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Effect of Disease Incidence on Physical and Biochemical Parameters of Dragon Fruit under Variable Storage Environments

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ABSTRACT

The present study was conducted at ICAR-National Institute of Abiotic Stress Management (ICAR-NIASM), Baramati (Pune) in collaboration with School of Agriculture, Lovely Professional University, Phagwara (Punjab). In order to determine the effect of disease incidence on physical and biochemical parameters of dragon fruit under variable storage environments, the experiment was designed as a completely randomized block design with four replications of five fruits each. As a result of the study, at anthracnose spore inoculated area white dragon fruit had a greater length of the fruit, a larger diameter of the fruit, and a larger weight of the fruit (161.10 g). When fruit kept at non-inoculated area, similar results were also reported for fruit length (80.32 cm), fruit diameter (65.24 cm), and fruit weight (171.09 g). However, biochemical parameters, such as TSS (12.02°Brix), non-reducing sugar (4.56 %), reducing sugar (5.20 %), total phenol (244.50 mg/GAE/100 g), and total flavonoids (72.00 mg CE/100 g) were better for red dragon fruit compared to white dragon fruit.

Key words: *Anthracnose, Inoculated, Biochemical, Physical parameter, Spore*

Introduction

Dragon fruit (*Hylocereus spp.*), also known as pitaya, is an exotic fruit that has gained significant popularity worldwide due to its unique appearance, nutritional benefits, and potential economic opportunities. Dragon fruit is a tropical fruit known for its vibrant colors, refreshing taste, and rich nutritional profile (Bordoh *et al.*, 2020). Its growing popularity among consumers has resulted in increased commercial cultivation worldwide (Guo *et al.*, 2014). To meet the demand, dragon fruit is often harvested and stored before reaching the consumer market. However, during storage, the fruit is susceptible to various diseases, including (*Colletotrichum* spp.) anthracnose, which can lead to significant post-harvest losses (Balendres and Bengoa, 2019). Anthracnose is a fungal disease that affects various parts of the dragon fruit, including the stem, branches, and fruit (Cannon *et al.*, 2012). The disease manifests as small, dark-colored lesions on the fruit's surface, which gradually enlarge and may become sunken. *Colletotrichum* spp not only affects the fruit's visual appearance but also causes changes in its physical and biochemical attributes. These alterations can have detrimental effects on the fruit's quality, shelf

life, and market value (Rao *et al.*, 2015).

Anthracnose disease incidence can significantly affect the physical characteristics of dragon fruit. Infected fruits may exhibit visible symptoms such as weight loss, decay loss, loss in length and diameter, browning, shriveling, and softening (Liu *et al.*, 2006). The severity of the disease can vary, ranging from superficial skin lesions to extensive rotting, leading to complete fruit decay. These physical changes can render the fruit unmarketable and result in significant economic losses for growers and suppliers (Ngoc *et al.*, 2014). Apart from the physical changes, *Colletotrichum spp* can also affect the biochemical composition of dragon fruit. The disease may lead to alterations in the fruit's sugar content, acidity levels, vitamin content, phenol, flavonoids, and antioxidant properties (Rodeo *et al.*, 2018). These changes can impact the fruit's taste, nutritional value, and overall consumer acceptance. Moreover, anthracnose-infected fruit may exhibit reduced post-harvest shelf life, as the disease promotes the breakdown of cell walls and accelerates fruit deterioration (Zahid *et al.*, 2019).

The storage environment plays a crucial role in the development and progression of anthracnose disease in dragon fruit. Factors such as temperature, humidity, and ethylene levels can either exacerbate or mitigate disease incidence and progression (Zakaria *et al.*, 2021). On the other hand, proper storage conditions, such as controlled temperature and humidity, can help minimize disease development and preserve the quality of dragon fruit (Awang *et al.*, 2011). Understanding the impact of anthracnose disease under variable storage environments is essential for implementing effective disease management strategies and optimizing storage conditions to minimize post-harvest.

Materials and Methods

Study site

The study was carried out at research area ICAR-National Institute of Abiotic Stress Management (NIASM), Baramati (Maharashtra) located at 18° 09′ 30.62′′N latitude 74° 30′ 03.08′′E longitude with an altitude of 570 m above mean sea level. Baramati receives an average annual rainfall of 659 mm distributed over the months of June to September with an average temperature ranging from minimum 13.0°C to maximum 33.7°C.

Experimental detail

The Experiment was carried out in a completely randomized block design (CRD) with four replications. Comprising of red and white colored dragon fruit, kept at anthracnose spore inoculated and non-inoculated area. Different physical and biochemical parameters such as fruit length, width, weight, physiological loss in weight (PLW), decay loss, TSS, total sugar, reducing sugar, non-reducing sugar, phenol, flavonoids, and antioxidant etc. were determined to evaluate the effect of disease incidence on physical and biochemical parameters of dragon fruit under variable storage environments.

Physical parameters

An electronic vernier caliper (Mitutoyo company, Japan) was used to measure fruit length(cm) from stem end to bract end in centimeters, while an electrical weighing balance (Baker company, India) was used to measure fruit weight at harvest to assess physiological losses in weight after shelf life.

Similarly, decay loss (%) in fruits was evaluated by visual observation to evaluate over ripening during fruit storage using the following formula:

Decay loss (%) = [(Number of rotted fruits) / (Total number of fruits)] X 100

The estimation of physiological loss in weight and decay losses percentage under anthracnose spore inoculated and non-inoculated area would be helpful for the determination of final shelf life of the produce.

Biochemical parameters

The biochemical parameters are: TSS, total sugar, reducing sugar, non-reducing sugar, ascorbic acid, total phenol, total flavonoids, antioxidants etc. Were evaluated in red and white dragon fruit under both anthracnose spore inoculated and non-inoculated area.

Total soluble solids (°Brix)

As per the protocol designed by AOAC, 1965 (Milwaukee Electronics, US), the amount of total soluble solids (TSS) in the red and white dragon fruit was measured with the aid of a digital refractometer.

Total sugar (%)

In 1923, Lane and Eynon developed a method for estimating juice sugars. Two ml of lead acetate

(45%), 100 ml of distilled water, and 10 ml of red and white dragon fruit juice were combined in a conical flask. In 250 ml of distilled water, potassium oxalate (22%), was added two days after the potassium oxalate (22%). After 24 hours, 50 ml of the sample was treated with 5 ml of concentrated HCl. The boiling solution in Fehling's experiment contained Methylene blue indicator. The burette was used to titrate juice samples. Following is a formula we used to calculate total sugar content (%):

$$\text{Total sugars (\%)} = \frac{\text{Fehling's solution Factor} \times \text{Dilution made} \times 100 \times 100}{\text{Titer volume} \times \text{Weight of sample taken} \times 50}$$

Reducing sugar (%)

Rangana (1977) describes Lane and Eyon's titrimetric method for estimating reduced sugar. A conical flask containing 100 ml of distilled water and 100 ml of juice was filled with two ml of lead acetate (45%). After two days, 1.9 ml potassium oxalate (22%) was added, followed by 250 ml distilled water. In this sample, 50 ml of HCl was added for 24 hours. The sample was made up to 100 ml and neutralized again the following day after neutralization with 40% NaOH. Using juice samples in the burette, Fehling's solution was titrated using Methylene blue indicator. For calculating the total sugar content (%), the following formula was used:

$$\text{Total reducing sugars\%} = \frac{\text{Mg. of invert sugar} \times \text{final vol. made up} \times \text{original volume} \times 100}{\text{TR} \times \text{Wt. of sample} \times \text{aliquot taken for inversion} \times 1000}$$

Ascorbic acid (mg/100 g)

A titrate method was developed by Albert Szent-Gyorgyi to determine ascorbic acid using 2, 6-dichlorophenol-indophenol dye. Alkaline or acid solutions containing ascorbic acid reduce this dye to a colorless state (Ranganna, 1977). For measuring ascorbic acid, use the following reagents: 3% Metaphosphoric acid (HPO_3): 100 ml of distilled water with 3 g of HPO_3 sticks. By dissolving 100 mg of L-ascorbic acid in 100 ml of 3% HPO_3 and diluting it ten times with 3% HPO_3, a standard ascorbic acid was prepared. It is mixed with 5 ml of ascorbic acid and 5 ml of HPO_3 and titrated against the dye until a pink color appears and persists for at least 15 seconds. The dye factor can be calculated using the following formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre value of standard}}$$

Using a mortar and pestle, five grams of bitter gourd fruit were homogenized in 100 ml of 3% HPO_3. After titrating with 2, 6-dichlorophenol-indophenol dye for 15 seconds after filtering with Whatman No. 1 filterpaper, a 10 ml aliquot was taken from the sample and titrated with 2, 6-dichlorophenol-indophenol dye. The observations were recorded and expressed in mg $100g^{-1}$.

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{vol. made up (mL)} \times 100}{\text{Aliquot (mL)} \times \text{weight or volume of sample (g)}}$$

Total Phenols (mg/GAE/100 gm.)

According to Singleton and Rossi (1965), Folin-Ciocalteu reagent and 630 nm absorbance measurements were used to determine the total phenolic content of the reaction mixture. The results were expressed as catechol equivalents. In 50 ml Falcon tubes, dragon fruit samples weighing 0.5 g were taken. The tubes were shaken overnight with 10 ml of 80% methanol. The sample was centrifuged at 5000 RPM for five minutes. A second tube was used to remove the supernatant. 10 ml of 80% methanol was added to the extract after shaking and centrifuging. For vortexing, test tubes were kept after that. For 30 minutes, 2 ml of 20 % Na_2CO_3 was added to a test tube. The absorbance was measured at 630 nm. By using Gallic acid as a standard, the total phenol content was calculated and expressed as mg of Gallic acid (GA) equivalent per gram of fresh weight sample.

$$\text{Total Phenols (mg/100g)} = \frac{\text{OD} \times \text{Vol. made up} \times 100}{0.02 \times \text{wt. of sample taken} \times \text{aliquot} \times 100}$$

Total flavonoid (mg CE /100 g)

The total flavonoids were estimated using a colorimetric method by Zhishen *et al.* (1999). An extract of the sample was added to a volumetric flask containing 4 ml of distilled water and 10 ml of distilled water. 0.3 ml of 5% $NaNO_2$ was added to this mixture and allowed to stand for five minutes at room temperature. After 0.3ml of 10% $AlCl_3.6H_2O$ was added, it was allowed to stand for 6 minutes at room temperature. The solution was diluted to the desired volume (10 ml) with IN NaOH and the absorbance of the solution was measured immediately at 510 nm versus the blank. Using a standard curve (absorbance versus concentration), results were expressed as catechin equivalents (CE).

Antioxidant (DPPH) (%)

The antioxidant activity of fruit juice was deter-

mined by its ability to scavenge the DPPH free radical (Brand-Williams *et al*., 1995). In 70% methanol, DPPH reagent and sample were prepared. The optical density at 517 nm was measured using 100 l of sample and 3.9 ml of DPPH using a UV-Vis spectrophotometer (UVD-3200, Labomed, Inc., Culver City, USA). The supernatant was used for further analysis after centrifuging the homogenate for 20 minutes at 10,000 rpm. In a test tube, 200 liters of sample were combined with 4.5 ml of ethanol, 800 ml of Tris-HCl, and 1 ml of DPPH solution. After 30 minutes, the absorbance at 517 nm was measured. Using following equation, the data obtained was analyzed:

Results and Discussion

Physical Parameters

Fruit Length (cm)

In fruit length there was a significant variation was observed among red and white different dragon fruit species. A higher final fruit length (80.32cm) was observed for white fleshed fruit in comparison to red fleshed dragon fruit (71.29 cm) at anthracnose spore inoculated area. Similarly, a higher fruit length was also observed for white fleshed fruit (80.17 cm) over red fleshed dragon fruit (64.03 cm) even fruit kept in non-inoculated area (Table 1). This may be due to there is a possibility that the anthracnose infection in white dragon fruit may cause the fruit to elongate more in response to the disease. Alternatively, cultivars more susceptible to anthracnose may have been bred for longer fruit. It is possible that this explains the difference observed (Mohd, 2010).

Fruit diameter (cm)

The date present in (Table 2) reveals a significant variation among two dragon fruit species, i.e. red and white fleshed dragon fruit for fruit diameter. It was observed that white fleshed dragon fruit had significantly higher fruit diameter (65.24 cm) in comparison to red fleshed dragon fruit (57.999 cm) at anthracnose spore inoculated area. Similar results were also observed for white fleshed dragon fruit (57.45 cm) over red fleshed dragon fruit. (51.44 cm) when fruit kept in non-inoculated area. This may be due to the fact that dragon fruit size is influenced by various factors, such as genetics, growing conditions, fertilization, and pest and disease management. Due to this, it is unlikely that Anthracnose alone could explain the significant difference between red and white dragon fruits (Prashanth *et al*., 2022).

Fruit weight (g)

The significant variation was also observed among two different dragon fruit species for fruit weight. White fleshed dragon fruit reported more fruit weight (161.10 g) in comparison to red fleshed

Table 1. Fruit length for anthracnose spore inoculated and non-inoculated fruits of red and white dragon fruit

Anthracnose	Initial Length		Final Length		Percentage Loss in Length %	
	White	Red	White	Red	White	Red
Inoculated	87.80 ± 1.24	75.72 ± 1.24	80.32 ± 1.13	71.29 ± 1.13	8.28 ± 0.09	8.78± 0.09
Non-Inoculated	84.24 ± 1.24	66.82 ± 1.24	80.17 ± 1.13	64.03 ± 1.13	3.07 ± 0.09	3.93 ± 0.09
Mean	86.02	71.27	84.74	70.66	5.67	6.36
CD (0.05)	Factor A	3.873.87NS	3.513.51NS	0.290.29NS		
Factor B						
A×B						

Table 2. Fruit diameter for anthracnose spore inoculated and non-inoculated fruits of red and white dragon fruit

Anthracnose	Initial diameter		Final diameter		Percentage Loss in Width %	
	White	Red	White	Red	White	Red
Inoculated	74.56 ± 0.94	63.58 ± 0.94	65.24 ± 0.84	57.99 ± 0.84	7.58 ± 0.09	9.59 ± 0.09
Non-Inoculated	61.67 ± 0.94	61.21 ± 0.94	57.45 ± 0.84	51.44 ± 0.84	3.90 ± 0.09	4.28 ± 0.09
Mean	68.12	62.39	61.34	54.72	5.74	6.94
CD (0.05)	Factor A	2.94	2.61	0.30		
	Factor B	2.94	2.61	0.30		
	A×B	4.16	NS	0.43		

dragon fruit (158.69 gm.) when kept at anthracnose spore inoculated area and (171.09 gm.) fruit weightwhen fruit kept at non-inoculated area over red fleshed dragon fruit (141.11.40 gm). (Table 3). It is possible that there are minor differences in fruit size and weight between dragon fruit cultivars, including white and red variants. There are many variables that may influence these variations, such as genetics, environmental conditions, and management practices. Anthracnose susceptibility varies between cultivars. This might potentially impact the size and weight of the fruit on affected plants Ali *et al.* (2013).

Physiological Loss in Weight (%)

For the purpose of observing Physiological Loss of Weight, significant variation was seen between two different species of dragon fruit for red and white fleshed dragon fruits. A maximum Physiological Loss in weight (15.65%) was reported for white dragon fruit as compare to red dragon fruit (12.29 %) at anthracnose spore inoculated area. Similarly, a maximum Physiological Loss in Weight observed when fruit kept in non-inoculated area. (8.95 %) for white dragon fruit over red dragon fruit (6.74 %) (Table 4). This might be due to resistance of fruit peel towards fruit deteriorating fungi, such as anthracnose. Also, variations in the fruit's internal structure can be another contributing element. Compared to red dragon fruit, white dragon fruit has softer, more permeable flesh. This could make it more susceptible to fungus infection and cause greater physiological weight loss Zakaria *et al.* (2021).

Decayloss (%)

The date present in (Table 4) reveals a significant variation among two dragon fruit species i.e. red and white fleshed dragon fruit for decay loss percentage. It was observed that red fleshed dragon fruit had significantly higher decay loss percentage (12.99 %) in comparison to white fleshed dragon fruit (9.99 %) at anthracnose spore inoculated area. Similar result was also observed for red fleshed dragon fruit (4.99 %) over white fleshed dragon fruit. (3.99 %) when fruit kept at non-inoculated area. This may be due to the fact that red pulped dragon fruit may be more susceptible to anthracnose infection than white dragon fruit. This could be due to differences in the chemical composition or physical structure of the fruit. This may make red dragon fruit more vulnerable to fungal attack. In addition, some studies suggest red dragon fruit may be more vulnerable to cracking and other physical damage. This can create entry points for fungal pathogens like those that cause anthracnose Bordoh *et al.* (2020).

Table 3. Fruit weight for anthracnose spore inoculated and non-inoculated fruits of red and white dragon fruit

Anthracnose	Initial Weight		Final Weight		Percentage Loss in Weight %	
	White	Red	White	Red	White	Red
Inoculated	215.60 ± 2.82	167.19 ± 2.82	161.10 ± 2.32	158.69 ± 2.32	15.65 ± 0.16	12.29 ± 0.16
Non -Inoculated	189.54 ± 2.82	152.20 ± 2.82	171.09 ± 2.32	141.11 ± 2.32	8.95 ± 0.16	6.74 ± 0.16
Mean	202.57	155.19	166.09	154.40	12.30	9.52
CD (0.05)	Factor A	8.79	7.23	0.51		
	Factor B	8.79	7.23	0.51		
	A×B	12.44	10.22	0.72		

Table 4. Physiological loss in weight and decay loss for anthracnose spore inoculated and non-inoculated fruits of red and white dragon fruit

Anthracnose	Decay %		Physiological Loss in Weight	
	White	Red	White	Red
Inoculated	9.99 ± 0.12	12.99 ± 0.12	15.65 ± 0.16	12.29 ± 0.16
Non- Inoculated	3.99 ± 0.12	4.99 ± 0.12	8.95 ± 0.16	6.74 ± 0.16
Mean	7.49	8.49	12.30	9.52
CD (0.05)	Factor A	0.39	0.51	
	Factor B	0.39	0.51	
	A×B	0.56	0.72	

Biochemical parameter

Total soluble solids (TSS) (°Brix)

A significant variation in total soluble solid (TSS) of red and white fleshed dragon fruit was observed when fruit kept at anthracnose spore inoculated and non-inoculated area. The data revealed that there was a significant reduction in TSS of red fleshed dragon fruit for anthracnose spore inoculated area and it ranged from 12.02°Brix to 10.87°Brix and similar result, were also observed for white dragon fruit when kept at anthracnose spore inoculated area (10.65°Brix) and non-inoculated area (8.62°Brix) (Table 5). According to studies, betacyanins work as natural antioxidants and have antibacterial properties that can fight against a variety of diseases, including fungus. It's probable that red dragon fruit's betacyanin content aids in the fruit's defence against Anthracnose infection, allowing it to maintain a greater TSS concentrationthan white dragon fruit (Awang *et al.*, 2011).

Ascorbic acid (mg/100 g)

The data pertaining to ascorbic acid content in dragon fruit has been presented in Table 5. The result revealed a higher and significant variation among red and white fleshed dragon fruit for ascorbic acid content. It was observed that when kept at anthracnose spore inoculated area a higher value of ascorbic acid (9.61 mg/100 g) was obtained in red dragon fruit over white dragon fruit (9.05 mg/100 g). However, when fruit kept at non-inoculated area there was a minimal variation for ascorbic acid in red dragon fruit (9.15 mg/100 g) whereas, it dropped down to (8.69 mg/100 g) in white dragon fruit. This may be due to the Ascorbic acid levels may have been higher in red dragon fruit because of higher antioxidant levels, such as betacyanins, which give red dragon fruit its vibrant color. In addition to protecting the fruit from damage caused by anthracnose infection, antioxidants could potentially preserve vitamin C levels. Additionally, it is possible that the higher vitamin C content in red dragon fruit is simply due to genetic variation between the two varieties, as different dragon fruit varieties can have varying levels of vitamin C, even under normal growing conditions, and this can also be observed under anthracnose-infected conditions (Aziz *et al.*, 2018).

Total sugar (%)

Calculating the total sugar content of red and white fleshed dragon fruits reveals that there is significant variation between the two dragon fruit species. At anthracnose spore inoculated area, red fleshed dragon fruit had the lowest total sugar content (9.34%) and white fleshed dragon fruit had the highest total sugar content (9.77%). Similarly, even at non-inoculated area, white fleshed dragon fruit has more total sugar (9.37%) than red fleshed dragon fruit (8.78%) (Table 6). There may be a difference in sugar content due to variations in how the two types of dragon fruit respond to anthracnose infection. In white dragon fruit, certain enzymes or metabolic pathways may increase sugar production, but in red dragon fruit, a different response may occur (Dutra *et al.*, 2018).

Reducing sugar (%)

Two different species of dragon fruit were found to have significant variation, according to observations that were recorded for estimating reducing sugar. The results revealed that red dragon fruit (5.20%) had greater value than white dragon fruit (4.85%) for reducing sugar when they were inoculated with anthracnose spore. Even when kept in non-inoculated area the red dragon fruit had a higher percentage of reducing sugar (4.41%) than white dragon

Table 5. TSS and Ascorbic acid (Vitamin-C) present in red and white dragon fruit in anthracnose spore inoculated and non-inoculated fruits

Anthracnose	TSS		Ascorbic acid	
	White	Red	White	Red
Inoculated	10.65 ± 0.15	12.02 ± 0.15	9.05 ± 0.13	9.61 ± 0.13
Non- Inoculated	8.62 ± 0.15	10.87 ± 0.15	8.69 ± 0.13	9.15 ± 0.13
Mean	9.63	11.45	8.87	9.38
CD (0.05)	Factor A	0.47	0.41	
	Factor B	NS	0.41	
	A×B	0.67		NS

fruit (4.28%) (Table 6) this may be due to Reducing sugars are a type of carbohydrate readily metabolized and can be measured in a variety of ways. Studies have found that both red and white dragon fruit can be infected with Anthracnose, resulting in a higher level of reducing sugars. The increase is generally greater in red dragon fruit. Red and white dragon fruit may have different chemical compositions, which may explain this difference. There are more betacyanins and betaxanthins in red dragon fruit. These pigments may interact with the fungal infection in a way that leads to a higher reducing sugar content. (Zahid *et al.,* 2019).

Non-reducing sugar (%)

The date present in (Table 6) reveals a significant variation among two dragon fruit species, i.e. red and white fleshed dragon fruit for non-reducing sugar. It was observed that white fleshed dragon fruit had significantly higher non-reducing sugar (4.56 %) in comparison to red fleshed dragon fruit (4.48 %) when fruit kept at anthracnose spore inoculated area. Similar result were also observed for white fleshed dragon fruit (5.08 %) over red fleshed dragon fruit. (4.36 %) at non-inoculated area (Table 6). It may be due to the fact that red dragon fruit infected with Anthracnose have lower non-reducing sugar levels than white dragon fruit. There might be a difference in the fruit's metabolism and response to infection. Complex sugars are more difficult for the body to break down and use for energy than simple sugars like glucose and fructose. Thus, consumers may not find an increase in non-reducing sugars in dragon fruit to be desirable (Arivalagan *et al.,* 2021).

Total Phenol (mg/GAE/100 g)

Two different species of dragon fruit showed significant variance in total phenols. At anthracnose spore inoculated area, red dragon fruit had a higher value for total phenol (244.50 mg/GAE/100 g) than white dragon fruit (182.75 mg/GAE/100 g), which was seen to be Similar to this, red dragon fruit had a higher value for total phenol (212.00 mg/GAE/100 g) than white dragon fruit (168.50 mg/GAE/100 g), even when kept at non-inoculated area (Table 7). It may be due to differences in phenolic content in the two varieties. The phenolic compounds in red dragon fruit are higher than in white dragon fruit even under normal conditions. When both varieties of dragon fruit are infected with anthracnose, the red dragon fruit's higher phenolic content may result in a greater increase in phenolic content than the white dragon fruit. It is also possible that the anthracnose fungus may elicit a stronger response in red dragon fruit than in white dragon fruit, resulting in

Table 6. Total sugar, reducing sugar and non-reducing sugar for anthracnose spore inoculated and non-inoculated fruits of red and white dragon fruit

Anthracnose	Total Sugar		Reducing Sugar		Non reducing sugar	
	White	Red	White	Red	White	Red
Inoculated	9.77 ± 0.13	9.34 ± 0.13	4.85 ± 0.06	5.20 ± 0.06	4.56 ± 0.06	4.48 ± 0.06
Non-Inoculated	9.37 ± 0.13	8.78 ± 0.13	4.28 ± 0.06	4.41 ± 0.06	5.08 ± 0.06	4.36 ± 0.06
Mean	9.57	9.06	4.74	4.63	4.82	4.42
CD (0.05)	Factor A	0.420.42NS	NS 0.210.29	0.20NS 0.29		
	Factor B					
	A×B					

Table 7. Total phenol, flavonoids and antioxidant content for anthracnose spore inoculated and non-inoculated fruits of red and white dragon fruit

Anthracnose	Phenol		Flavonoids		Antioxidant (DPPH)	
	White	Red	White	Red	White	Red
Inoculated	182.75 ± 2.99	244.50 ± 2.99	69.00 ± 0.94	72.00 ± 0.94	0.58 ± 0.00	0.62 ± 0.00
Non- Inoculated	168.50 ± 2.99	212.00 ± 2.99	58.00 ± 0.94	61.00 ± 0.94	0.44 ± 0.00	0.51 ± 0.00
Mean	175.62	228.25	63.50	66.50	0.51	0.56
CD (0.05)	Factor A	9.349.34NS	2.942.94NS	0.020.02NS		
	Factor B					
	A×B					

a higher phenolic content. There could be differences in how the two varieties respond to fungal infection, such as differences in gene expression or immune system function (Arivalagan *et al.* 2019).

Total Flavonoids (mg CE /100 g)

Observation recorded for calculating value for total flavonoids shows that the significant difference among two different dragon fruit species. At when fruit inoculated with anthracnose spore, it was found that red dragon fruit has a substantially higher flavonoid content (72.00 mg CE/100 g) than white dragon fruit (61.00 mg CE /100 g). Similar to this, even when fruit kept at non-inoculated area, a higher value for total flavonoids was found for red-fleshed dragon fruit (61.00 mg CE/100 g) than for white-fleshed dragon fruit (58.00 mg CE/100 g). In the case of red dragon fruit, anthracnose can increase flavonoid production, which contributes to its distinctive red color. A white dragon fruit, on the other hand, does not contain as much pigment, so anthracnose may not have as noticeable an effect on the fruit's appearance. Furthermore, red dragon fruit contains higher levels of flavonoids than white dragon fruit. The red pigment in the fruit, betacyanin, is a flavonoid, so red dragon fruit naturally contains more flavonoids (Ankita *et al.*, 2022).

Antioxidant (DPPH %)

The data pertaining to antioxidant content in dragon fruit has been presented in Table 7. The result revealed a higher and significant variation among red and white fleshed dragon fruit for antioxidant content. It was observed that when fruit kept at anthracnose spore inoculated area a higher value of antioxidant (0.62 %) was obtain in red dragon fruit over white dragon fruit (0.58 %). However, at non-inoculated area there was a minimal variation for antioxidant in red dragon fruit (0.51 %) whereas, it dropdown to (0.44 %) in white dragon fruit. Studies have shown that red dragon fruit has higher levels of antioxidants than white dragon fruit, even under normal conditions. When infected with anthracnose, the difference in antioxidant content between the two varieties becomes more pronounced. As a defense mechanism, the red dragon fruit produces even more antioxidants when stressed by the pathogen, possibly because it has a higher baseline level of antioxidants (Hu *et al.*, 2019).

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