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Research article

Chitosan Coating Maintains Postharvest Quality and Extends Shelf Life of Dragon Fruit (*Hylocereus spp.)*

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A B S T R A C T

Although dragon fruit is gaining popularity worldwide, its postharvest management remains a major challenge due to rapid quality deterioration under ambient conditions. This study investigated the effect of chitosan coating on the postharvest quality and shelf life of three dragon fruit varieties (pink-, white-, and yellow-fleshed) using four concentrations of chitosan solution (control, 0.1%, 0.3%, and 0.5%) in a Completely Randomized Design with three replications. Significant variations were observed in physico-chemical parameters, including weight loss, firmness, total soluble solids, titratable acidity, vitamin C, total flavonoid and carotenoid contents, antioxidant activity, and shelf life. At 9 days after storage, pink-fleshed fruits coated with 0.5% chitosan exhibited the best quality attributes—lowest weight loss (3.2%), lowest TSS (10.67 °Brix), and highest firmness, vitamin C, flavonoid, carotenoid, and antioxidant levels—resulting in a shelf life extension to approximately 17 days, compared to 9 days in uncoated fruits. The findings highlight the novel use of 0.5% chitosan as a natural, biodegradable coating for maintaining the quality of dragon fruits under ambient storage, offering a practical and sustainable alternative for postharvest management where cold storage facilities are limited.

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Introduction

Dragon fruit (*Hylocereus* spp.)—also known as pitaya, pitahaya, strawberry pear and thang loy—is an exotic fruit produced by epiphytic, night blooming *Hylocereus species*. It is an oblong, oval fruit having bright red skin covered with green bracts or scales and non-climacteric in nature (Lobo et al., 2013; Paull, 2011) and the best quality is ensured if harvested at full red color (Nerd et al.,1999). The red purple or white flesh is delicate and sweet with numerous black tiny seeds and can be enjoyed as a fresh fruit or juice. It is commercially cultivated in Israel, Vietnam, Taiwan, Nicaragua, Australia, Malaysia, Thailand, Philippines and the United States (Merten, 2003). It is a popular fruit worldwide due to its elegant flavor, vivid color and diverse nutrient content. Among different species of dragon fruits, *H. undatus*, *H. costaricensis* and *H. megalanthus*, and their hybrids contributes lion share of the worldwide production. It has numerous health benefits including regulation of blood sugar, asthma, chronic cough, free radicals, and improvement of eye health (Luu et al., 2021). However, fruits are metabolically active living goods and therefore, highly perishable (Palumbo et al., 2022), As they undergo series of ripening and senescence processes (Palumbo et al., 2022), a bulk of fruits never reach to the consumers. Almost 40% fruits are wasted during handling and distribution at postharvest (Elik et al., 2019). In Bangladesh, a lot of dragon fruits are lost due to high temperature, humidity, and faulty postharvest management (Khatun et al., 2022).

Postharvest losses of fruits remain a major challenge in tropical and subtropical regions, limiting profitability and food security. Several strategies have been developed to minimize these losses, including the use of chitosan coatings (Asha et al., 2025; Aziz et al., 2021; Dhali et al., 2025; Munira et al., 2024, 2025; Prashanth et al., 2022; Parvin et al., 2023), improved packaging materials (Azene et al., 2014), modified atmosphere storage (Irtwange, 2006), calcium chloride treatments (Dhali et al., 2024;

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Dovel, 2018; Lekhon et al., 2024; Madani et al., 2014), aloe vera gel coatings (Shah & Hashmi, 2020; Jodhani & Nataraj, 2021), plant extracts (Kabir & Hossain, 2024), and chitin nanofibers (Bagchi et al., 2025; Munira et al., 2025). Among these, chitosan, a natural polysaccharide obtained through the deacetylation of chitin, has emerged as one of the most promising biopolymers for postharvest fruit preservation. Chitosan's film-forming ability, antimicrobial activity, biodegradability, and biocompatibility make it a sustainable alternative to synthetic preservatives (Lin et al., 2011; Terry & Joyce, 2004; Fisk et al., 2008). Its semi-permeable film acts as a protective barrier that limits oxygen diffusion, moisture loss, and respiration rate, thereby slowing ripening and senescence (Shi et al., 2013). By regulating permeability to water vapor, oxygen, and carbon dioxide, chitosan coatings help maintain internal fruit physiology, reduce microbial decay, and extend shelf life (Li & Yu, 2000).

Previous research has demonstrated the broad efficacy of chitosan across fruit species. In dragon fruit, coatings enhanced firmness, delayed changes in titratable acidity and total soluble solids, and extended storage life (Prashanth et al., 2022). Similarly, a 10% chitosan formulation prolonged guava shelf life by seven days through delayed ripening (Krishna & Rao, 2014). Studies in jujube and 'Neelumbori' mango reported that a 0.5% chitosan coating effectively reduced weight loss, disease incidence, and quality degradation under ambient conditions (Asha et al., 2025; Dhali et al., 2025). A comprehensive review by Munira et al. (2024) confirmed that chitosan consistently delays physicochemical deterioration, suppresses microbial infection, and preserves fruit quality across species. Despite its proven potential, limited information exists on the effectiveness of chitosan in maintaining postharvest quality of dragon fruit (Hylocereus spp.) under ambient storage conditions, where refrigeration is often unavailable. As dragon fruit gains commercial importance, developing an eco-friendly coating strategy is essential to reduce postharvest losses. Therefore, the present study was undertaken to evaluate the effects of different chitosan concentrations on the postharvest quality attributes and shelf life of dragon fruits under ambient conditions.

Materials and Methods

Experimental site and design

The experiment was carried out from 6 August to 23 August 2023 with the three varieties of dragon (pink, white and yellow) fruits and four levels of chitosan coating. The fruits were harvested at the commercial maturity stage, and they were selected when the peel color had uniformly changed from green to their respective mature hues (bright red, deep pink, or yellow), and the bracts exhibited a greenish-yellow tinge at the tips, indicating physiological maturity suitable for postharvest handling (Hoa et al., 2006). This stage typically occurs 28–35 days after flowering (anthesis), depending on cultivar and growing conditions. Fruits were collected from Jhikargacha, Jashore of Bangladesh and brought to Laboratory. The two-factors experiment was planned following a Completely Randomized Design (CRD) with three replications. Chitosan was extracted from the shrimp shell at the Forestry and Wood Technology Laboratory, Khulna University, Bangladesh. To prepare 1% stock solution of chitosan, 5 g chitosan was dissolved in 250 ml distilled water. About 240 ml vinegar was added to make the final volume 500 ml and mixed thoroughly. From 1% solution, 0.1%, 0.3%, and 0.5% solutions were prepared for the treatment. Fully matured, quality fruits were washed with tap water and air-dried. Each variety of dragon fruits (pink, white, and yellow) was divided into four groups, and each group contains seven fruits, i.e., there are seven fruits per treatment. To apply the treatments, fruits were dipped in the solution for 10 minutes and stored at ambient condition. The control set of fruits did not receive any treatments.

Determination of weight loss

Weight loss of dragon fruit was calculated according to the following formula (Kabir and Hossain, 2024; Munira et al., 2025).

$$\text{Weight loss } (\%) = \frac{M_0 - M_1}{M_0} \times 100 \qquad (1)$$

Here, M_0 and M_1 represent fresh weight of fruit at day 1 and at a particular day (such as day 5), respectively.

Firmness measurement

Firmness was measured with Shimadzu EZ-SX, USA texture analyzer with a cylindrical probe having a diameter of 2 mm. The probe was inserted 5 mm at a speed of 2 mms^{-1}. The maximum force firmness (N) was calculated from the force vs time curve (Lekhon et al., 2024).

Determination of TSS and TA

To determine total soluble solids (TSS), one drop of extracted dragon fruit juice was put on the refractometer prism and the reading was recorded (Asha et al., 2025; Dhali et al., 2024).

Titratable acidity (TA) was measured through the titration (Munira et al., 2025) as

$$\text{TA } (\%) = 100 \times \frac{d \times 0.064 \times c}{a \times b} \qquad (2)$$

Where,
a = sample weight, b = aliquot volume, c = final volume made with distilled water, d = mean burette reading. Titration factor: 0.064 (as 0.064 g citric acid is neutralized by 1 ml 0.1 N NaOH).

Determination of vitamin C content
Vitamin C content is determined (Nerdy, 2028; Munira et al., 2025) as

$$\text{Vitamin C (mg/100g)} = \frac{e \times d \times b}{c \times a} \quad (3)$$

Where, *a* is weight of sample, *b* is final volume (upon adding metaphosphoric acid), *c* is volume of aliquot, *d* is dye factor, and *e* represents mean reading of burette.

Determination of total flavonoid
To measure total flavonoid content, 10 g finely rushed fruit pulp was added with 100 ml of 80% methanol, incubated in a water bath (40 °C) for 10 hours, filtered, and the filtrate was evaporated to dryness in a water bath at room temperature. The remaining were weighed to determine the total flavonoid.

Determination of antioxidant activity
Amount of antioxidant was determined and expressed as DPPH (%).

$$\text{DPPH Scavenged (\%)} = ((A_C - A_S) / A_S) \times 100 \quad (4)$$

Where,
A_C = absorbance measured three times at 517 nm for control
A_S = absorbance measured three times at 517 nm for the test samples with dragon pulp extract

Determination of total carotenoid
Total carotenoid was determined according to the following formula.

$$\text{Carotenoid content} = (7.6\,(A480) - 1.49\,(A510) \times d \times FW \times 1000)\ \text{mg g}^{-1}\ \text{FW} \quad (5)$$

Here,
A = Absorbance of the specific wave length.
FW = Fresh weight of the dragon pulp extracted
d = Length of the path of light (1 cm)

Determination of shelf life
Shelf life was determined based on days of storage. The observation was started from the first day of harvesting until the fruits of all treatments lost their consumable condition.

Statistical analysis
Data were subjected to a two-way analysis of variance (ANOVA) using statistical software Statistix-10 and means were separated following Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Results

Physical attributes of dragon fruit

Weight loss of fruits
Weight loss of dragon fruits increased progressively throughout the storage period across all varieties and treatments (Table 1). A significant interaction effect between chitosan concentration and fruit variety was observed at all days after storage (DAS). At 9 DAS, the highest weight loss (8.67%) occurred in white-fleshed uncoated fruits, whereas the lowest (3.24%) was recorded in pink-fleshed fruits coated with 0.5% chitosan, which was statistically comparable to those coated with 0.3% chitosan. Similar trends were observed across earlier storage intervals, indicating that chitosan coating, particularly at higher concentrations, effectively reduced postharvest weight loss regardless of fruit variety.

Table 1: The combined effect of dragon fruit varieties and chitosan levels on the weight loss of fruit at different days after storage (DAS)

Treatments	Weight loss (%)			
Interaction (A×B)	3 DAS	5 DAS	7 DAS	9 DAS
V_1T_1	0.55e	1.12def	2.54g	4.97fg
V_1T_2	0.53e	1.05efg	2.42g	4.63g
V_1T_3	0.53e	1.00fg	2.06h	3.56h
V_1T_4	0.45f	0.95g	1.75i	3.24h
V_2T_1	0.84a	2.11a	4.76a	8.67a
V_2T_2	0.81a	2.06a	4.61b	7.66b
V_2T_3	0.75b	2.05a	4.58b	7.33b
V_2T_4	0.73bc	1.89b	4.35c	7.31b
V_3T_1	0.68cd	1.34c	3.60d	6.70c
V_3T_2	0.67d	1.21cd	3.08e	6.21d
V_3T_3	0.67d	1.17def	3.00e	5.62e
V_3T_4	0.66d	1.14def	2.80f	5.35ef
Level of significance	*	**	**	**
CV (%)	5.05	6.41	2.43	3.98

*V_1, V_2, and V_3 are Pink, White, and Yellow fleshed dragon fruits, respectively. T_1, T_2, T_3, and T_4 represent no chitosan (control), 0.1%, 0.3%, and 0.5% chitosan, respectively. * and ** indicate 5% and 1% level of significance, respectively. CV means coefficient of variation.*

Firmness of fruits

The interaction effects of chitosan coating and varieties were significant regarding firmness at all DASs except 5 (Table 2). At 9 DAS, the highest firmness (3.07 N) was found in pink fleshed fruits coated with 0.5% chitosan and the lowest firmness (2.28 N) was reported for uncoated white fleshed fruits which was statistically similar to white fleshed fruits coated with 0.5% chitosan and yellow fleshed uncoated fruits (Table 2).

Table 2: The combined effect of dragon fruit varieties and chitosan levels on firmness of dragon fruit at different days after storage (DAS)

Treatments	Firmness (N)			
Interaction: A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	5.12cd	3.28	3.04efg	2.64bc
V_1T_2	5.30abcd	3.40	3.13de	2.96ab
V_1T_3	5.22bcd	4.17	3.99a	3.02a
V_1T_4	5.65a	4.30	4.01a	3.07a
V_2T_1	4.22g	3.10	2.81g	2.28d
V_2T_2	5.48ab	3.34	3.08ef	2.46cd
V_2T_3	5.37abc	3.92	3.36bcd	3.07a
V_2T_4	4.35fg	4.12	3.41bc	2.24d
V_3T_1	4.66ef	3.28	2.82fg	2.24d
V_3T_2	4.99de	3.40	3.02efg	2.44cd
V_3T_3	5.14bcd	3.93	3.16cde	2.91ab
V_3T_4	5.08cd	4.16	3.59b	2.88ab
Level of significance	**	NS	*	*
CV (%)	4.07	2.35	4.78	7.18

*V_1, V_2, and V_3 are Pink, White, and Yellow fleshed dragon fruits, respectively. T_1, T_2, T_3, and T_4 represent no chitosan (control), 0.1%, 0.3%, and 0.5% chitosan, respectively. * and ** indicate 5% and 1% level of significance, respectively and NS indicates nonsignificant. CV means coefficient of variation.*

Chemical properties of dragon fruits

Total soluble solids (TSS) of fruits

A significant interaction between chitosan concentration and fruit variety was observed for total soluble solids (TSS) at all days after storage (DAS) (Table 3). At 9 DAS, the highest TSS value (20.56%) was recorded in uncoated white-fleshed fruits, whereas the lowest (10.67%) was observed in pink-fleshed fruits coated with 0.5% chitosan. This pattern indicates that chitosan coating, particularly at higher concentrations, effectively delayed the increase in TSS, thereby slowing the ripening process of dragon fruits during storage.

Table 3: The combined effect of dragon fruit varieties and chitosan levels on TSS of dragon fruit at different days after storage (DAS)

Treatments	TSS (ºBrix)			
Interaction A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	11.80h	12.43h	13.98i	15.10i
V_1T_2	11.70h	12.20i	13.87j	11.98j
V_1T_3	11.40i	12.14i	12.96k	11.20k
V_1T_4	11.30i	11.42j	11.67l	10.67l
V_2T_1	18.50a	18.85a	19.34a	20.56a
V_2T_2	18.13b	18.61b	19.13b	19.98b
V_2T_3	18.00b	18.42c	18.94c	19.08c
V_2T_4	17.31c	18.12d	18.36d	17.89d
V_3T_1	15.90d	16.54e	16.89e	17.00e
V_3T_2	15.60e	16.30f	16.71f	16.40f
V_3T_3	15.30f	16.26f	16.50g	16.20g
V_3T_4	14.75g	14.87g	14.90h	15.89h
Level of significance	**	**	**	**
CV (%)	0.58	0.48	0.26	0.6

*V_1, V_2, and V_3 are Pink, White, and Yellow fleshed dragon fruits, respectively. T_1, T_2, T_3, and T_4 represent no chitosan (control), 0.1%, 0.3%, and 0.5% chitosan, respectively. ** indicate 1% level of significance. CV means coefficient of variation.*

Titratable acidity (TA) of fruits

The interaction effect of chitosan coating and varieties were found significant for TA at 7 and 9 DAS (Table 4). At 9 DAS, the lowest TA value (0.13%) was recorded from pink fleshed fruits coated with 0.5% chitosan and the highest TA (0.33%) was observed in white fleshed uncoated fruits (Table 4).

Table 4: The combined effect of dragon fruit varieties and chitosan levels on TA of dragon fruit at different days after storage (DAS)

Treatments	TA (%)			
Interaction A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	0.37	0.35	0.24e	0.21efg
V_1T_2	0.34	0.30	0.22e	0.20fg
V_1T_3	0.31	0.26	0.21e	0.18g
V_1T_4	0.30	0.24	0.20e	0.13h
V_2T_1	0.50	0.42	0.37a	0.33a
V_2T_2	0.46	0.42	0.35ab	0.31ab
V_2T_3	0.45	0.40	0.34ab	0.31ab
V_2T_4	0.45	0.38	0.33abc	0.29abc
V_3T_1	0.43	0.37	0.32bcd	0.28bcd
V_3T_2	0.40	0.36	0.31bcd	0.25cde
V_3T_3	0.40	0.36	0.30cd	0.24def
V_3T_4	0.40	0.35	0.29d	0.24def
Level of significance	NS	NS	*	*
CV (%)	7.10	7.64	8.72	10.40

*V_1, V_2, and V_3 are Pink, White, and Yellow fleshed dragon fruits, respectively. T_1, T_2, T_3, and T_4 represent no chitosan (control), 0.1%, 0.3%, and 0.5% chitosan, respectively. * indicates 5% level of significance and NS indicates nonsignificant. CV means coefficient of variation.*

Vitamin C of fruits

Vitamin C content of dragon fruits varied significantly due to the interaction effects of varieties and treatments. At 9 DAS, the highest vitamin C (19.61 mg $100g^{-1}$) was found in pink fleshed fruits coated with 0.5% chitosan and the lowest (5.85 mg $100g^{-1}$) was observed in white fleshed uncoated fruits (Table 5).

Table 5: The combined effect of dragon fruit varieties and chitosan levels on vitamin C of dragon fruit at different days after storage (DAS)

Treatments	Vitamin C (mg/100g FW)		
Interaction: A×B	3DAS	7DAS	9DAS
V_1T_1	5.95ghi	5.58h	6.90fg
V_1T_2	8.15ef	12.80bc	12.5c
V_1T_3	16.25b	13.92b	15.80b
V_1T_4	23.70a	20.95a	19.61a
V_2T_1	5.25gh	5.62h	5.85g
V_2T_2	7.8efg	8.95g	7.84ef
V_2T_3	11.50cd	10.62defg	10.65cd
V_2T_4	12.15c	13.55b	10.93cd
V_3T_1	5.75gh	5.95h	6.75fg
V_3T_2	7.3fgh	9.52fg	9.6de
V_3T_3	9.8de	9.67fg	11.33cd
V_3T_4	13.0c	12.27bcd	11.55c
Level of significance	**	**	**
CV (%)	12.98	10.93	10.56

*V_1, V_2, and V_3 are Pink, White, and Yellow fleshed dragon fruits, respectively. T_1, T_2, T_3, and T_4 represent no chitosan (control), 0.1%, 0.3%, and 0.5% chitosan, respectively. ** indicate 1% level of significance. CV means coefficient of variation.*

Total flavonoid of fruits

Total flavonoid content of fruits differed significantly among the varieties, treatments, and interactions of varieties and treatments (Table 6). The highest total flavonoid (23.97 mg $100g^{-1}$) was observed in pink fleshed fruits coated with 0.5% chitosan which was statistically similar to pink fleshed fruits coated with 0.3% chitosan (23.3 mg $100g^{-1}$) and the lowest total flavonoid (1.67 mg $100g^{-1}$) was measured from white fleshed uncoated fruits at 9 DAS (Table 6). A very similar flavonoid content trend was also reported for other DASs (Table 6).

Table 6: The combined effect of dragon fruit varieties and chitosan levels on total flavonoid of dragon fruit at different days after storage (DAS)

Treatments	Total flavonoid (mg/100g FW)			
Interaction A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	4.50c	4.06ef	3.84g	3.55g
V_1T_2	14.66b	14.01cd	13.55d	12.08e
V_1T_3	25.79a	25.02a	24.64a	23.83a
V_1T_4	25.85a	25.05a	24.62a	23.97a
V_2T_1	4.43c	3.57f	2.09h	1.67j
V_2T_2	4.43c	4.04ef	3.58g	3.03h
V_2T_3	14.62b	14.38c	13.94d	13.65d
V_2T_4	25.70a	24.93a	24.04b	22.57b
V_3T_1	4.47c	4.24e	3.61g	2.52i
V_3T_2	14.45b	13.67d	12.80e	11.86e
V_3T_3	14.77b	13.59d	11.50f	10.38f
V_3T_4	25.73a	24.13b	23.22c	21.54c
Level of significance	**	**	**	**
CV (%)	10.40	2.34	2.22	1.95

*V_1, V_2, and V_3 are Pink, White, and Yellow fleshed dragon fruits, respectively. T_1, T_2, T_3, and T_4 represent no chitosan (control), 0.1%, 0.3%, and 0.5% chitosan, respectively. ** indicate 1% level of significance. CV means coefficient of variation.*

Antioxidant of fruits

The antioxidant activity, expressed as DPPH scavenging percentage, declined progressively with increasing storage duration. Significant variations were observed among fruit varieties, chitosan treatments, and their interactions (Table 7). At 9 DAS, the highest antioxidant activity (67.50%)

was recorded in pink-fleshed fruits coated with 0.5% chitosan, which was statistically comparable to those coated with 0.3% chitosan, while the lowest activity (23.02%) occurred in uncoated white-fleshed fruits. Similar patterns were consistent across other storage intervals, indicating that chitosan coating effectively preserved antioxidant capacity of dragon fruits under ambient conditions.

Table 7: The combined effect of dragon fruit varieties and chitosan levels on antioxidant of dragon fruit at different days after storage (DAS)

Treatments	**DPPH (%)**			
Interaction: A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	36.20c	33.93e	32.20d	30.37d
V_1T_2	70.10ab	60.40c	54.70c	50.07c
V_1T_3	70.00ab	69.20ab	68.01a	66.03a
V_1T_4	70.90a	69.50a	68.03a	67.50a
V_2T_1	36.10c	35.06e	28.07e	23.02f
V_2T_2	69.83ab	57.63d	54.10c	51.70c
V_2T_3	70.83ab	68.20ab	67.09ab	65.30a
V_2T_4	69.77ab	66.97b	65.20b	62.10b
V_3T_1	36.30c	33.02e	29.10e	25.90e
V_3T_2	36.80c	34.70e	33.41d	32.90d
V_3T_3	69.70b	68.01ab	67.60ab	67.00a
V_3T_4	70.77ab	68.97ab	67.00ab	66.50a
Level of significance	**	**	**	**
CV (%)	1.15	2.62	2.85	3.03

*V_1, V_2, and V_3 are Pink, White, and Yellow fleshed dragon fruits, respectively. T_1, T_2, T_3, and T_4 represent no chitosan (control), 0.1%, 0.3%, and 0.5% chitosan, respectively. ** indicate 1% level of significance. CV means coefficient of variation.*

Total carotenoid of fruits

Total carotenoid content declined progressively during storage, mirroring the trend observed in antioxidant activity, and exhibited significant differences among fruit varieties, chitosan treatments, and their interactions (Table 8). At 9 days after storage (DAS), the highest carotenoid content (28 mg 100 g^{-1}) was recorded in pink-fleshed fruits treated with 0.5% chitosan, statistically comparable to those treated with 0.3% and 0.1% chitosan. In contrast, the lowest content (15.03 mg 100 g^{-1}) was observed in uncoated white-fleshed fruits. This pattern was consistent across earlier storage intervals (3, 5, and 7 DAS) under ambient conditions.

Table 8: The combined effect of dragon fruit varieties and chitosan levels on total carotenoid of dragon fruit at different days after storage (DAS)

Treatments	**Total carotenoid (mg/100g FW)**			
Interaction: A×B	3DAS	5DAS	7DAS	9DAS
V_1T_1	29.73ab	28.00ab	26.60a	23.00b
V_1T_2	30.20a	28.60a	27.03a	26.40a
V_1T_3	30.20a	29.50a	28.40a	26.70a
V_1T_4	30.70a	30.00a	28.50a	28.00a
V_2T_1	18.00d	17.00c	16.60d	15.03de
V_2T_2	18.30d	17.30c	17.20cd	16.10cd
V_2T_3	29.67ab	25.97ab	21.43b	16.20cd
V_2T_4	30.40a	26.07ab	21.70b	17.20c
V_3T_1	18.20d	17.50c	17.67cd	16.50cd
V_3T_2	22.27cd	19.13c	16.67d	13.13e
V_3T_3	25.57bc	24.10b	19.80bc	16.57cd
V_3T_4	30.40a	28.50a	28.00a	27.80a
Level of significance	**	*	**	**
CV (%)	10.37	10.45	7.76	6.31

*V_1, V_2, and V_3 are Pink, White, and Yellow fleshed dragon fruits, respectively. T_1, T_2, T_3, and T_4 represent no chitosan (control), 0.1%, 0.3%, and 0.5% chitosan, respectively. * and ** indicate 5% and 1% level of significance, respectively. CV means coefficient of variation.*

Shelf-life of fruits

Shelf life of dragon fruit was significantly influenced by chitosan treatments (Fig. 1), with the longest duration observed in fruits coated with 0.5% chitosan (16.67 days), followed by 0.3% (13.56 days) and 0.1% (11.67 days) concentrations. Uncoated fruits exhibited the shortest shelf life (9.11 days). No significant variation in shelf life was detected due to fruit variety or the interaction between variety and treatment (data not shown).

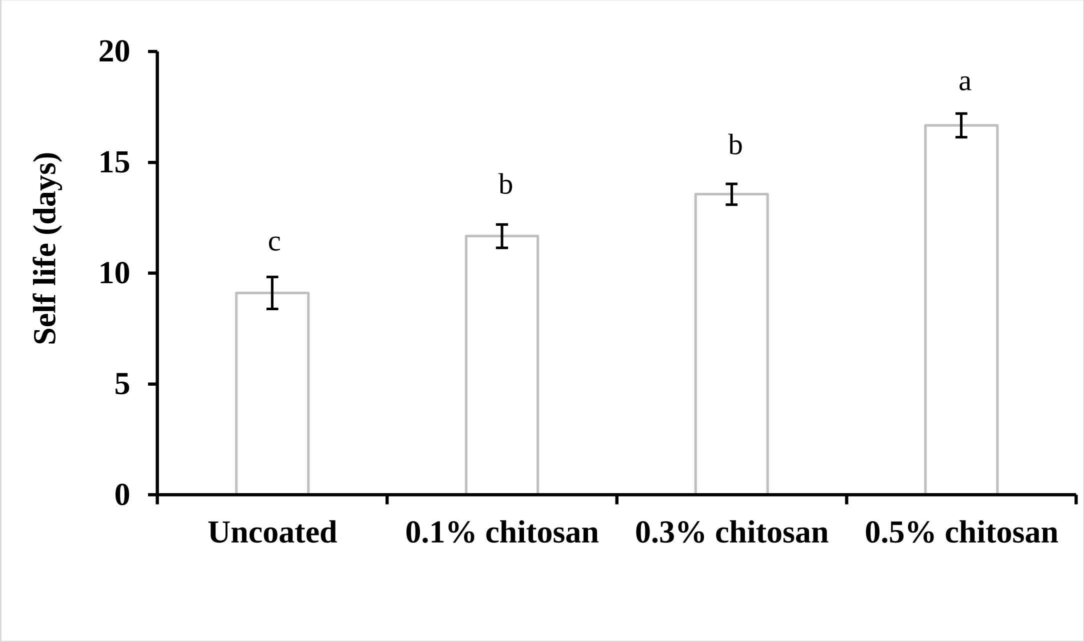

Figure 1: Shelf life of dragon fruits as affected by different chitosan concentrations under ambient storage conditions. The treatments included uncoated fruits (control), 0.1% chitosan, 0.3% chitosan, and 0.5% chitosan coatings. Each value represents the mean ± standard error (SE) of three replications. Chitosan-coated fruits, particularly at 0.5% concentration, exhibited a markedly longer shelf life compared to uncoated fruits.

Discussion

The varietal response to chitosan coating varied, with the pink-fleshed dragon fruit exhibiting the lowest weight loss and highest firmness retention at a 0.5% chitosan concentration. Such variation is attributed to inherent differences among fruit varieties in peel thickness, cuticle composition, and respiration rate, which influence coating adhesion and gas exchange dynamics (Parvin et al., 2023). The 0.5% chitosan concentration was selected based on its ability to form an optimal semi-permeable film that effectively reduces water loss and delays softening, without impeding respiration or altering the fruit's surface appearance. Lower concentrations tend to form inadequate barriers, while higher concentrations may result in excessive coating thickness, potentially leading to undesirable physiological effects (Adiletta et al., 2019). It is important to note that postharvest weight loss and firmness retention are also strongly influenced by storage conditions, particularly ambient temperature and relative humidity. In this study, fruits were stored under typical room conditions (approximately 25 °C and 70–80% RH), which are known to accelerate moisture loss and senescence in tropical fruits. Under such conditions, the effectiveness of chitosan coatings becomes especially critical. Similar results have been reported in dragon fruit, banana, and mango, where 0.5% chitosan consistently minimized weight loss and preserved firmness by forming a thin, translucent layer that moderates moisture loss, respiration, and ethylene diffusion (Adiletta et al., 2019; Parvin et al., 2023; Prashanth et al., 2022; Sikder & Islam, 2019).

Chitosan coating demonstrated a significant influence on the biochemical composition and storage physiology of dragon fruit. The gradual increase in total soluble solids (TSS) and titratable acidity (TA), accompanied by a decline in vitamin C during fruit maturation, is consistent with normal ripening behavior. However, fruits coated with chitosan exhibited a slower rate of change in these parameters, indicating delayed ripening and senescence. Similar trends have been reported for dragon fruit and banana, where chitosan delayed the alteration of TA and TSS (Hesami et al., 2021; Prashanth et al., 2022). This effect can be attributed to the semi-permeable nature of the chitosan film, which acts as a barrier to oxygen diffusion, thereby reducing respiration and metabolic activity (Jiang & Li, 2001). Moreover, the coating helps to maintain organic acid content by retarding oxidative degradation (Gao et al., 2018), a mechanism also noted in mango and other climacteric fruits (Reddy et al., 2000; Kumar et al., 2021).

Chitosan also plays a protective role in preserving vitamin C, one of the most sensitive antioxidant compounds in fruits. The reduction in ascorbic acid loss in coated fruits may result from limited oxygen permeability and the inhibition of oxidative enzymes responsible for vitamin C degradation (Bal, 2018). Similar preservation effects were observed in banana and mango (Parvin et al., 2023; Nga & Bac, 2021), suggesting that chitosan can maintain antioxidant integrity by reducing oxidative stress during storage. The flavonoid and carotenoid contents of dragon fruit are closely linked to ripening and oxidative metabolism. Typically, flavonoid levels increase up to the mid-ripe stage and decline thereafter (Garcia-Cruz et al., 2013). Chitosan coatings may slow down flavonoid degradation by regulating fruit surface temperature and reducing oxygen availability (Riva et al., 2020; Silva et al., 2018). Since carotenoids are susceptible to oxidative degradation following harvest (Ali et al., 2013), the barrier properties of chitosan likely contribute to maintaining their stability. Similar effects have been documented where edible coatings delayed the loss of total anthocyanins, phenolics, and antioxidant activity by reducing the breakdown rate of key metabolites such as fructose and citric acid during storage (Ghasemnezhad et al., 2013; Gao et al., 2018). Collectively, these findings reinforce that chitosan acts as an effective postharvest coating by reducing respiration, transpiration, and microbial infection, which together contribute to prolonged shelf life (Sikder & Islam, 2019; Hossain & Iqbal, 2016). The effectiveness of this coating has been confirmed in other tropical fruits including banana and papaya (Dotto et al., 2015; Prashanth et al., 2022).

However, this study was conducted only under ambient conditions and did not consider different storage environments or coating formulations that may influence fruit physiology. Additionally, the study was limited to selected concentrations of chitosan and did not assess microbial load or enzymatic activity, which are critical to fully understanding the preservation mechanism. Future research should therefore focus on evaluating chitosan coatings under controlled temperature and humidity, exploring nanocomposite or bioactive chitosan formulations, and incorporating microbiological and enzymatic analyses to develop a more comprehensive understanding of its mode of action in dragon fruit and other high-value tropical fruits.

Conclusion

This study demonstrates the potential of chitosan coating as an effective postharvest treatment to preserve the quality and extend the shelf life of dragon fruits under ambient conditions. Among the tested treatments, 0.5% chitosan applied to pink-fleshed dragon fruits showed the most promising results, suggesting that both varietal characteristics and coating concentration are key determinants of postharvest performance. The findings highlight the practical applicability of chitosan as a biodegradable, eco-friendly coating suitable for small-scale and commercial storage systems where cold facilities are limited. Future research should focus on optimizing coating formulations, integrating nanocomposite or bioactive additives, and evaluating performance under different environmental and packaging conditions to develop a robust, sustainable postharvest management strategy for dragon fruits and other tropical fruits.

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Conflict of Interest

The authors declare no conflict of interest

Credit Author Statement

AP: Methodology, Investigation, Writing – original draft; MAM: Supervision, Conceptualization, Analysing, Writing – review & editing, Fund acquisition; MYK: Co-supervision; Writing – review & editing

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