International Journal of Horticultural Science and Technology
Journal homepage: https://ijhst.ut.ac.ir

Chitosan Improves Postharvest Quality Attributes of Neelumbori Mango (*Mangifera indica* L. cv. Neelumbori)

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ARTICLE INFO

Article history:

Received: 25 July 2024,
Received in revised form: 25 October 2024,
Accepted: 5 January 2025

Article type:

Research paper

Keywords:

Chemical quality,
Decay incidence,
Decay severity,
Physicochemical attributes,
Shelf life,
Weight loss

ABSTRACT

Mango is a widely cultivated tropical fruit in Bangladesh, but its high perishability limits its storability and shelf life, resulting in significant postharvest losses. Chitosan has shown potential for preserving fruit quality and extending the postharvest life of mangoes. This study aimed to evaluate the effects of different chitosan concentrations on mango fruit quality, including shelf life. The experiment was conducted on 'Neelumbori' mangoes at Khulna University, Bangladesh, using a completely randomized design with four chitosan treatments (0.1%, 0.3%, 0.5%, and an untreated control), each replicated three times. Various physicochemical and microbial attributes, including shelf life, were assessed. Compared to the control, the 0.5% chitosan treatment effectively reduced cumulative fruit weight loss (17.1% vs. 24.5%), disease incidence (26.7% vs. 80.0%), and disease severity (48.3% vs. 81.7%), while extending shelf life (10.42 d vs. 8.82 d). Chitosan also helped maintain fruit color attributes, total soluble solids, and titratable acidity. However, vitamin C content fluctuated across treatments. Overall, the 0.5% chitosan concentration was the most effective in preserving fruit quality and prolonging shelf life. Further research is recommended to determine the optimal chitosan concentration for mango preservation.

Abbreviations: Analysis of variance (ANOVA), Bangladesh Bureau of Statistics (BBS), Blueness or yellowness (b*), Chromacity (C*), Cultivar (cv.), Days after treatment (DAT), Food and Agriculture Organization Statistics (FAOSTAT), Honestly Significant Difference (HSD), Hue angle (h°), Lightness (L*), Microcomputer Statistical Package (MSTAT), National Science and Technology (NST), Redness or greenness (a*), Relative humidity (RH), Titratable Acidity (TA), Total Soluble Solids (TSS)

Introduction

Fruits are highly valued in the human diet as they are rich sources of essential vitamins (e.g., A, B, and C) and minerals (e.g., iron, calcium, and iodine) (Pokhrel, 2021). However, they are highly perishable and susceptible to decay and damage due to natural ripening, enzymatic reactions, and microbial attacks, significantly reducing their storability and transportability (Hu et al., 2017; Duan et al., 2019). Additionally, premature harvesting and inadequate postharvest handling can accelerate fruit deterioration, leading to substantial postharvest losses (Adhikari and Aarati, 2021; Pokhrel, 2021; The Business Standard, 2021).

Mango (*Mangifera indica* L.), often referred to as the "king of fruits," belongs to the Anacardiaceae family and is widely appreciated for its unique taste, color, aroma, and nutritional value (Purseglove, 1972; Candolle, 1984). Bangladesh, with its favorable soil and climatic conditions, is a major mango producer, ranking first in the country's fruit production and seventh globally (BBS, 2019). The country produces approximately 1.44 million tons of mangoes annually from an area of 122,498 hectares (FAOSTAT, 2020). Mangoes are rich in antioxidants, energy, carbohydrates, fats, vitamins A, C, and B6, fiber, copper, magnesium, and potassium. However, they are highly prone to postharvest issues such as browning, off-flavor development, decay, and texture breakdown, leading to significant losses (Le et al., 2022).

In Bangladesh, approximately 24% of mangoes, worth BDT 36 billion, are wasted each season due to poor postharvest management (The Business Standard, 2021). Under optimal storage conditions at 13°C, mangoes can have a shelf life of up to three weeks (Carrillo-Lopez et al., 2000). Various postharvest treatments, including thermal treatments, synthetic polymer packaging, irradiation, plant extracts, calcium chloride, nitric oxide, sulfur dioxide, antimicrobial and anti-browning agents, ozone, and ethylene scrubbers, are used to extend shelf life and reduce spoilage (El-Ramady et al., 2015; Kabir and Hossain, 2024). However, some postharvest techniques, such as chemical treatments, thermal processing, and cold storage, may negatively impact fruit flavor, taste, color, and texture, while also posing potential health risks (De Kock et al., 2020; Panghal et al., 2018; Shah et al., 2023).

Given the need for safe and eco-friendly preservation techniques, chitosan presents a promising alternative. Chitosan is a non-toxic, biodegradable, and environmentally friendly organic polysaccharide derived from the deacetylation of chitin (Verlee et al., 2017). Its film-forming ability, biodegradability, biocompatibility, and antimicrobial properties—effective against bacteria, fungi, algae, and mold—make it a potential solution for maintaining fruit quality and extending shelf life (Lin et al., 2011; Terry and Joyce, 2004; Fisk et al., 2008).

Due to its unique physicochemical characteristics, chitosan can reduce transpiration and limit oxygen uptake from the surrounding air, thereby significantly prolon fruit shelf life (Shi et al., 2013). Its semipermeable film-forming capacity alters the internal fruit environment by regulating permeability to water, oxygen, and carbon dioxide. This modification helps reduce transpiration and respiration rates, inhibits mold growth, slows fruit ripening, and preserves overall quality (Li and Yu, 2000). When effectively applied as a coating, chitosan can extend storage life while preventing physical and chemical deterioration (Shi et al., 2013).

Furthermore, chitosan delays the ripening of fruits by decreasing water loss, color development, respiration, decay, and microbial attack and increases physical appearance, leading to extended shelf life (Shiekh et al., 2013). Few or no reports are available regarding postharvest preservation of 'Neelumbori' mango using chitosan. Therefore, this study assessed the effects of chitosan concentration on fruit appearance, texture, flavor, nutritive value and shelf life of mango cv. 'Neelumbori'.

Material and methods

Experimental site and climate

The experiment was conducted from July 25 to August 3, 2022, at the Horticulture Laboratory of Khulna University, Bangladesh. During the study period, the storage room conditions were hot and humid. The average maximum and minimum air temperatures were 30.42°C and 29.29°C, respectively. Afternoon relative humidity (RH) ranged from 79% to 87%, with an average of 82.6% (Table 1).

Experimental material

Mango (*Mangifera indica* L. cv. 'Neelumbori') fruits were harvested in the morning from Satkhira, a renowned mango-producing district, and immediately transported to the Horticulture Laboratory at Khulna University using an air-cooled vehicle. Special care was taken during transportation to prevent any physical damage. Upon arrival, the mangoes were cleaned to remove soil and debris. To eliminate field heat, they were pre-cooled using a fan. Mature 'Neelumbori' mangoes were identified based on key ripeness indicators, including a flat shoulder at the stem end, full cheeks, a light-green peel, and light-yellow pulp. Only high-quality mangoes with uniform shape, size, and color were selected for the experiment. 'Neelumbori' mangoes are medium-sized, measuring approximately 9.26 cm in length and 6.18 cm in width, with a flesh thickness of 2.10 cm. The average fruit weight was 350 g, with an edible portion comprising 87.3% of the fruit. The annual fruit yield of a mature tree was approximately 10.15 kg (Rahman and Akter, 2019).

Table 1. Daily maximal and minimal room temperatures (°C) and afternoon relative humidity (%) during the experimental period from 25 July to 03 August 2022.

Day	Room Temperature (°C)		Afternoon Relative Humidity (%)
	Maximum	Minimum	
7/25/2022	30.5	28.5	87
7/26/2022	30.1	28.8	85
7/27/2022	31	29.4	83
7/28/2022	30.3	29.3	85
7/29/2022	30.5	29.5	85
7/30/2022	31	30.2	80
7/31/2022	30.9	29.3	79
8/01/2022	30.1	29.2	80
8/02/2022	30.1	29.6	82
8/03/2022	29.7	29.1	80

Treatments and experimental design

The experiment consisted of four chitosan treatment levels: control (no chitosan), 0.1%, 0.3%, and 0.5%, following a completely randomized design (CRD) with three replications per treatment. Each replication included 10 fruits, resulting in a total of 120 high-quality, uniformly mature mangoes used in the study.

To prepare the 0.5% chitosan solution, 5 g of chitosan (Research-Lab Fine Chem Industries, Mumbai, India) was thoroughly mixed with 350 mL of vinegar (1% acetic acid) and 500 mL of distilled water. The final volume was adjusted to 1000 mL by adding additional distilled water (Adımcılar et al., 2023). The 0.1% and 0.3% chitosan solutions were then prepared through dilution from the 0.5% stock solution. These solutions were uniformly sprayed onto the mangoes using the same nozzle, while the control group received no treatment.

Each set of mangoes was placed separately on fresh newspaper in the storage room for evaluation of physicochemical attributes at different days after treatment (DAT). Data on physical attributes, such as weight loss and color, were recorded daily, while chemical attributes, including total soluble solids (TSS), titratable acidity (TA), and vitamin C content, were measured every other day (1, 3, 5, 7, and 9 DAT). On each chemical measurement date, a total of 12 fruits were sampled from the four treatments (three fruits per treatment).

Visual assessment

The color of mango fruits was assessed visually following a color rating scale (1 to 5) according to Dang et al. (2008) (Fig. 1) as stated below

(1) 100% green (2) 1- 25% yellow (3) 26 - 50% yellow

Fig. 1. Categorizing ripening 'Kensington Pride' mango on the basis of skin color.

Assessing Fruit color by using a HunterLab ColourFlex

Fruit skin color values L*, a*, and b* were measured by a spectrophotometer (HunterLab ColorFlex, Hunter Associates Inc., Reston, VA, USA). The Chroma value $[C^*, C^* = (a^{*2} + b^{*2})^{1/2}]$ and hue angle $[h°, h° = tan^{-1}\frac{b^*}{a^*}]$ were calculated (McGuire, 1992).

Determination of weight loss (%)

Mango fruit weight loss was measured according to a standard formula (1) (Kabir and Hossain, 2024).

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100 \quad (1)$$

Determination of total soluble solid (TSS, °Brix) and titratable acidity (TA%)

Titratable acidity (TA) was determined by titrating a 5.0 mL aliquot of diluted fruit juice. Fresh juice was extracted from the fruits of each replication and diluted with distilled water in a 1:2 ratio (e.g., 10 mL juice mixed with 20 mL water). A 5 mL aliquot of this diluted solution was then titrated with 0.1 N NaOH, following the formula (2) described by Nerdy (2018).

$$\text{Malic acid (\%)} = \frac{0.0067 \times \text{Vol. of NaOH} \times 30 \times 100}{5 \times 10} \quad (2)$$

Where,

0.0067= Milliequivalent weight of malic acid
30= Total volume (mL)
5= Extract juice sample (mL)
10= Volume of aliquot (mL)

TSS was measured from the extracted juice using a refractometer (REF 105) and was referred to as the degree of Brix. TA was divided by the corresponding TSS to calculate the TA/TSS ratio.

Determination of vitamin C

Vitamin C was estimated using a dye (2,6-dichlorophenol indophenol) titration method according to formula (3) from Nerdy (2018).

$$\text{Vitamin C (mg 100g}^{-1}) = \frac{e \times d \times b}{c \times a} \quad (3)$$

Where,
a= Weight of sample
b= Volume made with metaphosphoric acid
c= Volume of aliquot taken for estimation
d= Dye factor
e= Average burette reading for sample

Assessment of decay incidence and severity

Decay incidence describes the percentage of infected fruits and is calculated according to formula (4) from Kabir and Hossain (2024).

$$\text{\% Decay incidence} = \frac{\text{Number of infected fruits}}{\text{Total number of fruits}} \times 100 \quad (4)$$

Decay severity estimates the percentage of fruit surface with disease symptoms and is determined visually (Roy et al., 2011).

Shelf life (days)

Shelf life is the number of days required for mango to ripen, maintaining optimum edibility and marketability. It was determined on the basis of physical attributes such as weight loss, skin color, firmness, and disease severity. These

attributes were judged visually from a consumer perspective as marketable or unmarketable. When fruit decay severity was less than 12%, visual color change less than 5, and cumulative weight loss less than 10%, fruits were considered acceptable (marketable).

Statistical analysis

The data were subjected to one-way analysis of variance (ANOVA) and F-test with the MSTAT program. The mean differences were tested by Tukey's HSD Test at 5% probability level.

Results

Cumulative weight loss of fruit

Chitosan significantly reduced fruit weight loss immediately (2-4 DATs) after application of treatments compared to the control. However, as time elapsed, the effect of chitosan on the cumulative fruit weight loss disappeared statistically (5-10 DAT), although the data were numerically too different, such as at 10 DAT, maximum and minimum cumulative weight loss were 24.84 and 17.14% in response to 0.5% chitosan and the control, respectively (Fig. 2). Similar trends of cumulative weight loss were also observed for other DATs (DAT 7, DAT 8). Cumulative weight loss increased gradually during the storage period.

Fruit color

Fruit skin color coordinates L*, a*, h° (Fig. 3) and b* and C* (data not shown) remained unaffected by the chitosan treatments. However, generally the values of L* and a* increased and hue angle (h°) decreased gradually during the period of experiment. At 10 DAT, 0.5% chitosan resulted in higher L* and a* values compared to the control. The h° was also higher in response to 0.5% chitosan than the untreated control (Fig. 3). Changes in fruit color were evaluated in visual color scales that varied significantly and the untreated fruit developed color rapidly compared to the treated ones. At 10 DAT, the highest color rating value (4.06) was obtained from the control (fruits were mostly yellow with very soft flesh) and the lowest color rating value (2.32) was obtained from the 0.5% chitosan treatment (fruits were mostly green with very firm flesh) indicating that untreated fruits changed color faster and, thus, ripened quickly compared to the 0.5% chitosan treated fruits (Fig. 4).

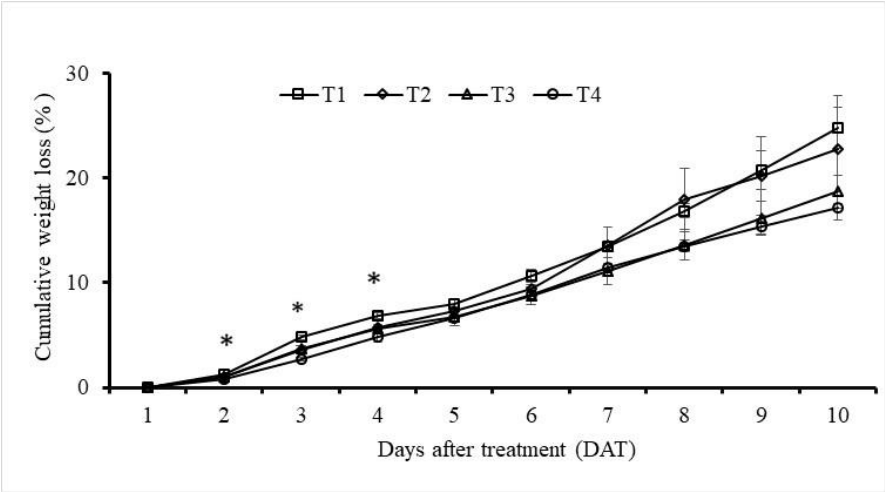

Fig. 2. Cumulative weight loss (%) of mango 'Neelumbori' fruit as affected by chitosan. T_1, T_2, T_3, and T_4 represent untreated control, 0.1% chitosan, 0.3% chitosan, and 0.5% chitosan, respectively. Fruits were kept at 29.8 °C and 82.8% RH. The error bar represents mean ± SE (standard error). * represents significance at a 5% level of probability.

Fruit chemical attributes

The TSS, TA, and TA: TSS ratio of mangoes responded inconsistently to chitosan treatments (Fig. 5). TSS content varied significantly across treatments on all DATs, with the highest value (26.8%) observed in the control treatment and the lowest (9%) in the 0.1% chitosan treatment at 9 DAT. Unlike TSS, TA showed significant variation only at 7 DAT, where the highest TA (0.84%) was recorded in both the 0.1% and 0.3% chitosan treatments, while the lowest (0.44%) was observed in the 0.5% chitosan treatment. As TSS and TA fluctuated, their ratio also varied, with a TA: TSS ratio of 0.02 for all chitosan treatments at 9 DAT, decreasing to 0.01 in the control. Similarly, vitamin C content varied inconsistently and showed significant differences at 3, 7, and 9 DATs (Fig. 6). The highest vitamin C content (11.45 mg $100g^{-1}$) was recorded in the control

treatment, while the lowest (7.6 mg $100g^{-1}$) was found in the 0.5% chitosan treatment at 9 DAT. The control treatment also resulted in the highest vitamin C content at 7 DAT (Fig. 6).

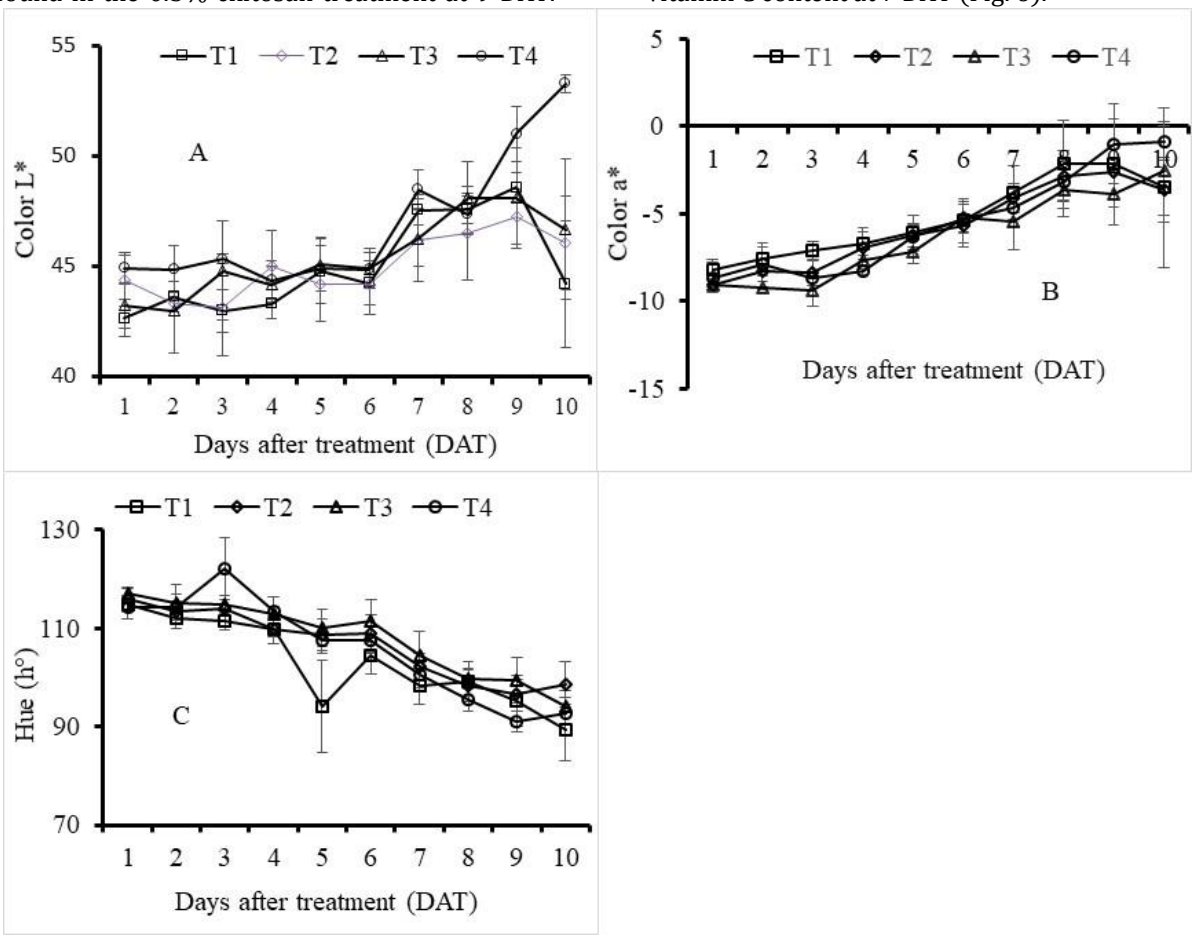

Fig. 3. Color attributes L* (A), a* (B), and h° (C) of mango 'Neelumbori' as affected by chitosan. T_1, T_2, T_3, and T_4 represent untreated control, 0.1% chitosan, 0.3% chitosan, and 0.5% chitosan, respectively. Fruits were kept at 29.8 °C and 82.8% RH. The error bar represents mean ± SE (standard error).

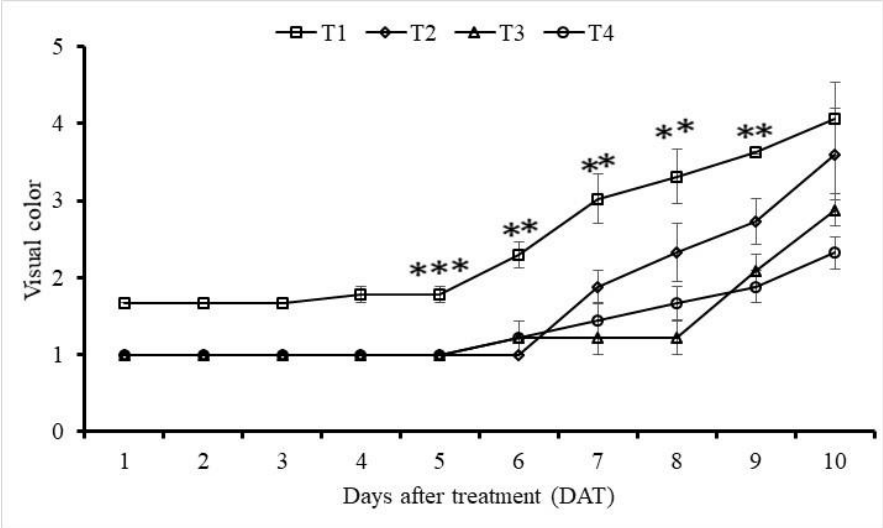

Fig. 4. Effect of chitosan on visual color (scale 1-5, where 1 indicates 100% greenness, 2 equals 1%- 25% yellow, 3 means 26%- 50% yellow, 4 means 51%-75% yellow, and 5 is 100% yellow) of mango 'Neelumbori'. T_1, T_2, T_3, and T_4 represent untreated control, 0.1% chitosan, 0.3% chitosan, and 0.5% chitosan, respectively. Fruits were kept at 29.8 °C and 82.8% RH. The error bar represents mean ± SE (standard error). **, *** mean 1 and 0.1% levels of probability, respectively.

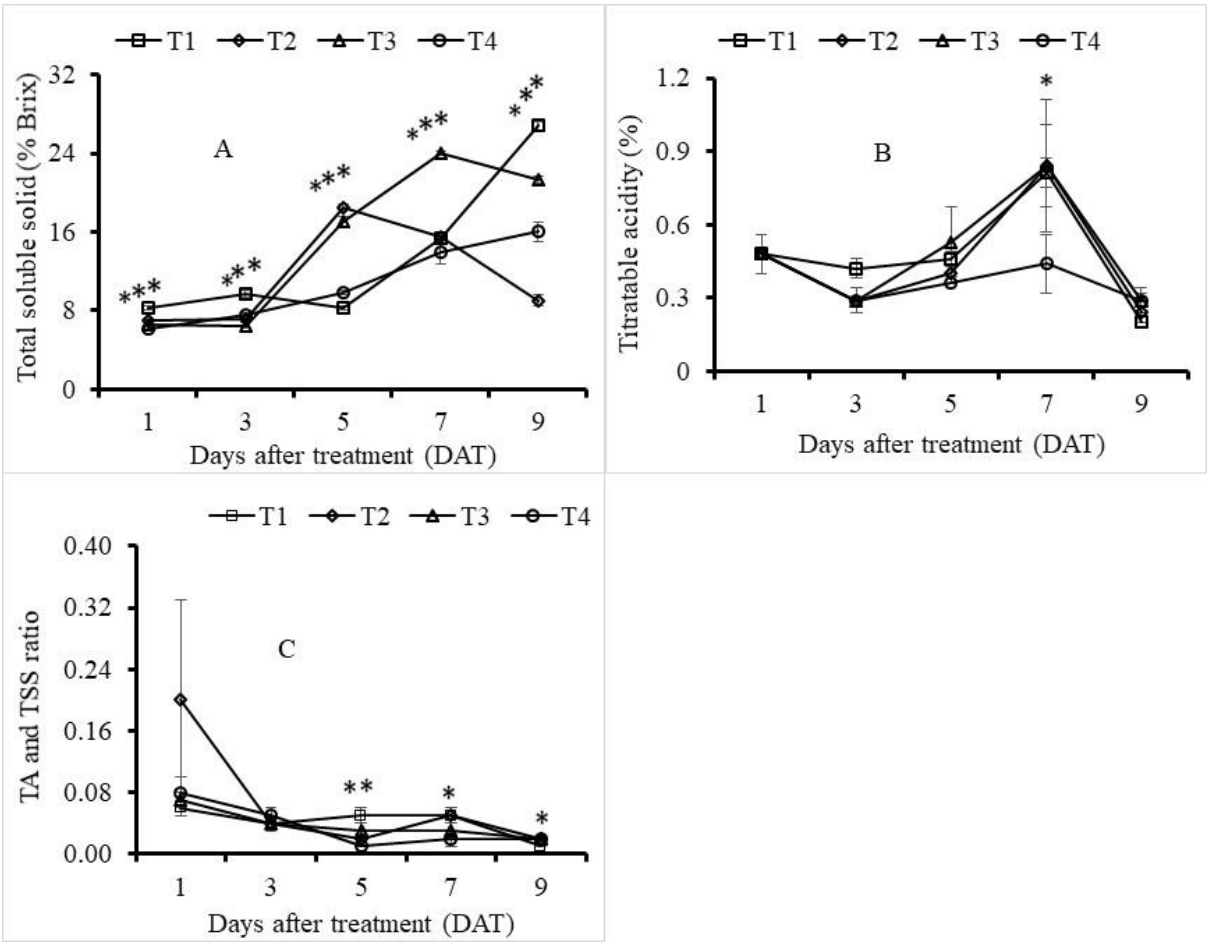

Fig. 5. TSS (total soluble solids) (A), TA (titratable acidity) (B), and TA: TSS (C) of mango 'Neelumbori' as affected by chitosan concentration. T_1, T_2, T_3, and T_4 represent untreated control, 0.1% chitosan, 0.3% chitosan, and 0.5% chitosan, respectively. Fruits were kept at 29.8 °C and 82.8% RH. The error bar represents mean ± SE (standard error). Significance levels are indicated by asterisk (*) as * means 5%, ** means 1%, and *** means (P≤0.01).

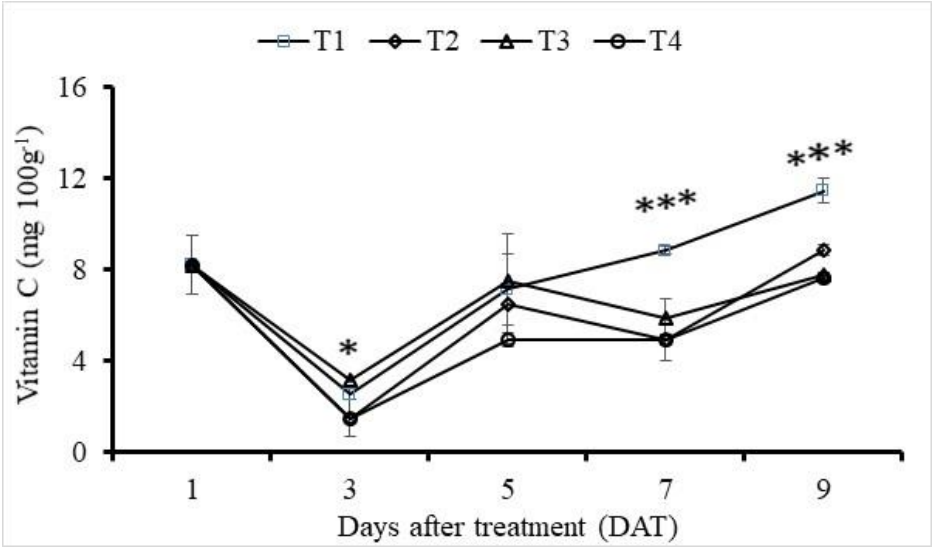

Fig. 6. Vitamin C of mango 'Neelumbori' fruit as affected by chitosan concentration. T_1, T_2, T_3, and T_4 represent untreated control, 0.1% chitosan, 0.3% chitosan, and 0.5% chitosan, respectively. Fruits were kept at 29.8 °C and 82.8% RH. The error bar represents mean ± SE (standard error). Significance levels are indicated by asterisk (*) as * means (P≤0.05) and *** (P≤0.01).

Decay incidence and severity

Chitosan treatments significantly reduced decay incidence compared to the control (Fig. 7). At 9 DAT, decay was observed in 63.3% of fruits in the control group, whereas only 16.7% of fruits treated with 0.5% chitosan showed signs of decay. Similarly, at 10 DAT, the lowest disease incidence (27%) was recorded in the 0.5% chitosan treatment, which was statistically similar to the 0.1% and 0.3% chitosan treatments, while the highest incidence (80%) occurred in the control group (Fig. 7). Similar to decay incidence, decay severity increased over time across all treatments. However, decay severity during storage was lowest in the 0.5% chitosan treatment and highest in the control. By 10 DAT, disease severity reached 48.3% in the 0.5% chitosan-treated fruits, compared to 82% in the control (Fig. 8).

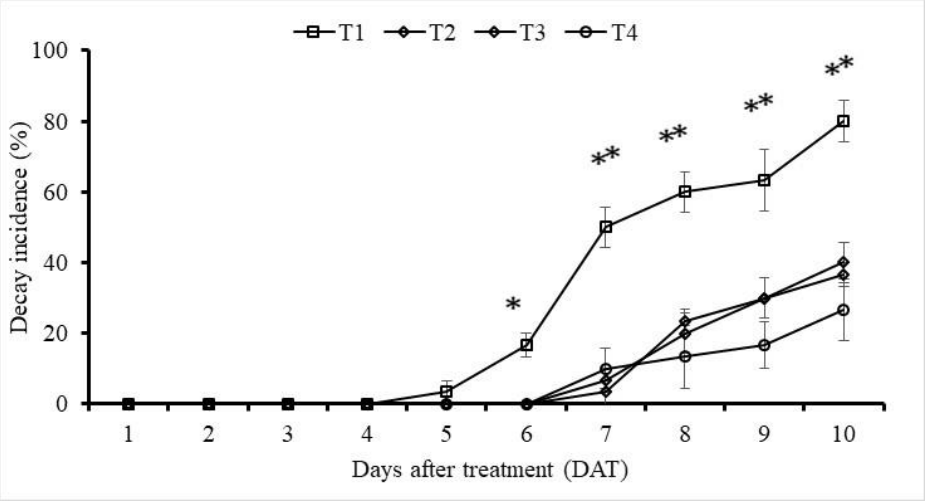

Fig. 7. Disease incidence of mango 'Neelumbori' as affected by chitosan concentration. T_1, T_2, T_3, and T_4 represent untreated control, 0.1% chitosan, 0.3% chitosan, and 0.5% chitosan, respectively. Fruits were kept at 29.8 °C and 82.8% RH. The error bar represents mean ± SE (standard error). Significance level is indicated by an asterisk (*) as ** means of the data are statistically significant (P≤0.01).

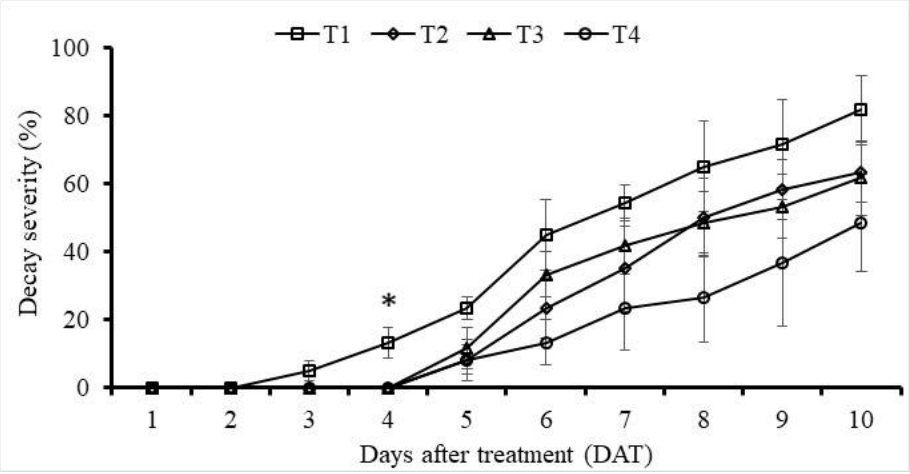

Fig. 8. Disease severity of mango 'Neelumbori' as affected by chitosan concentration. T_1, T_2, T_3, and T_4 represent untreated control, 0.1% chitosan, 0.3% chitosan, and 0.5% chitosan, respectively. Fruits were kept at 29.8 °C and 82.8% RH. The error bar represents mean ± SE (standard error). Significance level is indicated by an asterisk (*) as * means of the data are statistically significant (P≤0.05).

Shelf life

The shelf life of mangoes varied significantly among the treatments (Fig. 9) and the maximum shelf life (10.42 d) occurred in response to using 0.5% chitosan, which was statistically similar to other chitosan treatments. The minimum shelf life (8.82 d) was recorded from the control (Fig. 9). Thus, 0.5% chitosan increased the shelf life of mangoes by 1.6 d. The shelf life obtained from 0.1 and 0.3% chitosan were 9.58 and 9.67 d, respectively (Fig. 9).

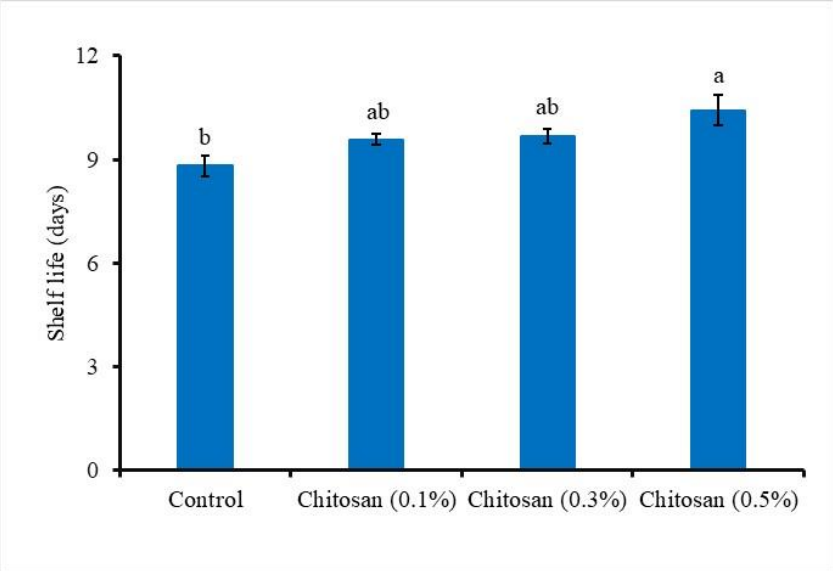

Fig. 9. Mango 'Neelumbori' shelf life as affected by chitosan concentration. Fruits were kept at 29.8 °C and 82.8% RH. The error bar represents mean ± SE (standard error). The treatment means (average of three measurements) are separated by Tukey's HSD test at $\alpha = 5\%$.

Discussion

Storage cooling is essential for maintaining the quality of fresh fruit (Rodrigues et al., 2021). During the experimental period, the average temperature exceeded 30 °C, which accelerates fruit ripening by increasing respiration rates (Cannon et al., 2012). Additionally, the combination of high temperature and high relative humidity (RH) promotes fruit decay, reducing shelf life, edible quality, and marketability. In Bangladesh, the hot and humid climate contributes to significant postharvest losses of mangoes. Postharvest water loss in fruit leads to changes in color, tissue softening, shrinkage, and reduced brightness (Díaz-Pérez, 2019). Rapid weight loss further diminishes firmness, ultimately deteriorating fruit quality. In this study, chitosan—particularly at 0.5% concentration—effectively reduced fruit weight loss and increased firmness compared to the untreated control. Similar results have been reported in mangoes, where chitosan coatings minimized weight loss by inhibiting endogenous respiration (Zhu et al., 2008; Jongsri et al., 2016; Parvin et al., 2023). Chitosan has also been shown to reduce weight loss in bananas, Gala apples, sweet cherries, longans, Feijoa (guavasteen), and apricots by limiting water loss (Dang et al., 2010; Ghasemnezhad et al., 2010; Shao et al., 2012; Petriccione et al., 2015; Hossain and Iqbal, 2016; Lin et al., 2020; Aziz et al., 2021; Zárate-Moreno et al., 2023).

In this study, chitosan application did not significantly affect fruit color. However, mangoes exhibited a tendency toward delayed color development, as observed in previous studies (Ngo et al., 2021). Chitosan combined with Aloe vera gel and papaya leaf extract has also been reported to slow color changes in mangoes (Nga and Bac, 2021). Additionally, chitosan has been shown to extend the visual quality of 'Hindi-Besennara' mangoes (Awad et al., 2017) and slow color changes in bananas and strawberries (Petriccione et al., 2015; Aziz et al., 2021). In papaya, chitosan treatment delayed color development and extended shelf life by reducing respiration and ethylene production (Ali et al., 2011). Fruit maturation is accompanied by the hydrolysis of starch and sucrose, leading to increased total soluble solids (TSS) (Akhtar et al., 2010). However, under high temperatures, fruit respiration intensifies, resulting in greater glucose consumption and a subsequent decrease in TSS, as observed in this study. Similar trends have been reported in 'Alfonso' mangoes (Doreyappa-Gowda and Huddar, 2001). The use of a chitosan-pullulan composite delayed TSS changes in mangoes (Kumar et al., 2021), while chitosan alone slowed TSS fluctuations in plums (Kumar et al., 2017) and sweet cherries (Petriccione et al., 2015), though it had no effect on TSS in apricots (Ghasemnezhad et al., 2010).

Titratable acidity (TA) naturally declines as fruits mature (Famiani and Walker, 2009). This occurs due to increased respiration and ethylene biosynthesis, leading to the breakdown of high molecular weight organic acids into esters, terpenoids, ketones, and aldehydes (Stavang et al., 2015). Chitosan has been shown to help maintain higher TA levels in mangoes (Jongsri et al., 2016). Regardless of concentration, chitosan

increased mango vitamin C content at 7 and 9 DAT (Fig. 6), a finding supported by Khalil et al. (2022). Additionally, chitosan, either alone or combined with Aloe vera and papaya leaf extract, helped reduce vitamin C loss in mangoes (Nga and Bac, 2021; Parvin et al., 2023). Over time, vitamin C (L-ascorbic acid) undergoes oxidation, converting into dehydroascorbic acid, which leads to its gradual decline during storage (Akram et al., 2017).

The application of chitosan effectively reduced fruit decay incidence and severity in mangoes (Jitareerat et al., 2007; Zhu et al., 2008; Jongsri et al., 2016). Specifically, chitosan at 0.8% inhibited microbial growth in mango, likely by disrupting bacterial cell permeability (Bambalele et al., 2021). Similarly, a 1% chitosan treatment reduced decay incidence and severity in bananas (Hossain and Iqbal, 2016; Esyanti et al., 2019). Chitosan has also been shown to suppress pathogens such as *Colletotrichum gloeosporioides*, *Alternaria*, and *Dothoriella* spp. (Bambalele et al., 2021). The delayed onset of disease could be attributed to reduced pathogen attacks, as well as slower pathogen growth and dissemination (Doreyappa-Gowda and Huddar, 2001). By inhibiting microbial proliferation, chitosan likely contributes to the reduction in decay severity.

This study demonstrated that chitosan, particularly at 0.5%, significantly extended the shelf life of mangoes. Similar results have been observed with chitosan, chitosan-pullulan (50:50), and pomegranate peel extract, all of which effectively prolonged mango shelf life (Abbasi et al., 2009; Kumar et al., 2021). Chitosan has also been shown to delay the ripening of 'Hindi-Besennara' mangoes, thereby extending their shelf life (Zhu et al., 2008; Awad et al., 2017). Additionally, chitosan application has successfully increased the shelf life of bananas, papayas, dragon fruits, apples, plums, sweet cherries, strawberries, and Feijoa (El Ghaouth et al., 2007; Dotto et al., 2015; Chepngeno et al., 2016; Kumar et al., 2017; Sultana et al., 2020; Aziz et al., 2021; Prashanth et al., 2022; Zárate-Moreno et al., 2023). The observed increase in shelf life of chitosan-treated fruits may be attributed to reduced weight loss, slower physicochemical changes, and inhibited pathogen growth and multiplication.

Conclusions

Chitosan effectively extended the shelf life and preserved the quality of mangoes. After 11 days of storage at room temperature, the 0.5% chitosan treatment outperformed the control in reducing fruit weight loss (17.1% vs. 24.5%), disease incidence (26.7% vs. 80.0%), and disease severity (48.3% vs. 81.7%), while also extending shelf life (10.42 vs. 8.82 d). Additionally, chitosan helped maintain fruit quality by delaying changes in color, total soluble solids (TSS), and titratable acidity (TA). Based on these findings, the postharvest application of 0.5% chitosan is recommended for preserving the quality and extending the shelf life of '*Neelumbori*' mangoes.

Funding

This research was supported by the National Science and Technology (NST) Fellowship 2021 from the Government of Bangladesh in favor of the first author.

Acknowledgement

The authors are grateful to the Ministry of Science and Technology of the Government of Bangladesh for funding the research. The authors express their sincere gratitude to the Lab of Horticulture as well as Agrotechnology Discipline, Khulna University, Bangladesh, for their supports during the experimental period.

Author contributions

SD: methodology, investigation, writing – very preliminary draft; SUK: conceptualization, co-supervision; JCD: writing – review and editing; MYK: supervision, conceptualization, analyzing, writing – original draft, review and editing, and fund acquisition.

Conflict of Interest

The authors indicate no conflict of interest in this work.

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