applications in the food industry, dragon fruit varieties, namely *H. undatus* and *H. polyrhizus*, were thoroughly analyzed for their physical, nutritional, and phytochemical properties. The focus was on pulp and juice, emphasizing color, mineral content, proximate analysis, and phytochemical constituents. Red flesh dragon fruit displayed a bright pink color, a slightly smaller length (9.1 cm), and a larger diameter (8.3 cm) compared to white flesh dragon fruit (9.9 cm length, 7.53 cm diameter). Red flesh dragon fruit also exhibited higher circumference and weight. White flesh dragon fruit demonstrated superior juice yield (36.23 %) compared to red flesh dragon fruit (35.28 %). Red flesh dragon fruit had higher levels of total sugar (8.45 %), protein (1.36 %), and ascorbic acid (19.83 mg/100g) in its pulp. It also showed elevated mineral content of calcium, magnesium, and phosphorus. Conversely, white flesh dragon fruit had higher fat content (0.65 %) and carbohydrate content (9.76 %) in its pulp. White flesh dragon fruit displayed brighter color characteristics with higher L*, a*, and b* values. Phytochemical analysis revealed the presence of betacyanin in red flesh dragon fruit (30.87 mg/100g) but not in white flesh dragon fruit. Red flesh dragon fruit exhibited significantly higher total phenolic content in pulp (49.67 mg GA/100g) and juice (41.25 mg GA/100g) than white flesh dragon fruit. These findings highlight substantial differences ($P < 0.05$) between red and white flesh dragon fruit in physical, nutritional, and phytochemical aspects, offering valuable insights for their incorporation into diverse food products, such as beverages and ice cream.

Key words: Dragon fruit, betacyanin, total phenolic content, pulp, juice

Introduction

Dragon fruit (*Hylocereus* spp.), a tropical fruit thriving in Southeast Asia, Central America, and South America, has gained global cultivation due to burgeoning commercial interest (Luu *et al*., 2021). Despite its worldwide popularity, global dragon fruit production, at 21,00,777 metric tons, sees India contributing a modest 1 % (12,200 MT), with Gujarat emerging as a significant producer (Mahesh *et al*., 2021). Renowned for its adaptability to diverse environmental conditions, dragon fruit stands out for its drought resistance, tolerance to varying soil salinities, and numerous health benefits.

The five primary *Hylocereus* species exhibit distinct fruit traits, with pulp and skin color variations. For instance, *Hylocereus costaricencis* boasts violet-red pulp and pink skin, while *Hylocereus undatus* features white-pulped fruits with pink skin. Other varieties, like *H. polyrhizus* and *H. costaricensis*, are recognized for scarlet fruits and vigorous vines with scarlet ovoid fruit, respectively (Perween *et al*., 2018). Dragon fruit, considered a "superfood," typically yields 40 to 100 fruits per wave on one pole, weighing 300 to 800 grams each, and is available year-round.

Notable for its nutrient-rich composition, encompassing proteins, fats, carbohydrates, fiber, vitamins, minerals, and bioactive compounds, dragon fruit has garnered attention for its potential medicinal properties. Rich in bioactive compounds like betalains, flavonoids, and polyphenols, it exhibits varied phenolic content among clones, with red pulp clones surpassing white pulp clones. Recognized for health benefits, including antioxidant properties, immune system enhancement, and potential in diabetes management, dragon fruit is particularly rich in Vitamin C.

The fruit's bioactive compounds contribute to antimicrobial and antiproliferative properties, with studies exploring its potential in wound healing, asthma, and cough relief (Luu *et al*., 2021; Mahesh *et al*., 2021). Dragon fruit's versatility extends to various products such as juices, jams, jellies, candies, syrups, wines, and ready-to-serve beverages blended with other fruit juices and ice cream (Kakade *et al*., 2020; Rathinasamy *et al*., 2021).

Materials and methods

Sample collection: The dragon fruits from red and white varieties were procured from the dragon fruit farm at Pedgaon, Dist. Parbhani, Maharashtra, India. Ensuring uniform ripeness and absence of visible defects, fruits were randomly selected for analysis.

Physical properties: The physical properties of dragon fruits, including weight, length, width, thickness, shape, colour, edible index, waste index, and juice yield, were measured, while colour was assessed using the Hunter Lab Colour Flex meter by the method given by Jambamma *et al.* (2011).

Chemical properties: Total soluble solids (T.S.S.) were assessed through refractometry, yielding the sugar content in dragon fruit in °Brix. The pH of dragon fruit pulp and juice was determined using a calibrated digital pH meter. Titrable acidity, reducing sugar content, and total sugar content were estimated following Ranganna's methodologies (2007), while ascorbic acid levels were determined using the AOAC method (2005).

Proximate analysis: The moisture, ash and carbohydrate content of dragon fruit's juice and pulp were analyzed by AOAC (2005) methods while protein, fat and crude fibre were determined by AACC (2000) method.

Phytochemical analysis: The total betacyanin content was determined using a colourimetric method as described by Rebecca *et al.* (2008) and Stintzing *et al.* (2003). The total phenolic content was determined as outlined by Lim *et al*. (2007).

Mineral analysis: The preparation of the mineral solution adhered to Ranganna's procedures (2007). Iron content was determined utilizing the a-a, dipyridyl method, employing a standard curve for quantification as per AOAC (2005). Magnesium estimation employed a colorimetric method described by Ranganna (2007), while potassium determination utilized flame photometry following digestion with HClO4 and HNO3, as outlined by Ranganna (2007).

Statistical analysis: Unless otherwise specified, all analyses were done in triplicate. Statistical significance was established using one-way analysis of variance (ANOVA), and data were reported as mean ± standard deviation. Mean comparison and separation were done using Tukey's test ($P < 0.05$). Statistical analysis was carried out using the Jamovi 2.4.11 (https://www.jamovi.org/) software.

Results and discussion

Physical properties of dragon fruit: Various physical properties, including color, length, diameter, circumference, and weight, were measured and are summarized in Table 1.

Table 1. Physical properties of dragon fruit

	White flesh dragon fruit	Red flesh dragon fruit
Colour	Pink	Bright Pink
Length (cm)	9.9[a]	9.1[a]
Diameter (cm)	7.53[a]	8.3[a]
Circumference (cm)	23.65[a]	26.06[b]
Weight (g)	319[a]	375[b]

Means in the rows with different superscripts are significantly ($P < 0.05$) different.

White dragon fruit's average length was longer than the red variety's. The diameter of red flesh dragon fruit exceeded that of white flesh dragon fruit. The circumference of red flesh dragon fruit was greater than that of white flesh dragon fruit. Additionally, the weight of red flesh dragon fruit in grams was comparatively higher than that of white flesh dragon fruit. Similarly, Abirami *et al*. (2021) focused on the morphological characterization of three dragon fruit species adapted to the Andaman and Nicobar Islands, with comparable variations observed in fruit and pulp weight. The findings align closely with studies by Liaotrakoon (2013) and Perween *et al*. (2018).

The results indicated a significant difference ($P < 0.05$) in circumference and weight between white flesh and red flesh dragon fruit. However, no significant difference ($p > 0.05$) was observed in length and diameter between the two dragon fruit types.

Yield and recovery of pulp and juices from dragon fruit: Significant differences ($P < 0.05$) were observed in the average initial weight, weight of pulp, weight of juice, juice yield, weight of peel, and edible index between white and red flesh dragon fruit. However, no significant difference was noted in the inedible index and pulp-to-peel ratio between the two dragon fruit types.

White flesh dragon fruit demonstrated a higher juice yield than red dragon fruit due to its greater fruit weight and a higher T.S.S.: acid ratio, indicating a superior balance of sweetness and acidity. This balance contributed to the increased juice yield. Furthermore, white dragon fruit exhibited lower pectin content compared to red flesh dragon fruit (Deep *et al*., 2022). Similar juice yield values were reported by Sharma (2016); Arivalagan *et al*., (2021) and Liaotrakoon (2013).

Table 2. Yield and recovery of pulp and juice from dragon fruit

Parameter	White flesh dragon fruit	Red flesh dragon fruit
Average initial weight (g)	319.0[a]	375.66[b]
Weight of pulp (g)	203.78[a]	268.4[b]
Weight of juice (g)	102.4[a]	132.6[b]
Yield of juice (%)	36.23[a]	35.28[b]
Weight of peel (g)	78.88[a]	107.2[b]
Edible index (%)	72.09[a]	71.45[b]
Inedible index (%)	27.89[a]	28.59[a]
Pulp-to-peel ratio	2.58[a]	2.5[a]

Means in the rows with different superscripts are significantly ($P < 0.05$) different.

Colour measurement of extracted juice and pulp: The values for L*, a*, and b* measured for extracted dragon fruit juice and pulp are depicted in Table 3. It reveals that L* values, indicating brightness, were higher for white flesh dragon fruit pulp than red flesh dragon fruit. However, L* values for extracted juice were lower than pulp, with red flesh dragon fruit juice at 0.88 and white flesh dragon fruit juice at 10.97.

Table 3. Colour measurement of extracted juice and pulp

Parameters	White flesh dragon fruit		Red flesh dragon fruit	
	Pulp	Juice	Pulp	Juice
L*	31.98[a]	10.97[A]	12.91[b]	0.88[B]
a*	2.33[a]	1.57[A]	34.06[b]	3.15[B]
b*	5.05[a]	5.0[A]	9.06[b]	0.26[B]
Hue	65.65[a]	71.37[A]	345.14[b]	355.01[B]
Chroma	5.56[a]	5.13[A]	35.26[b]	3.01[B]

Means in the rows of pulp with different lowercase superscripts are significantly different ($P < 0.05$).

Means in the rows of juice with different uppercase superscripts are significantly different ($P < 0.05$).

For a* values representing redness to greenness, and b* values representing yellowness or blueness, both were higher in pulp compared to juice. The a* value for red flesh dragon fruit pulp and juice were 34.06 and 3.15, while for white flesh dragon fruit, pulp and juice had values of 2.33 and 1.57, respectively. The b* values for red and white flesh dragon fruit pulp were 9.06 and 5.05, and for juices, they were 0.26 and 5.0, respectively.

Hue values for red and white flesh dragon fruit pulp were 345.14 and 65.65; for juices, they were 355.01 and 71.37, respectively. Chroma values showed decreasing trends for fruit juice compared to pulp. Significant differences ($P < 0.05$) were observed within the rows of pulp for each parameter and within the rows of juice for each parameter.

Chemical analysis of extracted pulp and juice: Table 4 depicts a comparative analysis of the parameters for red flesh dragon fruit and white flesh dragon fruit. Red dragon fruit varieties showed similar total soluble solids (T.S.S.) values for both pulp and juice, while white flesh dragon fruit exhibited slightly lower T.S.S. for both pulp and juice. Notably, acidity levels differed significantly between the two varieties, with red flesh dragon fruit having lower acidity than white flesh dragon fruit having higher acidity. The pH values for red and white dragon fruit pulp were 4.78 and 4.12, respectively, while the pH values for the juice of red and white dragon fruit were 4.95 and 4.15, respectively.

Table 4. Chemical analysis of extracted pulp and juice

Parameter	White flesh fruit		Red flesh fruit	
	Pulp	Juice	Pulp	Juice
T.S.S. (˚Brix)	12^{a}	12^{A}	13^{b}	13^{B}
Acidity (%)	0.42^{a}	0.39^{B}	0.3^{b}	0.28^{B}
pH	4.12^{a}	4.15^{A}	4.78^{b}	4.95^{B}
Total sugar (%)	7.49^{a}	6.23^{A}	8.45^{b}	6.87^{B}
Reducing sugar (%)	5.2^{a}	4.56^{A}	6.95^{b}	5.63^{B}
Non-reducing sugar (%)	2.29^{a}	1.73^{A}	1.8^{b}	1.24^{B}
Sugar to acid ratio	17.83^{a}	15.97^{A}	28.16^{b}	24.53^{B}
Ascorbic (mg/100g)	16.76^{a}	14.92^{A}	19.83^{b}	15.71^{B}

Means in the rows of pulp with different lowercase superscripts are significantly different ($P < 0.05$). Means in the rows of juice with different uppercase superscripts are significantly different ($P < 0.05$).

Concerning total sugar content, red flesh dragon fruit had higher levels at 8.45 % in pulp and 6.87 % in juice, while white flesh dragon fruit exhibited slightly lower total sugar content at 7.49 % in pulp and 6.23 % in juice. Red flesh dragon fruit also had higher percentages of reducing and non-reducing sugars in both pulp and juice than white flesh dragon fruit. The sugar-to-acid ratio was significantly higher in red flesh dragon fruit, indicating a sweeter taste than white flesh dragon fruit. Additionally, red flesh dragon fruit contained more ascorbic acid (vitamin C) with 19.83 mg/100g in its pulp and 15.71 mg/100g in its juice, while white flesh dragon fruit had slightly lower levels with 16.76 mg/100g in its pulp and 14.92 mg/100g in its juice. Significant differences ($P < 0.05$) were observed within the rows for each parameter, both in the pulp and juice segments. In the pulp segment, T.S.S., acidity, pH, total sugar, reducing sugar, non-reducing sugar, sugar-to-acid ratio, and ascorbic acid content all exhibited significant differences. Similarly, these parameters displayed significant differences in the juice segment, denoted by uppercase superscripts.

Similar results were found by Arivalagan *et al*. (2021) in their investigation of the nutritional and biochemical composition of *Hylocereus* species *H. undatus* and *H. polyrhizus*, revealing comparable pH values (4.8–5.4), total soluble solids (8–12%), and total sugar content (5.13–7.06%) between the two varieties.

Proximate analysis of extracted pulp and juice: A comparative analysis of the nutritional parameters of different types of dragon fruits *i.e.*, red flesh dragon fruit and white flesh dragon fruit are summarized in Table 5. Significant differences ($P < 0.05$) were observed within the rows when comparing juice to juice and pulp to pulp. Regarding moisture content, both varieties exhibited high water content. Red flesh dragon fruit had lower fat content in both

Table 5. Proximate analysis of extracted pulp and juice (percent)

Parameter (%)	White flesh dragon fruit		Red flesh dragon fruit	
	Pulp	Juice	Pulp	Juice
Moisture	86.63^{a}	91.5^{2A}	85.4^{3b}	90.46^{B}
Fat	0.6^{5}a	0.19^{A}	0.57^{b}	0.13^{B}
Protein	0.95^{a}	0.4^{3A}	1.3^{6b}	0.66^{B}
Carbohydrate	9.76^{a}	7.3^{8A}	10.0^{8b}	7.96^{B}
Ash	0.78^{a}	0.2^{1A}	1.0^{6b}	0.37^{B}
Crude fiber	1.23^{a}	0.2^{7A}	1.^{5b}	0.41^{B}

Means in the rows of pulp with different lowercase superscripts are significantly different ($P < 0.05$). Means in the rows of juice with different uppercase superscripts are significantly different ($P < 0.05$).

its pulp and juice than white flesh dragon fruit, which had slightly higher fat in its pulp and juice.

Protein levels showed that red flesh dragon fruit had higher protein content in both pulp and juice than white flesh dragon fruit. Carbohydrate content was slightly higher in red flesh dragon fruit, with 10.08 % in its pulp and 7.963 % in its juice, compared to white flesh dragon fruit, which had 9.76 % in its pulp and 7.38 % in its juice.

Similarly, red flesh dragon fruit had higher crude fiber content in both categories, with 1.5 % in its pulp and 0.41 % in its juice, while white flesh dragon fruit had lower crude fiber levels, with 1.23 % in its pulp and 0.27 % in its juice. Arivalagan *et al.* (2021) revealed comparable levels of moisture (82–85%), ash (0.7–0.85%), protein (0.90–1.1%), and dietary fiber (0.8–1.0%). Parameters' results were similar to earlier reports (Liaotrakoon, 2013; Kumar, 2021).

Mineral content of dragon fruit pulp and juice: The mineral content of both red and white flesh dragon fruit has been analyzed and compared in Table 6.

Table 6. The mineral content of dragon fruit pulp and juice

Minerals (mg/100g)	White flesh dragon fruit		Red flesh dragon fruit	
	Pulp	Juice	Pulp	Juice
Calcium	8.23^{a}	2.21^{A}	6.75^{b}	2.45^{B}
Magnesium	42.4^{a}	11.41^{A}	20.43^{b}	7.45^{B}
Phosphorus	26.49^{a}	7.13^{A}	27.85^{a}	8.67^{A}
Potassium	232.^{5}a	62.59^{A}	195.0^{b}	62.0^{9}A
Iron	1.55^{a}	0.41^{A}	5.59^{b}	0.95^{A}

Means in the rows of pulp with different lowercase superscripts are significantly different ($P < 0.05$). Means in the rows of juice with different uppercase superscripts are significantly different ($P < 0.05$).

Red flesh dragon fruit pulp showed significantly lower ($P < 0.05$) magnesium content compared to the white flesh variety, a difference also observed in the juices where red flesh dragon fruit juice contained notably less magnesium than white flesh dragon fruit juice.

Phosphorus content exhibited no significant differences ($p > 0.05$) between the two varieties, with both pulp and juice displaying comparable values. Regarding potassium content, the white flesh dragon fruit pulp had significantly higher levels ($P < 0.05$) than red flesh dragon fruit. Although distinct potassium content levels were present in the juices, these differences were not statistically significant ($P > 0.05$).

Red flesh dragon fruit pulp demonstrated significantly higher levels of iron ($P < 0.05$) compared to the white flesh variety, while the juices of both varieties displayed no significant differences ($P > 0.05$).

Minerals are primarily found in the solid parts of the fruit such as flesh and seeds. Filtering removes these solid components, leading to a reduction in mineral contents in juice. The results are in conformity with the findings of Arivalagan *et al.* (2021) and Kumar (2021) who observed that the red flesh dragon fruit had fewer mineral content values than white flesh dragon fruit.

Phytochemical analysis of pulp and juice: The data presented in Table 7 showed that the pulp obtained from red flesh dragon fruit had 30.87 mg per 100 gm of betacyanin and 21.11 mg per 100 gm in its juice. Betacyanin is a pigment responsible for the characteristic reddish-purple colour of the fruit. On the other hand, white flesh dragon fruit exhibits no detectable betacyanin content in its pulp or juice, giving it a notably different appearance from its red counterpart (Table 7).

Table 7. Phytochemical analysis of pulp and juice

Parameter	White flesh dragon fruit		Red flesh dragon fruit	
	Pulp	Juice	Pulp	Juice
Betacyanin (mg per 100 g)	Nil	Nil	30.87	21.11
Total phenolic content (mg GA/100 g)	27.87^{a}	23.14^{A}	49.67^{b}	41.25^{B}

Means in the rows of pulp with different lowercase superscripts are significantly different (P < 0.05). Means in the rows of juice with different uppercase superscripts are significantly different (P < 0.05).

Both red flesh dragon fruit pulp and juice displayed significantly higher (P < 0.05) total phenolic content than white flesh dragon fruit pulp and juice.

The pigments, phytochemicals and the color of juice filtered from pulp may be influenced by factors such as the removal of solid content, the breakdown of pigment-bearing structures, and changes in temperature and pH, which affect the stability of both phytochemicals and pigments (Enaru et al., 2021). The present findings closely align with those reported by Liaotrakoon (2013), Liaotrakoon et al. (2013), Thakkar (2019), and Arivalagan et al. (2021).

In summary, the study highlights significant differences between white and red flesh dragon fruit. Red flesh dragon fruit exhibited greater weight, circumference, and nutritional quality, including higher sugar content, phenolics, betacyanin, and iron. White flesh dragon fruit, though yielding more juice, had lower nutritional values and lacked the vibrant color of red flesh dragon fruit. These findings align with previous studies, emphasizing the superior nutritional and antioxidant properties of the red variety.

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