

Exploring the Physicochemical Properties and Nutritional Value of Dragon Fruit (*Hylocereus polyrhizus*) for Functional Food Development

T. Harish

harisht25595@gmail.com

Indian institute of horticultural research

C. K. Narayana

Indian institute of horticultural research

D. V. Sudhakar Rao

Indian institute of horticultural research

G. Karunakaran

Indian institute of horticultural research

R. H. Laxman

Indian institute of horticultural research

Shamina Azeez

Indian institute of horticultural research

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Abstract

This study aimed to evaluate the physico-chemical composition, bioactive compounds and antioxidant activity of selected red-pulp dragon fruit cultivar grown in the Bengaluru region of Karnataka. The fruits for the present study were pulped and analysed for various parameters. The results of this experiment showed that the average weight of dragon fruit was 364.11 ± 12.19 grams with specific gravity of 1.06. Upon processing it yielded 66.99 per cent pulp and 33.01 per cent peel with a pulp to peel ratio of 2.32 ± 1.74 . The fruit surface (peel) had a lightness value (L^*) of 29.6 ± 0.98 and redness value of 17.05. The pulp had lesser lightness value (14.3) compared to the peel, but had deeper redness value (42.06 ± 1.21) and blueness value (-2.14) on Hunter L^* , a^* and b^* scale. The fruit pulp had a moisture content of 87.03 ± 0.164 per cent and TSS of 11.87 ± 0.09 . The fruit pulp was found with low acidity (pH of 5.12 ± 0.02) and titratable acidity (0.4%). The pulp had total sugars of 6.40 ± 0.05 per cent, protein of 0.1 per cent and fat 0.48 per cent. The total phenol and flavonoid content of the pulp were 90.48 ± 0.45 mg GAE/100g and 76.25 ± 0.42 mg CE/100g respectively contributing to total antioxidant activity of 38.13 ± 0.29 mg AEAC/100g and radical scavenging activity (RSA %) of 69.42 ± 0.22 per cent. The dragon fruit cultivar evaluated under present investigation exhibited higher levels of nutrients and bioactive compounds, making them a promising candidate for functional food development. These properties highlight their potential for diverse applications in food and pharmaceutical product formulation and development.

1. Introduction

Dragon fruit (*Hylocereus sp.*) is a newly introduced minor tropical fruit crop that is gaining popularity in the country. Owing to its medicinal and health benefits, it is recognized as the super fruit all over the world. It is native to southern Mexico, Guatemala and Costa Rica. The crop is being commercially grown in Vietnam, Israel, China, Australia, Nicaragua, the United States of America, Taiwan, Malaysia, Indonesia, India and some parts of Sri Lanka. There are three species with different pulp colour. White pulp (*Hylocereus undatus*), red pulp (*Hylocereus polyrhizus*) and purple pulp (*Hylocereus costaricensis*). Among these white and red pulp types are more popular. The total area under dragon fruit cultivation in the world is around 1,12,264 ha, with a production of 21,00,777 metric tonnes [1]. The three most important countries producing dragon fruit are Vietnam, Israel and China, which account for 93 per cent of global dragon fruit production. Vietnam is the largest producer and supplier of dragon fruit, accounting for 51 per cent of global production. The total area of dragon fruit in Vietnam is around 55,419 hectares, with an average productivity of 28.5 metric tonnes per hectare per year. About 80 per cent of the total dragon fruit produced in Vietnam is exported to China [2]. The Vietnamese dragon fruit is in high demand due to its excellent quality and year-round production (including 'off-season' production).

In India, dragon fruit (Kamalam) was introduced in the late 1990s as a backyard crop. Later, the area under cultivation gradually increased from 4 to 400 ha during 2003-04. Initially, its cultivation was restricted to parts of Karnataka, Maharashtra, Gujarat and Andhra Pradesh. Later, due to its adaptability to varied environmental conditions and shorter crop cycles, dragon fruit gaining popularity among Indian

growers. Presently, its cultivation has extended to Madhya Pradesh, Haryana, Punjab, Uttar Pradesh and North Eastern (NE) states. As a result, the total area of dragon fruit cultivation in India has increased to 3084 ha, with an estimated total production of 12113 metric tonnes [3]. More than 80 per cent of the dragon fruit orchards are less than 3-year-old. Considering the importance of dragon fruit (kamalam), Mission for Integrated development of Horticulture (MIDH) under Ministry of Agriculture and Farmer's Welfare, Government of India has targeted to expand the area under dragon fruit cultivation to 50,000 ha in the country [2]. MIDH also approved establishment of a Centre of Excellence (CoE) on kamalam (dragon fruit) at Horticultural Experimental Farm of ICAR-Indian Institute of Horticultural Research located at Tumukuru. In Karnataka, it is grown in places like Lakshmeshwara, Bagalkot, Dakshina Kannada, Tumukuru, Belagavi, Vijayapura, Kalaburagi, Shivamogga, Mysuru, Bengaluru Rural districts [4].

The red pigment (betalains) is the potent antioxidant present in dragon fruit [5]. These betalains are nitrogenous, water-soluble pigments and are classified as either red or crimson betacyanins, or yellow betaxanthins. These are natural food colorants [6,7] good electron donors [8] and possess health-promoting properties because of antioxidants and their biological activities.

Due to the presence of various nutrients, dragon fruit provides several health benefits. It reduces cardiovascular heart problems and regulates blood pressure, it is cholesterol-free and packed with antioxidants. It is also reported to help in weight loss, enhance digestion, lower blood LDL cholesterol and boost the immune system. The pulp of dragon fruit includes polysaccharides and mixed oligosaccharides that act as growth promoters for *Lactobacilli* and Bifidobacteria, that are pre-biotic gut bacteria.

It is commercially processed on a limited scale into different value-added products like jam, jelly, ready-to-serve beverages, cakes, yogurt, ice creams and few cosmetic products. Edible natural colours can also be extracted from the peel and pulp of dragon fruit (Kamalam) and these colours can be used in the food, bakery and cosmetic industries as a healthy alternative to synthetic colours.

In recent years, dragon fruit cultivation has rapidly expanded, with its large-scale adoption by farmers owing to its compatibility with local climatic conditions, optimal light intensity and soil types. This crop has gained significant traction in various regions of Karnataka. However, comprehensive and detailed information regarding its physicochemical and nutritional quality attributes is lacking. To fill this gap, a research study was designed to evaluate the physicochemical properties, antioxidant activity and bioactive compound content of red-fleshed dragon fruit grown under tropical conditions of Karnataka, with particular emphasis on its potential as functional food.

2. Material and methods

Experimental Location

The dragon fruits for the present investigation were collected from KVK, Hirehalli, Tumkuru district, Karnataka, India. It is situated at longitude 77° 11' East and latitude 28° 38' North at an altitude of 845

meters above mean sea level and about 40 kilometers from ICAR-IIHR campus, Bengaluru in the south India. The investigation on physico-chemical analysis of the red pulp dragon fruit was carried out in PHT Lab-I of the Division of Post-Harvest Technology and Agricultural Engineering, ICAR- Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, Karnataka.

Experimental Details

Ripe fruits were harvested and packed in corrugated fibre board boxes and brought to the laboratory for further study. The fruits were washed under clean running water. Subsequently, the pulp and peel were separated and the pulp was ground using an industrial-scale blender. The extracted pulp was preliminarily analyzed for various physico-chemical parameters. The dragon fruit pulp was then packed in 5 kg polyethylene bags and stored at -20°C until further assessment.

Observation recorded

Average fruit, pulp and peel weight (g)

The weight of 40 individual fruits and their pulp and peel was weighed separately using an electronic balance (Sartorius GPA 5202, Germany) and the average of each parameter was calculated. The weight was expressed in grams.

Pulp to peel ratio

Fruits were peeled and weight of peel and pulp were recorded separately. Pulp to peel ratio was calculated by dividing the weight of pulp with peel weight.

Specific gravity

Specific gravity was determined through the measurement of both the volume and weight of the fruit. The water displacement method, as outlined by [9] was followed to measure the volume of each fruit. The specific gravity was then calculated by dividing the weight with the volume and expressed without any unit.

Peel and pulp colour

The colour of dragon fruit pulp and peel were assessed using colorimeter (Konica, Minolta Model: CR-10, Japan) and the results were expressed as L^* , a^* and b^* values. The L^* value, indicating lightness ranges from 0 (black) to 100 (white). The green colour is represented by a negative or smaller value of a^* , while

the red colour is denoted by a positive or higher a^* value. The b^* value reflects variations from blue (-b) to yellow (+ b). For each parameter, 3 values were recorded and their average was calculated as the final value.

Moisture content (%)

The moisture content of dragon fruit pulp was determined using a Infrared moisture analyzer (Model: P1019319, Make: A&D Company Limited, Japan). One gram of the sample was placed in a sample petridish and subjected to drying in the electric moisture analyzer until it automatically indicated a constant moisture percent.

Total soluble solids (TSS)

The fruits were cut into halves, and juice was extracted by pressing them. TSS (Total Soluble Solids) in the juice was measured using a digital refractometer (ATAGO PAL-3, Japan) and expressed as degree Brix ($^{\circ}$ Brix).

pH

The pH was determined using a digital pH meter (Make: ELICO Model: LI 612) after standardizing it with buffers of pH 4.0 and 9.2.

Titratable acidity (%)

Titratable acidity was estimated using the method described by [10]. Ten grams of pulp were crushed, homogenized and made up to 20 ml. The extract was then centrifuged at 8000 rpm for 10 minutes. A few drops of phenolphthalein indicator were added to 10 ml of the clear extract and titrated against 0.1 N NaOH until it reached pH 8.1 (Microprocessor-based pH system, ESICO RS232PC, India) as the endpoint. The observed titre value was used to calculate the percentage acidity as citric acid equivalent using the following formula.

$$\text{TA (\%)} = \frac{\text{Titre value} \times \text{N of Alkali} \times \text{Vol. made up} \times \text{Eq. wt. of acid} \times 100}{\text{Vol. of sample taken for titration} \times \text{Wt. or Vol. of sample taken} \times 1000}$$

Fat content (%)

Fat content was estimated in dragon fruit pulp following the method outlined by [11]. A five-gram sample was taken in a beaker and a known volume of petroleum ether was added to it. The contents in the

beaker were thoroughly mixed and allowed to rest until all the particles settled down. Subsequently, the clear solution of petroleum ether was drained into a pre weighed beaker. This process was repeated for three to four times. The beaker containing the petroleum ether extractant was then left undisturbed at room temperature until the petroleum ether gets completely evaporated. The final weight of the beaker was measured using an electric weighing balance. The fat per cent was calculated using the formula.

$$\text{Fat (\%)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Weight of the sample}} \times 100$$

Protein content (g/100g)

Protein content was estimated in dragon fruit pulp using Folin phenol reagent method [12]. One-gram sample was homogenized with distilled water and the volume was made up to 25 ml. The sample was then centrifuged at 8000 rpm for 10 minutes and the supernatant was used for protein estimation. The reaction mixture containing 1 ml of the extract and 5 ml of reagent C (mixture of Reagent A (2% Na₂CO₃ in 0.1N NaOH) + Reagent B (0.5% CuSO₄.5H₂O + sodium potassium tartrate) was mixed and kept for 10 minutes. Subsequently, 0.5 ml of Folin Ciocaltue Reagent (FCR) was added, mixed well and incubated at room temperature for 30 minutes in the dark. Absorbance was measured at 660 nm against the reagent blank. Protein present in the sample was calculated using a standard graph plotted using Bovine Serum Albumen and expressed in g/100g.

Ascorbic acid content (mg/100g)

Ascorbic acid present in the fruit pulp was estimated by the iodine titration method [13]. Five grams of pulp was homogenized (Model: IKA T25 Make: digital ultra Turarax) with distilled water and the final volume was made up to 50 ml. Then, 1 ml of starch indicator was added to 10 ml of the aliquot. After mixing, the aliquot was titrated against iodine solution until the appearance of a dark blue or purple colour as the end point. A stock solution of standard L-ascorbic acid was used to calculate the dye factor. The final result was calculated using the following formula and the result was expressed as mg/100 g.

$$\text{Ascorbic acid Content (mg/100g)} = \frac{\text{Titrate value} \times \text{Dye factor} \times \text{Volume made up}}{\text{Weight of sample} \times \text{Volume of sample taken}} \times 100$$

Total betalain content (mg BCE/100g)

For estimating total betalain content, [14] method was used with slight modification. One g of dragon fruit pulp was dipped in acidified methanol: water (1:1) solvent and kept overnight for maximum colour

extraction. Sample was extracted repeatedly by using same solvent till full colour extraction. Extracted sample was made up to 25 ml with acidified methanol: water (1:1) solution. After that extracted sample was centrifuged at 8000 rpm for 10 min to get a clear extract. Supernatant was used to record the absorbance at 538 nm in a spectrophotometer (Model: T80 + UV/VIS spectrophotometer, Make: PG instruments Ltd. UK) against a blank reagent (same solvent used for sample). Betanin (betacyanin) (Sigma-Aldrich, CAS Number: 7659-95-2) was used to prepare the standard curve. Total betalain content was calculated using standard curve and expressed as mg betacyanin content (BCE)/100 g.

Reducing and total sugars (%)

The [15] method was followed to determine the sugar content in dragon fruit pulp. Pre-weighed samples of crushed pulp (10g) were homogenized (Model: IKA T25 Make: Digital ultra Turarax) with distilled water (DW) and the volume was adjusted to 100 ml with distilled water. Subsequently, 5 ml of lead acetate was added and left for 30 minutes. The precipitation of the lead solution was achieved by adding potassium oxalate and the final volume was adjusted to 150 ml with DW. The solution was then filtered through Whatman no. 1 and the clear filtrate was used for titration.

In a conical flask, 5 ml each of Fehling's solution A and B were mixed and boiled. Methylene blue indicator was added to the Fehling solution mixture and titration was carried out until the blue colour of the Fehling solution turned into a brick-red colour. The titre value obtained was utilized for further calculations. The percentage of reducing sugars was calculated using the titre value in the formula (Lane and Eynon, 1923).

$$\text{Reducing sugar (\%)} = \frac{\text{Glucose factor} \times \text{Volume made up (ml)}}{\text{Titre value} \times \text{Weight of sample (g)}} \times 100$$

Same filtrate was used for the estimation of total sugars. For this, 25 ml of filtered sample was transferred into a volumetric flask and 5 ml concentrated HCl was added into it and left for 24 hours at room condition. After that few drops of phenolphthalein indicator was added to the sample and sodium hydroxide (20%) was used to neutralize the HCl. Light pink colour was the indication of complete neutralization of acid. Then final volume was made up to 50 ml and titrated against Fehling solution after adding few drops of methylene blue indicator. End point was judged by change of blue colour into dark brick red colour.

Percentage of total sugars was calculated using the titre value in the formula (Lane and Eynon, 1923).

$$\text{Total sugars (\%)} = \frac{\text{Factor} \times \text{Volume made up (ml)} \times \text{volume taken (ml)}}{\text{Titre value} \times \text{Weight of sample (g)}} \times 100$$

Free radical scavenging activity (DPPH assay) (% RSA)

Free radical scavenging activity was assessed using the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay [16] with slight modification. The method is based on measuring the scavenging ability of antioxidants against stable DPPH radicals. Sample preparation involved using 80% methanol, 2g of pulp adjusting the volume to 20ml. A sample extract (0.2 ml) was mixed with 2.5 ml of 0.0634 mM DPPH reagent and 0.3 ml acetate buffer (pH-5.4) and the mixture was shaken thoroughly. The reaction mixture was then incubated for 30 minutes and absorbance was recorded at 517 nm using a spectrophotometer. The percentage radical scavenging activity (RSA) was calculated using the formula: $\text{RSA (\%)} = (\text{Abs}_0 - \text{Abs}_1) \times 100 / \text{Abs}_0$, where Abs₀ represents the absorbance of the blank, and Abs₁ is the absorbance of the sample.

Ferric reducing antioxidant power (FRAP assay) (mg AEAC/100g)

The FRAP (ferric reducing antioxidant power) assay was conducted following the method outlined by [17]. Pulp (2 g) was homogenized in 80% methanol, volume made upto 20 ml and then centrifuged at 8000 rpm for 10 min. The reaction mixture comprised 0.2 µl of the extractant and 1.8 µl of the FRAP reagent (freshly prepared by combining acetate buffer, FeCl₃, and TPTZ in a ratio of 10:1:1). After incubating for 30 minute, the absorbance was measured at 593 nm. An ascorbic acid standard curve was utilized and the results were expressed as mg ascorbic acid equivalent (AEAC)/100 g.

Total phenols (mg GAE/100g)

The concentration of phenolic compounds in dragon fruit pulp was determined using the method of [18] with slight modifications. Two g of pulp sample was crushed in 80% ethanol. After homogenization, the final volume was adjusted to 20 ml with the same solvent and then centrifuged at 10,000 rpm for 20 min at 4°C. The supernatant (0.5 ml) was mixed with 0.2 ml of Folin-Ciocalteu reagent (diluted with DW in a 1:1 ratio) and 3.3 ml of distilled water. After 3 minutes, 1 ml of 20% Na₂CO₃ solution was added and mixed thoroughly. The reaction mixture was incubated for 30 min in the dark. The absorbance of the sample was recorded at 760 nm using a spectrophotometer. Gallic acid was used to calibrate the standard curve. The total phenols were expressed as milligrams of gallic acid equivalent per 100 grams (mg GAE/100 g).

Total flavonoids (mg CE/100g)

Flavonoids content was determined by the method of [19]. Two gram of pulp was crushed in 80% ethanol and made up to 20 ml and kept for centrifugation (8000 rpm for 15 minutes at 4°C). Supernatant was collected and 1 mL of it was used for preparing the reaction mixture. Reagents namely 0.3 mL each of

sodium nitrite and aluminium chloride was added in extract. After 2 minutes sodium hydroxide (4.4 mL) solution was poured into the reaction mixture. The sample was incubated in dark for 15 minutes and optical density was recorded at 510 nm. Total flavonoids were expressed as mg catechin equivalent (CE) /100 g.

3. Results and Discussion

Physical parameters

The physico-chemical composition of red dragon fruit is detailed in Table 1. The average fruit weight was 364.11 ± 12.19 g, with a specific gravity of 1.06. The fruit yielded 66.99% pulp and 33.01% peel, resulting in a pulp-to-peel ratio of 2.12 ± 0.07 . These values emphasize the high edible portion of the fruit, making it an efficient raw material for processing into value-added products. The peel color of red dragon fruit was assessed using the Hunter color scale, exhibited a lightness (L^*) value of 29.6 ± 0.98 and a redness (a^*) value of 17.05 reflecting its visually appealing vibrant color. In contrast, the pulp showed a lower lightness value (14.3) but a higher redness value (42.06 ± 1.21) along with a blueness (b^*) value of -2.14. The deeper redness of the pulp can be attributed to its high betalain pigment content, which contributes to both its color intensity and potential health benefits. The findings regarding the average fruit weight align with those reported by [20], who noted that white and red pulp varieties under Bengaluru conditions ranged from 421–554 g and 100–501 g, respectively. Furthermore, studies by [21,22,23 and 24] corroborate the results for other physical parameters such as fruit weight and peel-to-pulp ratio emphasizing the consistency of these traits across different cultivars and growing conditions.

Table 1
Physical parameters of red pulp dragon fruit
(*Hylocereus polyrhizus*)

Sl. No	PARAMETERS	Mean $\pm$ SE
1	Fruit weight (g)	364.11 $\pm$ 12.19
2	Specific gravity	1.06 $\pm$ 0.01
3	Pulp weight (g)	243.91 $\pm$ 9.77
4	Peel weight (g)	115.47 $\pm$ 3.46
5	Pulp/peel ratio	2.12 $\pm$ 0.07
6	Moisture content (%)	87.03 $\pm$ 0.164
7	Peel colour L^*	29.6 $\pm$ 0.98
8	a^*	21.32 $\pm$ 1.74
9	b^*	17.05 $\pm$ 1.27
10	Pulp colour L^*	14.3 $\pm$ 0.83
11	a^*	42.06 $\pm$ 1.21
12	b^*	-2.14 $\pm$ 0.57
All values were calculated on fresh weight basis.		

The high pulp yield and appealing color characteristics of red dragon fruit make it an excellent candidate for processing into functional foods, natural colorants and other value-added products. The specific gravity and color values further highlight its potential to cater to consumer preferences for vibrant, nutrient-rich fruit products.

Chemical parameters

The chemical composition of the red dragon fruit pulp is summarized in Table 2. The fruit pulp had a moisture content of 87.03 $\pm$ 0.164 per cent reflecting its high water content, which contributes to its perishable nature. The total soluble solids (TSS) of the pulp were 11.87 $\pm$ 0.09°Brix indicating a moderate level of natural sugars which is essential for sweetness and flavor development.

Table 2
Chemical compositions of red pulp dragon fruit
(*Hylocereus polyrhizus*)

Sl. No	PARAMETERS	Mean $\pm$ SE
1	Moisture content (%)	87.03 $\pm$ 0.16
2	TSS ($^{\circ}$ brix)	11.87 $\pm$ 0.09
3	Titratable acidity (%)	0.14 $\pm$ 0.04
4	Ascorbic acid (mg/100g)	7.69 $\pm$ 0.01
5	Total sugars (%)	6.40 $\pm$ 0.05
6	Reducing sugar (%)	5.42 $\pm$ 0.08
7	Protein (g/100g)	0.16 $\pm$ 0.01
8	Fat (%)	0.40 $\pm$ 0.01
9	pH	5.12 $\pm$ 0.02
All values were calculated on fresh weight basis.		

The pH of the pulp was 5.12 ± 0.02 , placing it within the range of slightly acidic fruits. This observation aligns with findings by [25], who reported a pH of 4.77 in red-pulp dragon fruit varieties. The titratable acidity measures the total concentrations of total acids present in food. Titratable acidity in the present study was observed at 0.40 per cent. Similar acidity levels in dragon fruit pulp have been noted in previous studies by [26 and 27]. These values suggest a balanced acidity that enhances the fruit's palatability and preservation potential. Ascorbic acid is a key antioxidant contributes significantly to the fruit's health benefits by neutralizing free radicals and enhancing its shelf life. The ascorbic acid content of red-pulp dragon fruit was found to be 7.69 ± 0.01 mg/100 g, which is consistent with the findings of [28 and 29] who reported similar levels of ascorbic acid in dragon fruit pulp. The total sugar content of the fruit pulp was 6.40 ± 0.05 per cent, protein content was 0.1 per cent and the fat content was 0.48 per cent. The sugar content aligns with the natural sweetness characteristic of dragon fruit, making it suitable for direct consumption and as a base for various processed products. The low protein and fat content highlight its suitability as a low-calorie food ideal for individuals seeking weight management or diabetic-friendly diets. These findings are consistent with prior studies, including those by [20, 21, 23, 30, 31, 32 and 33] across the world.

The moderate TSS and sugar content make the fruit ideal for processing into powder, juices and other functional food products without the need for addition of sweeteners. However, the presence of higher moisture content in fruit pulp ($87.03 \pm 0.164\%$) makes it imperative to go for proper dehydration. Additionally, the low fat and calorie content enhance its suitability for health-conscious consumers.

Bio active compounds and Antioxidant activity

The bioactive composition and Antioxidant activity of red dragon fruit pulp is detailed in Table 3. The pulp had a total phenol content of 90.48 ± 0.45 mg GAE/100 g and a total flavonoid content of 76.25 ± 0.42 mg CE/100 g. These bioactive compounds contributed to total antioxidant activity of 38.13 ± 0.29 mg AEAC/100g and radical scavenging activity (RSA) of 69.42 ± 0.22 per cent. The high levels of phenolic and flavonoid compounds are consistent with their established roles in reducing oxidative stress by neutralizing free radicals. In contrast, [35] reported a lower total phenolic content (TPC) of 24.22 ± 0.95 mg GAE/100 g in the dragon fruit pulp. This variation in TPC could likely be attributed to differences in environmental conditions during growth as well as disparities in the maturation stage of the dragon fruit. These findings suggest the influence of external and developmental factors on the bioactive composition of the fruit.

Table 3		
Bioactive compounds and antioxidant activity of red pulp dragon fruit (<i>Hylocereus polyrhizus</i>)		
1	Total Phenol (mg GAE/100g)	90.48 ± 0.45
2	Total flavonoid (mg CE/100g)	76.25 ± 0.42
3	FRAP activity (mg AAE/100g)	38.13 ± 0.29
4	DPPH (% RSA)	69.42 ± 0.22
5	Total betalain (mg BCE/100g)	128.40 ± 0.62
* BCE- betacyanin equivalent, RSA- radical scavenging activity, AEAC-ascorbic acid equivalent, GAE- gallic acid equivalent, CE- catechin equivalent. All values were calculated on fresh weight basis.		

Betalains are the group of water soluble nitrogen containing bioactive compound present in flesh and peel of dragon fruit. In the present assessment, the pulp had a betalain pigment content of 128.40 ± 0.62 mg BCE/100g (Table 3). The observed results are comparable with previous findings reported by [3, 23, 24, 27 and 36]. However, the variations in the betalain composition observed in this study compared to others may be attributed to factors such as cultivar differences, regional and climatic conditions and soil characteristics. These factors play a pivotal role in influencing the bioactive and nutritional composition of fruits.

The bioactive profile of red dragon fruit indicates its potential as a functional food ingredient. The presence of antioxidants, particularly phenols and flavonoids, along with betalains positions this fruit as a natural source for combating oxidative damage and promoting overall health. Additionally, the relatively low fat and calorie content of the fruit pulp make it suitable for incorporation into diets aimed at managing weight and metabolic disorders, including diabetes.

4. Conclusion

This study provides valuable insights into the composition and nutritional profile of red-pulp dragon fruit cultivars grown in the tropical regions of Karnataka. The findings highlight that red dragon fruit is a

nutrient rich food with significant health benefits. Its composition is influenced by cultivar, region, climate and soil factors. The pulp is particularly rich in ascorbic acid, total phenols, total flavonoids and antioxidants, making it a valuable functional food. Additionally, its high betalain content observed in present study contributes to its vibrant color and potential health-promoting properties. With low fat and calorie content, red dragon fruit is an ideal dietary option for individuals with diabetes. Overall, the results highlights the potential of red dragon fruit as a nutrient-rich and health-promoting fruit with applications in functional foods and nutritional interventions.

Declarations

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***Consent to participate:** NA

***Ethics approval:** NA

*The author's contribution to the paper as follows:

1. **Mr. Harish T:** Data collection, analysis and interpretation of results and Draft manuscript preparation
2. **Dr. Narayana C. K.:** Study conception and design, Supervision of the experiment, Validation of results , Project administration and Funding acquisition
3. **Dr. SudhakarRao, D.V:** Review, Supervision and Validation
4. **Karunakaran, G:** Resources for the experiment
5. **Dr. Laxman, R. H.:** Review & supervision
6. **Dr. Shaminaazeez:** Review & supervision

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