Food Research 7 (4) : 194 - 203 (August 2023)
Journal homepage: https://www.myfoodresearch.com

FOOD RESEARCH

FULL PAPER

Physico-chemical properties, antioxidant activity and bioactive compounds in edible and non-edible portions of dragon fruit cultivars native to Bangladesh

[1,*]Alam, M., [1]Biswas, M., [1]Ahmed, J., [1]Hosain, M.A., [1]Alam, A., [2]Khan, M.H.H. and [2]Molla, M.M.

[1]*Department of Agro Product Processing Technology, Jashore University of Science and Technology, Jashore-7408, Jashore, Bangladesh*

[2]*Postharvest Technology Division, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh*

Article history:
Received: 5 May 2022
Received in revised form: 25 July 2022
Accepted: 12 May 2023
Available Online: 18 August 2023

Keywords:
Antioxidant activity,
Bioactive compounds,
Dragon fruit cultivars,
Edible and non-edible portions,
Nutritive values

DOI:
https://doi.org/10.26656/fr.2017.7(4).243

Abstract

The research was conducted to assess the variability and relationship regarding physico-chemical properties, antioxidant activity and bioactive compounds in edible and non-edible portions (peel, flesh and seed) of dragon fruit cultivars native to Bangladesh. The most popular and largely cultivated Bangladesh Agricultural Research Institute (BARI) released BARI Dragon Fruit-1 and Bangladesh Agricultural University (BAU) released BAU Dragon Fruit-1 cultivars were chosen in the study. The experiment was conducted in two factors completely randomized design where two cultivars and, three edible and non-edible portions were considered as treatments. The findings of the investigation revealed that there was a large discrepancy in the average weight in the selected cultivars where BAU Dragon Fruit-1 was found to be superior (347 g) to BARI Dragon Fruit-1 (284 g). These cultivars contained 31.86% to 35.44% peel, 59.74% to 65.08% flesh and 3.06% to 4.82% seed in their edible and non-edible portions. The BAU Dragon Fruit-1 provided a good recovery rate with the highest flesh to peel ratio (2.04:1). The highest amount of total soluble solids (10.20°Brix) was obtained in the flesh portion of BARI Dragon Fruit-1. The utmost quantities of ascorbic acid were found in the seeds of each cultivar, ranging from 24.40 to 31.41 mg/100 g. The BARI Dragon Fruit-1 cultivar's seed contained the highest tannin (444.64 mg TAE/100 g), whereas the flesh of the same cultivar had the lowest (335.04 mg TAE/100 g). In comparison, the phenolic content of BAU Dragon Fruit -1 cultivar's seed and flesh ranged from 162.86 to 163.13 mg GAE/100 g. The highest antioxidant activity (91.35%) was found in the seed portion of BARI Dragon Fruit-1. According to the findings, the edible and non-edible portions of Bangladesh's native dragon fruit cultivars have particular features, which will help in diverse food and pharmaceuticals product formulation and development.

1. Introduction

Dragon fruit (*Hylocereus* spp.) is an outlandish temperate zone rising grapevine cactus plant fruit having an eye-catching flamboyant structure with succulent, luscious flesh. The dragon fruit, also referred to as pitaya, is a mysterious barbarian plant with multiple health perks that has garnered international acclaim (Gunasena *et al.,* 2007). Over twenty tropical and subtropical countries, including Mexico, Indonesia, Philippines, Malaysia, Myanmar, Australia, Vietnam, Thailand, Taiwan, Florida, West Indies and Bangladesh, have commercially grown it (Mercado-Silva, 2018). Due to the lucrative appeal, lower cultivation costs and higher customer demand, the cultivation of the dragon fruit is aggregating day after day around the world (Crane *et al.,* 2017). It has turned into a prominent agronomic crop that charms attention and causes an escalation in curiosity among scientists and researchers, especially in recent years, as the functional food idea has risen in popularity (Patwary *et al.,* 2013).

The nutritional and medicinal features of dragon fruits are gaining prominence and are also termed a 'superfood' (Sonawane, 2017). Because of its nutritional richness, this fruit is considered a significant economic fruit species around the world (Rifat *et al.,* 2019). Due to its low water requirement and adaptability to high temperatures, dragon fruit has a lot of potential as the latest crop for Mediterranean growers (Trivellini *et al.,*

*Corresponding author.
Email: *ma.alam@just.edu.bd*

eISSN: 2550-2166
Published by Rynnye Lyan Resources

2020). BARI Dragon Fruit-1 (Bangladesh Agricultural Research Institute released variety) and BAU Dragon Fruit-1 (Bangladesh Agricultural University released variety) cultivars are commercial cultivars in Bangladesh because of their larger yield, disease resistance and compatibility with the environment. These cultivars have achieved wider consumer acceptance, with increased market demand and turning out to be a profitable crop for farmers (Patwary *et al.,* 2013). The taste and palatability fascinate people and command a higher market price. During the ripening process, the hue of red -fleshed Dragon fruit turned pigmented. The fruit is rich in carbohydrates and antioxidants, and has a savory flavor and crisp taste (Rao and Sasanka, 2015). Dragon fruit is water soluble and fiber rich edible fruit that seems to have abundant in vitamin C and antioxidants including betalains, hydroxycinnamates and flavonoids (Moshfeghi *et al.,* 2013). The bioactive components of Dragon fruit are sometimes affected by season, weather, cultural practices, water availability, transportation, handling, and storage (Franke *et al.,* 2004; Wall, 2006).

Owing to the appropriate temperate climate, light intensity and soil type, dragon fruit cultivation has emerged in several regions of Bangladesh. Based on the different cultivars, dragon fruit comprises edible and non -edible parts where a non-edible portion contributing almost fifty per cent of the whole fruit (Lim *et al.,* 2010). During processing a significant portion of the fruit needs to be discarded as processing wastage. However, all of the edible and non-edible portions of the fruit have functional potential in food product development and medicinal purposes. As a natural flavoring and coloring agent in the culinary sector patiya fruit can play a significant role. Both peel, seed and pulp can be utilized in the development of different delicious dessert food items like jam, jelly, marmalades, yoghurt, ice cream and fruit drinks (McMahon, 2003; Gunasena *et al.,* 2007). It is mandatory to make it profitable by proper utilization of the non-edible fruit portion in the development of natural health products which would also assist in reducing ecological and environmental problems associated with processing waste disposal. To utilize the both edible and non-edible portions of the dragon fruit in food product development, it is compulsory to determine the proximate composition, nutritive values, antioxidant capacity and bioactive compounds content in each portion. Physico-chemical properties determination along with antioxidant and other properties is important to generate information on the functionality of edible and non-edible portions to facilitate valued addition and commercial utilization (Jamilah *et al.,* 2011). Nowadays safe food is a burning issue in the processing and preparation of food products.

There was no complete and precise information regarding edible and non-edible portions of the native dragon fruit cultivars of Bangladesh. For that reason, it was crucial to study these cultivars to find out the information about characteristics and nutritive values in the specific portions. The research experiment was designed with an aim of assessing the variability and relationships among physico-chemical properties, antioxidant activity and bioactive compounds content in edible and non-edible portions of BARI Dragon Fruit-1 and BAU Dragon Fruit-1 cultivars in Bangladesh. The obtained data from the study possibly could provision the development of food products with the information precisely on the characteristics of each edible and non-edible portion of these dragon fruit cultivars making these fruit wastes into value-added products.

2. Materials and methods

2.1 Experimental site and duration

The research experimentation was conducted in the Analytical Laboratory of the Department of Agro Product Processing Technology, Jashore University of Science and Technology, Jashore, Bangladesh, from October 2021 to January 2022. Two native dragon fruit cultivars (BARI Dragon Fruit-1 and BAU Dragon Fruit-1) were used in this study which were collected from the farmer's orchard located at Kaliganj upazila of Jhenaidah district under Khulna division, Bangladesh. The orchard was located at the latitude and longitude 23.41°N and 89.13°E respectively and 11m altitude from the sea level. A schematic map of the experimental area has been depicted in Figure 1.

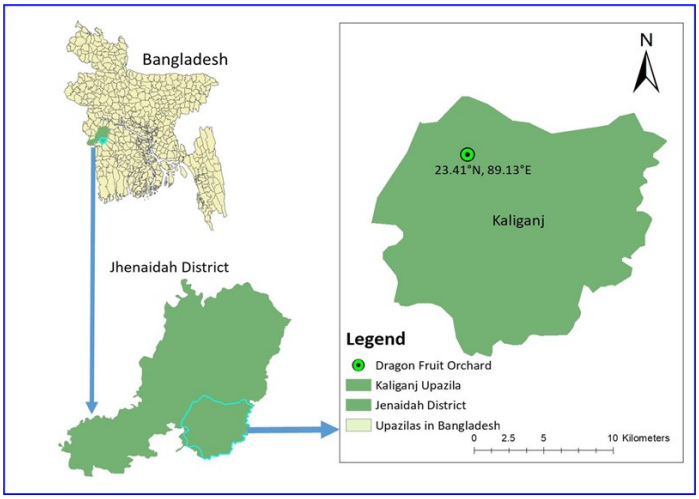

Figure 1. Schematic map of the experimental area representing Kaliganj Upazila of Jheneidah District.

2.2 Experimental sample and design

The experimental samples were harvested based on the maturity index at light red to green stage and brought to the analytical laboratory of the Department of Agro

https://doi.org/10.26656/fr.2017.7(4).243

Product Processing Technology, Jashore University of Science and Technology, Jashore. After sorting out the injured and damaged, fresh dragon fruits were separated and stored for 72 hrs at ambient temperature for complete ripening and color development. According to Completely Randomized Design (CRD) with three replications two factor experiments were conducted. The experimental treatments were two native dragon fruit cultivars (*viz*. i. BARI Dragon Fruit-1 and ii. BAU Dragon Fruit-1) and three edible and non-edible portions (viz. i. Peel, ii. Flesh and iii. Seed). In the experiment, red fleshed BARI Dragon Fruit-1 cultivar's peel, flesh and seed portions were denoted by red peel (RP), red flesh (RF) and red seed (RS). Where, white fleshed BAU Dragon Fruit-1 cultivar's peel, flesh and seed portions were denoted by white peel (WP), white flesh (WF) and white seed (WS). The summarized study design has been presented as a flow chart in Figure 2. The dragon fruit cultivars were carefully washed and the outer peel was removed by a sterilized sharp knife. Then the seeds were separated from the pulp through screening with porous wool fabric carefully without damage or injury. The weight proportion of peel, pulp and seed was also estimated based on whole fruit. Each edible and non-edible portion was macerated and homogenized completely using a blender. The samples were kept at -18°C for future analysis. Exposure to light during storage was consciously avoided to reduce possible losses of nutrients.

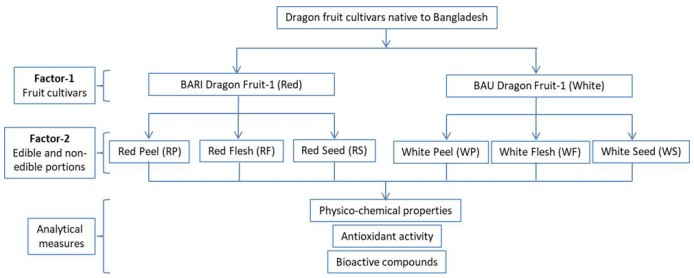

Figure 2. Flow chart of the summarized study design.

2.3 Physico-chemical properties analysis

2.3.1 Moisture and dry matter content

In the experiment, moisture and dry matter content was determined regarding the methods followed by AOAC (2005). At first, the weight of the Petri dish was recorded and tabulated. The samples of peel, flesh and seed of each dragon fruit cultivar were carefully separated using a sharp knife. Then the fresh samples were segmented and homogenized before the determination of the physico-chemical properties. In the Petri dish, 5 g sample of each portion was taken. The weight of the Petri dish and sample was measured and recorded once again. All three peel, flesh and seed samples were then placed in Petri dish and kept for 5-6 hrs in the oven at 105°C. Desiccators were used to bring the sample temperature to ambient after it had been heated. The weight of the Petri dish containing the sample was measured again and again until three consecutive weights become similar. Then the moisture and dry matter percentages were calculated using the following formulae.

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight of sample (g)} - \text{Dry weight of sample (g)}}{\text{Fresh weight of sample (g)}} \times 100$$

$$\text{Dry matter content (\%)} = 100 - \text{\% moisture content}$$

2.3.2 Determination of ash content

The ash content of a sample is a measure of the amount of inorganic non-combustible material it contains which was determined following the procedure explained by AOAC (2005). In a crucible, 2 g sample was taken. The crucible was placed on a burner and heated over a low flame to fill it with all of the charred material. The crucible was then placed in a Muffle furnace for around 6 hrs at 600°C. The crucible was then desiccated and weighed after cooling. To ensure that the ashing process was completed, the crucible was reheated for 0.5 hrs and then weighed. This method was continued until the ash was practically whitish or grayish and three consecutive weights were the same and calculated using the following formula.

$$\text{Ash content (\%)} = \frac{\text{weight of residue (g)}}{\text{weight of fresh sample (g)}} \times 100$$

2.3.3 Determination of pH and total soluble solids

The pH of the extracted juice from each proportion was measured using an electric pH meter. Using buffer solutions (pH 4.0, pH 7.0) the pH meter was calibrated before taking the reading. Total soluble solids (TSS) content was determined by a digital refractometer (HI 96801 refractometer, China). A drop of blended juice was squeezed and taken into the prism of the refractometer and the °Brix value was measured.

2.3.4 Protein content determination

The protein content was determined following the Micro Kjeldahl procedure for the determination of nitrogen and then crude protein was calculated by multiplying the nitrogen content by conversion factor (6.25). The amount of Nitrogen presents in the sample is converted into ammonium sulphate with sulfuric acid in the presence of a catalyst mixture by digestion at 380°C. The liberated Ammonia was distilled with sodium hydroxide solution to absorb by boric acid and then titrated and calculated nitrogen percentage using the following formula.

$$\text{Nitrogen } (N_2)\ \% = \frac{(V_1 - V_2) \times N \times 0.014}{\text{Weight of sample (g)}} \times 100$$

Where, V_1 = mL of HCl for sample; V_2 = mL of HCl

https://doi.org/10.26656/fr.2017.7(4).243

for Blank and N = Normality of HCl

$$\text{Protein content (\%)} = \text{Nitrogen (\%)} \times \text{Conversionfactor (6.25)}$$

2.3.5 Determination of titrable acidity

The titrable acidity was estimated through the titrimetric methods using phenolphthalein indicator as per AOAC (2005). At first, 5 mL sample was kept in a 50 mL volumetric flask. Distilled water was used to make fulfil the volume. Approximately three drops of phenolphthalein indicator were added and then titrated with 0.1 N standard NaOH solution to a faint pink end-point. Then the titrable acidity was calculated based on the following formula.

$$\text{Titrable acidity (\%)} = \frac{\text{ml of NaOH} \times \text{Normality of NaOH} \times \text{Correction factor (0.0064)}}{\text{Weight of sample}} \times 100$$

2.4 Determination of bioactive compounds

2.4.1 Sample extraction

According to the method described by Ding *et al.* (2015), the extracts were prepared from edible and non-edible portions of each dragon fruit cultivars. In 95% ethanol, 50 g fresh samples were homogenized for 5 mins using a homogenizer. The homogenates were mixed at room temperature for 15 mins before being centrifuged for 5 mins at 3000 rpm. After collecting the supernatant, the extraction operation was repeated. To re-extract the precipitate, 80 mL of 95% ethanol was added, homogenized for a few minutes and then centrifuged for 5 mins at 3000 rpm. The pooled supernatants were mixed and filtered twice with filter paper before being concentrated at 50°C in a vacuum rotary evaporator. The samples were then dissolved again in 95% ethanol through ultrasonic agitation to a volume of 20 mL to make the final concentration at 1 g fresh weight/L. The extracts were stored at -20°C as a stock solution for further use.

2.4.2 Determination of total phenolic content

The modified Folin-Ciocalteu technique was used to determine the total phenolic content in the edible and non-edible portion of each dragon fruit cultivar according to the method followed by Wootton-Beard *et al.* (2011). One (1) mL of each extract was blended with 5 mL of Folin-Ciocalteu and 4 mL of sodium carbonate. The mixture was vortexed 15 s for color development and left at 40°C for 30 mins. A double beam Thermo Scientific UV-Vis Spectrophotometer was used to detect the absorbance at 765 nm. Instead of the sample, water was used to make the blank. A blank was used to compare a set of Gallic acid standard solutions. Total phenolic content was calculated as mg of Gallic acid equivalents by using linear equation Y = 0.0074x+0.4075, R^2 = 0.9982 derived from a standard Gallic acid calibration graph.

2.4.3 Determination of total flavonoid content

The method described by Chang *et al.* (2002) was used with slight modifications for determining the flavonoid content in the extracts. A 2.5 mL $AlCl_3$ solution was mixed with 5 mL methanolic extract. Absorbance was measured at 430 nm using a double beam Scientific UV-Vis Spectrophotometer after 15 mins of incubation at room temperature. A 133 mg crystalline $AlCl_3$ and 400 mg crystalline Sodium Acetate were added to 100 mL de-ionized water to make the $AlCl_3$ reagent solution. A linear standard calibration curve with Y = 0.0154x+0.0301, R^2 = 9991 was generated using a series of Quercetin standards.

2.4.4 Determination of tannin content

According to Amorim *et al.* (2008), the tannin content was measured by using the Folin-ciocalteu phenol reagent. Firstly, 1 mL of sample extract was mixed with 7.5 mL distilled water and 0.5 mL Folin-Ciocalteu phenol reagent. After that, 1 mL of a 35% sodium carbonate solution was added. The mixture was thoroughly mixed and allowed to rest at room temperature for 30 mins. The absorbance was measured at 725 nm. Instead of the sample, water was used to make the blank. A blank was used to compare a collection of tannic acid standard solutions. Total tannin content was calculated as mg of tannic acid equivalent per 100 g of dried powder extract using the linear equation Y = 0.0075x+0.2132 and R^2 = 0.9993 using a standard tannic acid calibration curve.

2.4.5 Determination of ascorbic acid content

According to Nielsen (2017), the 2, 6-dichlorophenolindophenol titrimetric method was used in the determination of the total ascorbic acid content. To standardize the dye, 5 mL of ascorbic acid was put to a 100 mL conical flask, along with 5 mL of 2% oxalic acid. The mixture was titrated with dye using a micro burette, resulting in a pink tint that lasted for a few minutes. The dye factor was calculated with the following formula.

$$\text{Dye factor} = \frac{0.5}{\text{Titrate volume}}$$

The 5 g of sample was blended with 50 mL of 2% oxalic acid, homogenized and extracted for 20 mins, and made up to 100 mL by 2% oxalic acid. The solution was then filtered and centrifuged for 20 mins at 6000 rpm. At first 10 mL of extract was taken and aliquot it. Then it was titrated with the normal dye until it reached a pink endpoint that lasted 15 s. Then the ascorbic acid content was calculated as per the resulting formula.

$$\text{Ascorbic acid content (mg/100g)} = \frac{\text{titre} \times \text{dye factor} \times \text{final volume}}{\text{aliquot of extract} \times \text{weight of sample}} \times 100$$

https://doi.org/10.26656/fr.2017.7(4).243

2.5 Determination of antioxidant activity

2.5.1 DPPH radical scavenging activity

Method reported by Brand-Williams *et al.* (1995) the DPPH free radical scavenging activity of dragon fruits edible and non-edible portions was determined with slight modification. To prepare stock solution, 24 mg DPPH was dissolved in 100 mL methanol and kept in a refrigeration condition for further use. By diluting the DPPH stock solution with methanol working solution of the radical was prepared to take an absorbance of about 0.98 at 517 nm. Approximately 3 mL DPPH working solution was mixed with 100 µL plant extract in a test tube. At 517 nm for a period of 30 mins absorbance was measured. The following formula was used in calculating the antioxidant.

$$\text{Antioxidant activity (\%)} = \left(\frac{\text{Ac} - \text{As}}{\text{Ac}}\right) \times 100$$

Where, Ac and As indicated the absorbance of control and absorbance of the sample respectively. The control sample contained 100 µL methanol except the plant sample. Then IC_{50} was calculated from the linear equation of the DPPH assay scavenging activity.

2.6 Statistical analysis

The results of each analysis were expressed as the mean ± standard deviation (SD). The data was analyzed by ANOVA with Tukey's Multiple Comparisons Test as a post-hoc test. The 95% confidence threshold was used to determine the significance. The software SPSS Statistics 17.0 was used for statistical analysis and data processing (IBM INC., New York).

3. Results and discussion

3.1 Edible and non-edible portions

From the results, it was observed that the average weight of dragon fruit cultivars differed significantly. According to Table 1, the weight was higher in BAU Dragon Fruit-1 (347 g) than the BARI Dragon Fruit-1 (284 g). It indicated that the average weight of the fruit varied depending on the fruit variety. In contrast, 31.86% to 35.44% peel, 59.74% to 65.08% flesh and 3.06% to 4.82% seed made up the edible and non-edible portions of these dragon fruits. The BAU Dragon Fruit-1 cultivar contained the highest percentage of flesh and the lowest percentage of seed and peel. However, the BARI Dragon Fruit-1 cultivar produced 35.44% peel and 4.82% seed. The BAU Dragon Fruit-1 had the highest flesh to peel ratio (2.04:1), indicating a good recovery rate. The pulp to peel ratio had a negative correlation with peel percentage and a positive relationship with flesh percentage. Commonly dragon fruit is consumed raw as a dessert fruit item, at that time seed and flesh both are edible and peel becomes non-edible. But during processed products like beverages or juice, only pulp is edible and both flesh and seed are regarded as non-edible as well as byproducts. In comparison with BAU Dragon Fruit-1 cultivar, BARI Dragon Fruit-1 presented a higher percentage of non-edible components. When compared to an earlier study by Moo-Huchin *et al.* (2014) who claimed that dragon fruit contained 57.3% edible component. The pulp to peel ratio ranged from 2.69 to 4.81. Hirehalli white and Gujarat red had the lowest pulp to peel ratios among different dragon fruit cultivars 2.69 and 2.77 respectively.

3.2 Physico-chemical properties

3.2.1 Moisture content

Moisture percentages of the edible and non-edible portions of fresh dragon fruit cultivars differed greatly from one another, ranging from 39.37% to 93.91% demonstrated in Table 2. Comparatively, in the peel portion of each cultivar, the treatments RP and WP showed a moisture content of 86.95% and 91.88% respectively. The lowest percentage of moisture obtained in the seed portion, in the treatments of WS and RS ranged from 39.37% to 45.47% respectively. The flesh of BAU Dragon Fruit-1 had the highest moisture content (93.91%) in the treatment WF while BARI Dragon Fruit-1 had the lower (92.34%) in the treatment RF. According to Arivalagan *et al.* (2021), the moisture content of dragon fruit differed from 82.40% to 84.80% independently from cultivar to cultivar, which showed the relevant result with the experiment.

3.2.2 Dry matter content

Dragon fruit cultivars' dry matter content is inversely proportional to their moisture content. According to the data in Table 2, the dry matter content of dragon fruit cultivars ranges from 6.07% to 60.62%. In comparison, BARI Dragon Fruit-1 peel (RP), flesh (RF) and seed (RS) had 13.07%, 6.65% and 54.53% respectively. The higher dry matter content was obtained in the seed

Table 1. Edible and non-edible portions of the dragon fruit cultivars.

Fruit cultivars	Edible and non-edible fruit portions					
	Fruit weight (g)	Peel (%)	Flesh (%)	Seed (%)	Flesh peel ratio	Flesh seed ratio
BARI Dragon Fruit-1	284±5.29^{b}	35.44±0.15^{a}	59.74±0.31^{b}	4.82±0.46^{a}	1.68±2.09^{b}	12.39±0.67^{b}
BAU Dragon Fruit-1	347±4.16^{a}	31.86±0.09^{b}	65.08±0.27^{a}	3.06±0.29^{b}	2.04±2.75^{a}	21.26±0.93^{a}

Values are presented as mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

https://doi.org/10.26656/fr.2017.7(4).243

Table 2. Physico-chemical properties of dragon fruit cultivars in edible and non-edible portions.

Fruit cultivars	Treatments	Physico-chemical properties						
		Moisture content (%)	Dry matter (%)	Ash (%)	TSS (°Bx)	Titrable Acidity (%)	pH	Protein (%)
BARI Dragon Fruit-1	RP	86.95±0.03^{d}	13.07±0.01^{c}	3.56±0.01^{d}	0.50±0.00^{d}	2.74±0.01^{a}	4.90±0.01^{e}	1.08±0.00^{e}
	RF	92.34±0.01^{b}	6.65±0.03^{e}	2.38±0.01^{e}	10.20±0.10^{a}	0.22±0.00^{e}	5.43±0.00^{b}	2.62±0.02^{a}
	RS	45.46±0.00^{e}	54.53±0.01^{b}	3.53±0.02^{c}	0.31±0.01^{e}	1.07±0.01^{c}	4.98±0.01^{f}	1.31±0.01^{c}
BAU Dragon Fruit-1	WP	91.88±0.02^{c}	8.15±0.02^{d}	5.71±0.03^{b}	0.31±0.01^{e}	2.19±0.01^{b}	6.48±0.00^{a}	1.16±0.03^{d}
	WF	93.91±0.01^{a}	6.07±0.03^{f}	2.40±0.00^{e}	8.73±0.05^{b}	0.15±0.00^{f}	5.31±0.00^{c}	2.52±0.01^{b}
	WS	39.37±0.03^{f}	60.62±0.02^{a}	6.02±0.02^{a}	0.80±0.08^{c}	1.06±0.01^{d}	5.01±0.01^{d}	1.30±0.01^{c}

Values are presented as mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different ($p<0.05$). RP: Red peel, RF: Red flesh, RS: Red seed of BARI Dragon Fruit-1; WP: White peel, WF: White flesh, WS: White seed of BAU Dragon Fruit-1.

portion of dragon fruit. All treatments showed substantial differences in each cultivar, with the dry matter content of the flesh section ranging from 6.07% to 6.65% in the WF and RF, respectively.

3.2.3 Ash content

There was a significant variation in ash values between the two dragon cultivars ($p<0.05$) (Table 2). The percentage of ash in each edible and non-edible portion ranged from 2.38% to 6.02%. The BAU Dragon Fruit-1 seed (WS) provided the highest amount of ash content and the lowest in the flesh portion. Each cultivar's ash content in the peel ranged from 3.56% to 5.71%. The flesh portion of each cultivar showed negligible differences in ash content ranging from 2.38% to 2.40% in the treatments RF and WF respectively. There were similarities and differences in the amount of ash among different species of pitaya. It is suspected that the varying ash content of pitaya species is related to differences in growing and harvesting conditions (Lim *et al.,* 2010). According to Chemah *et al.* (2010), the total ash contents of the pitaya species of *H. polyrhizus*, *H. undatus* and *Seleniccreus megalanthus* were 6.1%, 3.1% and 3.8%, respectively that denoted similarities with our observations. According to Khalili *et al.* (2006), the total ash value of red pitaya was 0.7 g/100 g, and its mineral composition would be advantageous to one's health.

3.2.4 Total soluble solids content

The total soluble solids concentration, as shown in Table 2, exhibited significant differences across the treatments. In the treatments, the flesh component of the cultivar BARI Dragon Fruit-1 (RF) has the highest amount of TSS (10.20°Bx), while the seed portion of the same cultivar had the lowest amount of TSS (0.31°Bx). The flesh of the BAU Dragon Fruit-1 cultivar contained less TSS (8.73°Bx) than the BARI Dragon Fruit-1. The negligible amount of TSS was in the peel portion ranging from 0.31 to 0.50°Bx. The TSS concentration of the seed and peel portions, on the other hand, was exceedingly low. Sugars that have dissolved, organic acids, and other soluble components found in fruit make up TSS. Total soluble solid is a sweetness indicator that is mostly regulated by the interaction of soluble sugars and organic acids, but it has no bearing on consumer approval. TSS with a high acidity yields a superb flavor and taste combination with pleasant palatability (Dasenaki and Thomaidis, 2019).

3.2.5 Titrable acidity content

The titrable acidity of the dragon fruit cultivars varied significantly between 0.15% and 2.74% in each edible and non-edible component, as shown in Table 2. The BARI Dragon Fruit-1 cultivar's peel had a larger amount of acidity (2.74%) than the BAU Dragon Fruit-1 cultivar's peel, according to the data (2.19%). In the treatments, WF and RF, the flesh regions of each cultivar had lower acidity than the other portions, ranging from 0.15% to 0.22%. The dragon fruit is particularly enticing to customers because it has a substantial quantity of acidity as well as total soluble solids (Karunakaran *et al.,* 2019).

3.2.6 pH content

According to Table 2, the BAU Dragon Fruit-1 cultivar's peel in the treatment WP had the highest pH (6.48), while the treatment RP had the lowest (4.90) of the same cultivars. On the other hand, a significant quantity of pH ranged from 5.31 to 5.43 in the flesh region of each cultivar in the treatments WF and RF, respectively. Furthermore, the pH content (5.01) of BAU Dragon Fruit-1 cultivar seed was found in the treatment WS, which was greater than that of BARI Dragon Fruit-1 seed (RS). According to Arivalagan *et al.* (2021), the pH of dragon fruit pulp was somewhat acidic, ranging from 4.8 (Hirehalli white) to 5.40 (Long Red), with significant variances among the clones investigated. The pH of red pulped fruits was higher (5.2) than that of white pulped fruits (4.9), indicating that our experiment generated similar results.

https://doi.org/10.26656/fr.2017.7(4).243

3.2.7 Protein content

According to the findings in Table 2, protein content varied substantially between cultivars and different portions, ranging from 1.08% to 2.62%. The flesh sections of the treatments RF and WF had the greatest protein percentages, at 2.62% and 2.52% respectively. The lower protein content was observed in the peel portion of each cultivar in the treatments RP and WP. The study discovered that the entire edible and non-edible portions were high in protein, but the percentage of protein in the seed and peel portions were nearly comparable to the other treatments. The total protein content of the clones in 2021, according to Arivalagan *et al*. (2021) ranged from 0.887% (Hiriyur red) to 1.11% (Andaman white) relevant to our observations.

3.3 Ascorbic acid and bioactive compounds

3.3.1 Ascorbic acid content

The ascorbic acid content of these cultivars varied greatly, ranging from 6.23 to 31.41 mg/100 g, as shown in Table 3. The seed portion of each dragon fruit cultivar contained the most ascorbic acid, with 24.40 and 31.41 mg/100 g in RS and WS treatments, respectively. The BARI Dragon Fruit-1 cultivar had a significant proportion of ascorbic acid in the flesh part in the RF treatment (14.81 mg/100 g). In the peel portion, each treatment had a lower concentration of ascorbic acid, ranging from 6.23 to 8.23 mg/100 g. Choo and Yong (2011) found that ascorbic acid levels were 36.65 mg/100 g fresh pulp in *H. polyrhizus* and 31.05 mg/100 g fresh pulp in *H. undatus*, respectively. Another study discovered 55.8 mg/100 g of ascorbic acid in *Hylocereus sp*., cv. Red Jaina (red skin with red pulp) and 13.0 mg/100 g in *Hylocereus* sp., cv. David Bowie (red skin with white pulp) (Mahattanatawee *et al.*, 2006). As a result, vitamin C levels differ according to the species, crop, origin, stage of fruit ripeness, and technique of extraction (Rahmawati and Mahajoeno, 2009; Ramli and Rahmat, 2014).

3.3.2 Tannin content

Each cultivar of edible and non-edible portions has a large quantity of tannin content, as shown in Table 3. In the RS treatment, the largest level of tannin content (444.64 mg TAE/100 g) was identified in the seed of BARI Dragon Fruit-1 cultivar, and the lowest amount (335.04 mg TAE/100 g) was found in the flesh component of the same cultivar in the RF treatment. The results showed that there was a large quantity of tannin in the peel and flesh of the BAU Dragon Fruit-1 cultivar, with 364.77 mg TAE/100 g, 345.80 mg TAE/100 g and 417.08 mg TAE/100 g in the treatments WP, WF and WS respectively.

3.3.3 Phenolic content

The results of the phenolic content obtained in Table 3 exemplified the significant variations among the treatments. The treatment RP had the lowest phenolic content (105.1 mg GAE/100 g) and the treatment WF had the highest (163.13 mg GAE/100 g). In the seed portion of each cultivar, there was a significant quantity of phenolic content, ranging from 131.32 to 162.86 mg GAE/100 g in the RS and WS treatments, respectively. These results are similar to the findings reported by Mahattanatawee *et al.* (2006). It can be proven that each cultivar's edible and non-edible components comprise a large quantity of phenolic.

3.3.4 Total flavonoid content

The maximum amount of flavonoid was found in the treatment of RP (346.00 mg QE/100 g) and the lowest was in WP (96.72 mg QE/100 g) of the extract, according to Table 3. In the flesh portion of BARI Dragon Fruit-1 cultivar 249.04 mg QE/100 g flavonoid was found which was greater than BAU Dragon Fruit-1 cultivar's flesh. In comparison, each cultivar's edible and non-edible portions had considerable amounts of flavonoids. The levels of phenolic and flavonoids found in this study are similar to those found in a previous study by Moo-Huchin *et al.* (2014).

Table 3. Bioactive compounds content in the edible and non-edible portions of the dragon fruit cultivars.

Fruit cultivars	Treatments	Bioactive compounds			
		Ascorbic acid	Tannin	Phenolic	Flavonoid
BARI Dragon Fruit-1	RP	8.23±0.01^{e}	351.84±0.13^{d}	105.11±0.35^{d}	346.00±3.75^{a}
	RF	14.81±0.03^{c}	335.04±0.38^{e}	148.92±4.97^{b}	249.04±2.01^{b}
	RS	24.40 ± 0.01^{b}	444.64 ± 0.23^{a}	131.32 ± 0.81^{c}	104.02 ± 2.34^{de}
BAU Dragon Fruit-1	WP	6.23±0.02^{f}	364.77±0.24^{c}	125.74±0.96^{c}	96.72±2.75^{e}
	WF	9.99±0.00^{d}	345.80±0.77^{d}	163.13±1.12^{a}	147.16±2.91^{c}
	WS	31.41±0.01^{a}	417.08±0.85^{b}	162.86±0.22^{a}	104.79±1.73^{d}

Values are presented as mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different ($p<0.05$). RP: Red peel, RF: Red flesh, RS: Red seed of BARI Dragon Fruit-1; WP: White peel, WF: White flesh, WS: White seed of BAU Dragon Fruit-1.

https://doi.org/10.26656/fr.2017.7(4).243

3.4 Antioxidant activity

3.4.1 DPPH assay scavenging activity

The total antioxidant activity of the edible and non-edible portions of the cultivar represented significant differences, according to the data in Figure 3. In the treatment of RS and WS, the maximum antioxidant activity was detected in the seed portion of each cultivar, at 91.35% and 91.31%, respectively. The WF treatment had the highest antioxidant scavenging activity (89.75%) compared to the RF treatment (57.02%). Nurliyana *et al.* (2010) employed DPPH assays to assess the radical scavenging activity of *H. polyrhizus* and *H. undatus* pulps and peels, and found that the peels had stronger radical scavenging activity than the pulps in both species, indicating equivalent results to the present research. According to Wiset *et al.* (2012), super red dragon fruit peel has a percentage of DPPH free radical scavenging activity at 79.24% which was relevant to the present findings.

3.4.2 Half-maximal inhibitory concentration (IC_{50})

The half-maximal inhibitory concentration (IC_{50}) indicated the measure of the potency of a substance in inhibiting a specific biological or biochemical function. From the observation, in Figure 4 among the treatments, we found the highest IC_{50} value 309.83 mg/100 g in the seed portion of the treatment RS and the lowest IC_{50} value was 27.91 mg/100 g in the flesh portion of the treatment RF of the BARI Dragon Fruit cultivar. The seed portion of both cultivars represented the maximum amount of IC_{50} value compared to other portions.

4. Conclusion

The inference may be drawn that every edible and non-edible portion of the dragon fruit cultivars produces a large quantity of bioactive components with antioxidant characteristics. Based on the physico-chemical properties, the BARI Dragon Fruit-1 cultivar utmost performed than BAU Dragon Fruit-1. On the other hand, the seed and peel portions of the BAU Dragon Fruit-1 cultivar contained a considerable amount of bioactive compounds and antioxidant properties. According to the current research, the preliminary data on the edible and non-edible portions of Bangladesh's native dragon fruit cultivars provided unambiguous information. At the same time, these findings will make it easier to process both the edible and non-edible portions of dragon fruit, as well as play an important role in product development and byproduct utilization to prepare value-added food products, medicines and cosmetic products.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgments

The authors would like to acknowledge the research cell of Jashore University of Science and Technology, Jashore, Bangladesh for providing the research grant for facilitating analysis cost regarding the study in the laboratory of the Department of Nutrition and Food Technology and Centre for Sophisticated Instrumentation and Research Laboratory (CSIRL).

References

Amorim, E.L.C., Nascimento, J.E., Monteiro, J.M., Peixoto, Sobrinho, T.J.S., Araújo, T.A.S. and Albuquerque, U.P. (2008). A simple and accurate procedure for the determination of tannin and flavonoid levels and some applications in ethnobotany and ethnopharmacology. *Functional Ecosystems and Communities*, 2(1), 88-94.

AOAC (Association of Official Analytical Chemists International). (2005). Official methods of analysis of the Association of Official Analytical Chemists International. 18th ed. Maryland, USA: AOAC.

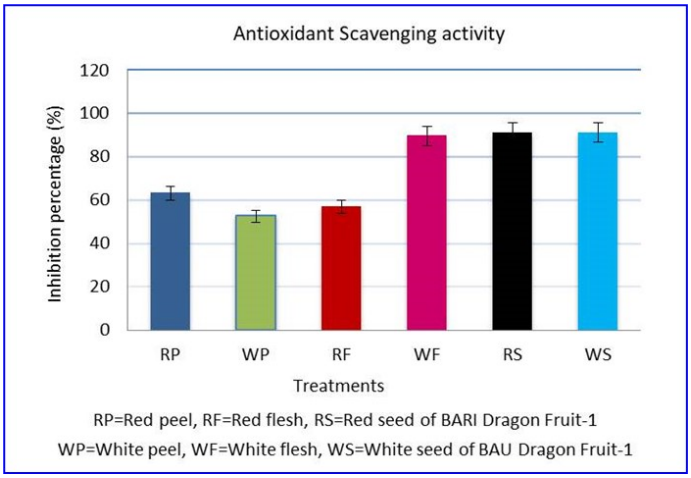

Figure 3. DPPH assay scavenging activity in edible and non-edible portions.

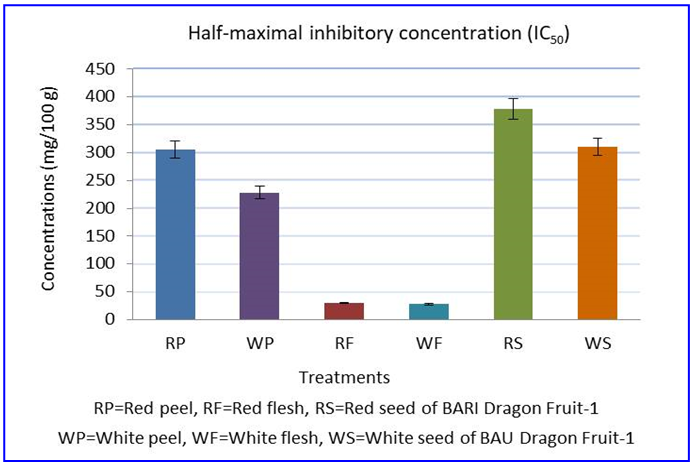

Figure 4. IC_{50} of DPPH assay scavenging activity of different edible and non-edible portions.

https://doi.org/10.26656/fr.2017.7(4).243

Arivalagan, M., Karunakaran, G., Roy, T.K., Dinsha, M., Sindhu, B.C., Shilpashree, V.M., Satisha, G.C. and Shivashankara, K.S. (2021). Biochemical and nutritional characterization of dragon fruit (Hylocereus species). *Food Chemistry*, 353, 129426. https://doi.org/10.1016/j.foodchem.2021.129426

Brand-Williams, W., Cuvelier, M.E. and Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT—Food Science and Technology*, 28(1), 25-30. https://doi.org/10.1016/S0023-6438(95)80008-5

Chang, C., Yang, M., Wen, H. and Chern, J. (2002). Estimation of total flavonoid content in propolis by two complementary colorimetric methods. *Journal of Food and Drug Analysis*, 10(3), 178-182. https://doi.org/10.38212/2224-6614.2748

Chemah, T.C., Aminah, A., Noriham, A. and Aida, W.W.M. (2010). Determination of pitaya seeds as a natural antioxidant and source of essential fatty acids. *International Food Research Journal,* 17(4), 1003–1010.

Choo, W.S. and Yong, W.K. (2011), Antioxidant properties of two species of *Hylocereus* fruits. *Advances in Applied Science Research*, 2(3), 418–425.

Crane, J.H., Balerdi, F.C. and Maguire, I. (2017). Pitaya growing in the home landscape. Florida, USA: University of Florida. Horticultural Sciences department, Florida Cooperative Extension Service. Institute of Food and Agricultural Sciences.

Dasenaki, M. and Thomaidis, N. (2019). Quality and Authenticity Control of Fruit Juices-A Review. *Molecules*, 24(6), 1014. https://doi.org/10.3390/molecules24061014

Ding, T., Ge, Z., Shi, J., Xu, Y.T., Jones, C.L. and Liu, D.H. (2015). Impact of slightly acidic electrolyzed water (SAEW) and ultrasound on microbial loads and quality of fresh fruits. *LWT-Food Science and Technology,* 60(2), 1195–1199. https://doi.org/10.1016/j.lwt.2014.09.012

Franke, A.A., Cluster, L.J., Arakaki, C. and Murphy, S.P. (2004). Vitamin C and flavonoid levels of fruits and vegetables consumed in Hawaii. *Journal of Food Composition and Analysis*, 17(1), 1-35. https://doi.org/10.1016/S0889-1575(03)00066-8

Gunasena, H.P.M., Pushpakumara, D.K.N.G. and Kariyawasam, M. (2007). Dragon fruit, *Hylocereus undatus* (Haw.) Britton and Rose. In Underutilized fruit trees in Sri Lanka, Vol. 1. New Delhi, India: World Agroforestry Centre.

Jamilah, B., Shu, C.E., Kharidah, M., Dzulkifly, M.A. and Noranizan, A. (2011). Physico-chemical characteristics of red pitaya (*Hylocereus polyrhizus*) peel. *International Food Research Journal,* 18(1), 279-286.

Karunakaran, G., Arivalagan, M. and Sriram, S. (2019). Dragon Fruit Country Report From India, presented at the Dragon Fruit Network: Marketing and the Whole Value Chain and Steering Committee Meeting 9-11th September. Vietnam: Y2019 FFTC and VAAS-SOFRI.

Khalili, R.M.A., Norhayati, A.H., Rokiah, M.Y., Asmah, R., Nasir, M.M. and Muskinah, M.S. (2006). Proximate composition and selected mineral determination in organically grown red pitaya (*Hylocereus* sp.). *Journal of Tropical Agriculture and Food Science*, 34(2), 269-275.

Lim, H.K., Tan, C.P., Karim, R., Ariffin, A.A. and Bakar, J. (2010). Chemical composition and DSC thermal properties of two species of Hylocereus cacti seed oil: *Hylocereus undatus* and *Hylocereus polyrhizus*. *Food Chemistry*, 119(4), 1326–1331. https://doi.org/10.1016/j.foodchem.2009.09.002

Mahattanatawee, K., Manthey, J.A., Luzio, G., Talcott, S.T., Goodner, K. and Baldwin, E.A. (2006). Total antioxidant activity and fiber content of select florida -grown tropical fruits. *Journal of Agricultural and Food Chemistry,* 54(19), 7355–7363. https://doi.org/10.1021/jf060566s

McMahon, G. (2003). Pitaya (dragon fruit). Australia: Department of Primary Industry, Fisheries and Mines.

Mercado-Silva, E.M. (2018). Pitaya-*Hylocereus undatus* (Haw). Exotic Fruits Reference Guide, 1st ed. USA: Academic Press. https://doi.org/10.1016/B978-0-12-803138-4.00045-9

Moo-Huchin, V.M., Estrada-Mota, I., Estrada-Leon, R., Cuevas-Glory, L., OrtizVazquez, E., Vargas, M. D.L.V. and Sauri-Duch, E. (2014). Determination of some physicochemical characteristics, bioactive compounds and antioxidant activity of tropical fruits from Yucatan, Mexico. *Food Chemistry,* 152, 508–515. https://doi.org/10.1016/j.foodchem.2013.12.013

Moshfeghi, N., Mahdavi, O., Shahhosseini, F., Malekifar, S. and Taghizadeh, S.K. (2013). Introducing a new natural product from Dragon fruit into the market. *International Journal of Research and Reviews in Applied Sciences,* 15(2), 269-272.

Nielsen, S.S. (Ed.) (2017). Vitamin C Determination by Indophenol Method. In Food Analysis Laboratory Manual, Food Science Text Series. New York, USA: Springer. https://doi.org/10.1007/978-3-319-44127-6

Nurliyana, R.D., Syed Zahir, I., Mustapha Suleiman, K., Aisyah, M.R. and Kamarul Rahim, K. (2010).

Antioxidant study of pulps and peels of dragon fruits: A comparative study. *International Food Research Journal,* 17(2), 367–375.

Patwary, M.M.A., Rahman, M.H., Barua, H., Sarkar, S. and Alam, M.S. (2013). Study on the growth and development of two dragon fruit (*Hylocereus undatus*) genotypes. *The Agriculturists*, 11(2), 52-57. https://doi.org/10.3329/agric.v11i2.17487

Rahmawati, B. and Mahajoeno, E. (2009). Variation of morphology, isozymic and vitamin C content of dragon fruit varieties. *Nusantara Bioscience*, 1, 131–137. https://doi.org/10.13057/nusbiosci/n010305

Ramli, N.S. and Rahmat, A. (2014). Variability in nutritional composition and phytochemical properties of red pitaya (*Hylocereus polyrhizus*) from Malaysia and Australia. *International Food Research Journal,* 21(4), 1689–1697.

Rao, C.C. and Sasanka, V.M. (2015). Dragon Fruit 'The Wondrous Fruit' for the 21st century. *Global Journal for Research Analysis*, 4(10), 261-262.

Rifat, T., Khan, K. and Islam, M.S. (2019). Genetic diversity in Dragon fruit (*Hylocereus* sp.) germplasms revealed by RAPD marker. *The Journal Animal and Plant Science*, 29(3), 809-818.

Sonawane, M.S. (2017). Nutritive and medicinal value of Dragon fruit. *The Asian Journal of Horticulture,* 12 (2), 267-271. https://doi.org/10.15740/has/tajh/12.2/267-271

Trivellini, A., Lucchesini, M., Ferrante, A., Massa, D., Orlando, M., Incrocci, L. and Mensuali-Sodi, A. (2020). Pitaya, an Attractive Alternative Crop for Mediterranean Region. *Agronomy*, 10(8), 1065. https://doi.org/10.3390/agronomy10081065

Wall, M.M. (2006). Ascorbic acid, vitamin A, and mineral composition of banana (*Musa* sp.) and papaya (*Carica papaya*) cultivars grown in Hawaii. *Journal of Food Composition and Analysis*, 19(5), 434-445. https://doi.org/10.1016/j.jfca.2006.01.002

Wiset, L., Poomsa-ad, N. and Srilaong, V. (2012). Comparisons of antioxidant activity and bioactive compounds of dragon fruit peel from various drying methods. *World Academy of Science, Engineering and Technology*, 6(10), 943-946.

Wootton Beard, P.C., Moran, A. and Rayan, L. (2011). Stability of the total antioxidant capacity and total polyphenol content of 23 commercially available vegetable juices before and after *in vitro* digestion measured by FREP, DPPH, ABTS and Folin-Ciocalteu methods. *Food Research International*, 44 (1), 217-224.

