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Chitin nanofiber coating retains postharvest quality and extends shelf life of mango

Shirazoom Munira[1], Md. Yamin Kabir[1,*], Shamim Ahmed Kamal Uddin Khan[2], and Md. Iftekhar Shams[3]

1, Agrotechnology Discipline, Khulna University, Khulna 9208, Bangladesh
2, Faculty of Agriculture, Khulna Agricultural University, Khulna 9100, Bangladesh
3, Forestry and Wood Technology Discipline, Khulna University, Khulna 9208, Bangladesh

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***Corresponding author:**
Agrotechnology Discipline, Khulna University, Khulna 9208, Bangladesh.

Email: yaminkabir@at.ku.ac.bd

ABSTRACT

Purpose: Mango is a well-known fruit in tropical and sub-tropical countries, including Bangladesh. However, mangoes are climacteric fruits and exhibit limited storage life due to a high respiration rate. Mangoes are also susceptible to particular storage pathogens at postharvest and thus possess a short shelf life. **Research Method**: Mature mangoes were treated with different concentrations of chitin nanofiber (CNF) and stored in ambient conditions to evaluate the effect of CNF (0.1%, 0.3%, 0.5%) on postharvest quality and shelf life. Disease-free and physiologically mature mangoes were collected from an orchard. The experiment was devised following a Completely Randomized Design with three replications, and each replication consisted of 10 fruits. Fruits were evaluated for physical quality (weight loss, fruit firmness, and color changes), chemical attributes [changes in total soluble solids (TSS), titratable acidity (TA), vitamin C content], microbial (disease incidence and disease severity), and shelf life. **Findings**: The application of 0.3% CNF maintains fruit color (6.33 vs. 4), decreases disease incidence (62.5% vs. 100%) and prolongs the shelf life (8.5 days vs. 6.02 days) of mangoes than the control. Similarly, 0.1% of CNF retains vitamin C (24.33 mg/100g vs. 12.33 mg/100g), decreases disease severity (62% vs. 85.68%), and 0.5% of CNF reduces weight loss (19.34% vs. 31.4%) than the control. **Research Limitations**: CNF preparation requires lab facilities and technical expertise, and it is costly. **Originality/Value**: CNF 0.3% has the potential to maintain postharvest quality and extend the shelf life of mangoes. However, more research is needed to make the final recommendation at the farmers' level.

INTRODUCTION

Mango (*Mangifera indica* L.) – the 'King of fruits' from Anacardiaceae – is a familiar fruit in the tropics and subtropics (Bini et al., 2024), and is widely cultivated in Bangladesh (Sampa et al., 2019). In Bangladesh, it occupies more than121 thousand ha of land having 1.95 million metric tons of an annual production, and the contribution of mango to the total fruit crop production is 26.38% (BBS, 2022). Mango is very popular in Bangladesh because of its excellent taste, amazing flavor, rich nutritive value, wide adaptability, and diversity. However, mangoes are highly perishable, ripe quickly after harvest, and, thus, susceptible to various postharvest diseases (Giovannoni et al., 2017). These problems restricted long-distance handling, storage, and transportation for marketing and consumption, which impacted the world mango trade. As a result, a considerable number of mangoes waste every year (Parvin et al., 2023). In addition, lack of postharvest management ultimately reduces the shelf life, and deteriorates the overall quality of mango.

Shelf life of mangoes and other perishable fruits can be extended by modified atmosphere (MA) packaging, controlled atmosphere (CA) storage (Thakur et al., 2022), edible coatings (Camatari et al., 2017), chemical treatments including calcium chloride (Lekhon et al., 2024; Shao et al., 2019), botanical extracts (Kabir & Hossain, 2024), and growth regulators (Naleo & Maiti, 2018). However, CA and MA storage is very costly, and the use of chemical fungicides for preventing storage decay in mangoes is no longer preferred due to the detrimental effects on the environment, the creation of chemical residue, and the development of resistance in the pathogen population (Sellitto et al., 2021). In this context, the necessity of searching ecofriendly and hazard free alternatives are of getting importance. Recently, fresh fruits have been coated with coating materials like chitin nanofiber (CNF), a natural substance, to increase shelf life and preserve quality after harvest. CNF is the nanofibrilation of chitin, diameters smaller than 100 nm, and a high aspect ratio more than 100 (Xia et al., 2003). Apart from its biomedical and mechanical uses (Ifuku, 2014), it is used as an environmentally friendly substance to prolong the storage life and preserving fruit quality (Zhang et al., 2011). Although the chitin is insoluble, CNF which is readily dissolves in water, is used in agricultural applications (Shamshina et al., 2019; Shams et al., 2025). Though the several studies have been conducted on the postharvest quality of dragon fruits, strawberries, and tomatoes (Fisk et al., 2008), studies on the potentiality of CNF for postharvest quality and storage life of mangoes are scanty. Therefore, the purpose is to evaluate how the chitin nanofiber treatment affects the quality and shelf life of mangoes at postharvest.

MATERIALS AND METHODS

Experimental site and materials

On a bright sunny day, visually blemish-free, fully matured uniform-sized mango fruits (var. Neelambari) were collected from a commercial farmer's orchard (Satkhira, Bangladesh, 88°40' to 89°50' east longitude and 22°47' to 23°47' north latitudes), and immediately transported to Horticulture Laboratory, Khulna University through an air-cooled vehicle. It is a medium-sized mango with 9.26 cm length and the breadth is about 6.18 cm, with an average weight of 350 g. The flesh thickness is 2.10 cm while an edible portion is about 87.26%, and the average yield is 10.15 kg plant^{-1} (Rahman & Akter, 2019).

Experimental design, preparation and application of treatments

The experiment was conducted following a Completely Randomized Design with four concentrations of CNF (0%, 0.1%, 0.3%, 0.5%) and replicated three times. CNF was extracted from the shells tiger shrimp (*Peneus monodon*). Shrimp shells were meticulously cleaned in water to wash the clinging dust, dirt, and other debris. Before letting them dry in the air, the shrimp shells were repeatedly cleaned with tap water. Using a typical grinder, the dry shells were reduced in size to particles between 2 and 4 mm. About 300 g dried, crushed shrimp shells were demineralized, deproteinized, and depigmented using HCI (37%), NaOH (99.9%), and Ethanol 50%, respectively (Ifuku et al., 2011, Ifuku, 2014). The suspension was blended with a super-speed blender (Vita-Mix Blender, Osaka Chem. Co. Ltd.) and a normal-speed blender (Panasonic MX Blender, Panasonic Holdings Corporation), and transferred to the super colloidal machine. The CNF was mechanically processed by passing it through a Super Masscolloider (MKCA6-51, Saitama-ken, Japan). The grinding stone clearance was set to -0.15 with a 1500 rpm rotating stone speed. After going through a super-speed blender for 10, 15, and 20 milling cycles, the CNF was extracted. The required concentrations (0.1%, 0.3%. and 0.5%) of CNF were prepared by adding more distilled water.

For each replication, 10 mangoes with similar physiological maturity were selected. Each set of mangoes was placed separately on the newspaper. The CNF were sprayed on the fruits uniformly through a hand sprayer, except for the control. On each date [4, 6, 8, and 10 days after treatment (DAT)] of chemical measurements, 12 fruits were sampled from four treatments (i.e., three fruits per treatment). However, data on physical parameters were collected on every day.

Firmness determination

Firmness of mango was estimated hedonically as stated by Hassan (2006) following scale of rating 1-6, where 1 is hard green, 2 represents sprung, 3 means between sprung and eating ripe, 4 indicates eating ripe, 5 is Overripe, and 6 means decayed.

Observation of changes in fruit color

Visual assessment

Mango color changes were visually assessed using a numerical rating system of 1–7, where 1 stands for green, 2 for breaker, 3 for up to 25% yellow, 4 for 25–50% yellow, 5 for 50–75% yellow, 6 for 75–100% yellow, and 7 for blackened (Hassan, 2006).

Assessment of fruit color by using a chromameter

Mango skin color was measured on color coordinates as L*, a*, b*, Chroma (C*), and hue angle (h°) from opposite positions of each fruit in Chroma Meter CR-410. Chromaticity L* means the lightness of the fruit color ranging between 0 (black) to 100 (white). Chromaticity a* denotes the redness (+a*) or greenness (-a*), and chromaticity b* signifies the yellow (+b*) or blue (-b*) color skin of fruit. The intensity of color saturation from dull to bright (low-to-high values, respectively) was referred to as chroma (C*). In terms of color interpretation, the angles of red, yellow, green, and blue were 0°, 360°, 90°, and 180°, respectively. Absorbance or reflection is indicated by the hue angle (h°), and the values relate to the intrinsic luminosity.

Determination of weight loss (%)

The weight loss of mango was calculated according to the technique stated by AOAC (2012). Throughout storage, the samples were weighed every day with a digital balance. The findings were expressed using the following formula to get the percentage weight loss (1):

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

Determination of total soluble solids (TSS), titratable acidity (TA), and vitamin C

TA, TSS and vitamin C content were measured on DATs 4, 6, 8, and 10 following standard methods. On a particular date, a single fruit from each replication was destroyed to determine TA, TSS and vitamin C. Moreover, three mangoes (out of 10) were spent on the chemical analysis. A Hand Refractometer (REF 105) was used to measure the total soluble solids (˚Brix) when a drop of juice is placed on its prism using the AOAC technique (2012). The amount of TA was quantified by titrating 5.0 ml of aliquot (fresh juice was extracted from the fruits of each replication and diluted with distilled water, maintaining a ratio of 1:2 (e.g., 10 ml juice: 20 ml water), and 5 ml aliquot was used for titration) against NaOH (0.1 N) as stated by Nerdy (2018) as follows (2):

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

Where,

0.0067 =	Milli-equivalent weight of malic acid
30 =	Total volume (ml)
5 =	Extract juice sample (ml)
10 =	Volume of aliquot (ml)

The dye (2,6-dichlorophenol indophenol) titration method was followed to evaluate Vitamin C (3) (mg/100g) (Nerdy, 2018; Lekhon et al., 2024).

$$\text{Vitamin C (mg100g}^{-1}\text{)} = \frac{e \times d \times b}{c \times a} \qquad (3)$$

Where a= Weight of specimen, b= Volume produced with metaphosphoric acid, c= Volume of the aliquot, d= Dye factor, and e= reading of the Burette (mean).

Assessment of disease incidence (%) and disease severity (%)

Disease incidence is defined as the percentage of diseased mangos. Fruits with infections were identified by their visual symptoms. Using the following formula, the proportion of disease incidence in mangos was calculated (4) (Dhali et al., 2024; Sivakumar et al., 2002):

$$\text{\% Disease incidence} = \frac{\text{Number of infected mangos}}{\text{Total number of mangos under study}} \times 100 \qquad (4)$$

The percentage of the wounded area of infected fruit indicates the disease severity, and was calculated through eye estimation. Severity of Disease was scored according to Sivakumar et al. (2002) using the scale as follows: 1= 0% of fruit surface rotten; 2 = 1-25% of fruit surface rotten; 3 = 26-50% of fruit surface rotten; 4 = 51-75% of fruit surface rotten; and 5 = 76-100% of fruit surface rotten.

Shelf life (days)

The storage life of mangoes was determined by calculating the number of days needed for them to ripen completely while retaining their best eating quality and marketing potential. Moreover, it was determined based on physical parameters including weight loss, skin color, firmness, and disease severity.

Statistical analysis

A one-way Analysis of Variance (ANOVA) for single-factor CRD was performed on the data through IBM SPSS Statistics for Windows (Version 27.0.1.0) IBM Corp. (2020), Armonk, NY, USA]. Tukey's Honestly Significance Difference (HSD) Test was used to compare treatment means at a 5% level using the same software.

RESULTS AND DISCUSSION

Microenvironment of the experimental room

The weather was hot and humid during the experimental period (25 July to 3 August 2022). The temperature ranges in the storage room were 28.5 to 30.9 °C, with an average of 29.47 °C, while the relative humidity ranges from 85% to 90%, with a mean of 84.7% (Appendix I). Such warm and humid weather favors quick growth of the disease and fungal decay and deteriorates postharvest fruit qualities (do Nascimento Nunes, 2008), leading to significant postharvest loss.

Cumulative weight loss

Weight losses (%) of mango increased gradually throughout storage and varied significantly ($P < 0.05$) only at DATs 7 and 9 (Table 1). At DAT 9, the highest weight loss (31.4%) was reported for control and the lowest (19.34%) for 0.5% CNF. A similar trend was found at DAT 7, in which control showed maximum weight loss (21.53%) while the minimum (13.74%) was recorded for 0.5% CNF (Table 1). Chitosan coating inhibited mango weight loss (Zhu et al., 2008; Parvin et al., 2023), which agrees with our present evaluation. It may occur due to a reduction in transpiration rate due to CNF application. Moreover, higher weight was lost from the uncoated mango compared to the chitosan and cinnamon essential oil treated fruits (Yu et al., 2021).

Table 1. Effect of chitin nanofiber (CNF) on cumulative weight loss of mango at different days after treatment (DAT).

Treatments	Cumulative weight loss (%)								
	DAT 1	DAT 2	DAT 3	DAT 4	DAT 5	DAT 6	DAT 7	DAT 8	DAT 9
Control	0.863[a]	3.4600 [a]	6.0567[a]	8.073[a]	11.320[a]	16.233[a]	21.530[a]	24.807[a]	31.400[a]
CNF0.1%	1.0800[a]	3.2533[a]	5.4300[a]	7.520[a]	9.893[a]	12.840[a]	15.827[b]	18.687[a]	21.347[bc]
CNF 0.3%	1.0567[a]	3.1833[a]	5.0467[a]	7.163[a]	10.077[a]	13.260[a]	15.397[b]	20.327[a]	23.953[b]
CNF 0.5%	1.0800[a]	3.8033[a]	6.0233[a]	7.940[a]	10.660[a]	12.167[a]	13.740[b]	17.630[a]	19.340[c]
P	0.8734	0.7025	0.5555	0.7976	0.6265	0.2303	0.0218	0.0711	0.0006

The data represent the mean of three measurements. The mean values were separated by Tukey's HSD Test at 5%. The mean is not statistically different among the treatments if a column has a similar letter(s).

Fruit firmness

As time passed in storage, the firmness of mango changed gradually from hard to over-ripe, which an indicator of fruit is ripening. From DAT 1 to DAT 3, firmness remained unchanged irrespective of the treatments (Fig. 1). However, fruits started ripening from DAT 4. Significant variation was observed among coated and uncoated fruits at DATs 5, 6, 7, and 8. Additionally, the changes in firmness were faster for control (2.67, 3, 3.67, 4.33, 6, 6). The slower changes were recorded for CNF 0.1% (1.33, 1.67, 1.67, 2, 5, 6) on DATs 5, 6, 7, 8, 9, and 10, respectively, which means the rate of changes in firmness was slower in CNF treated fruits. Firmness changed slowly if mango fruits coated with chitosan (Hasan et al., 2020). These changes in firmness occur as a result of converting starch into sugar.

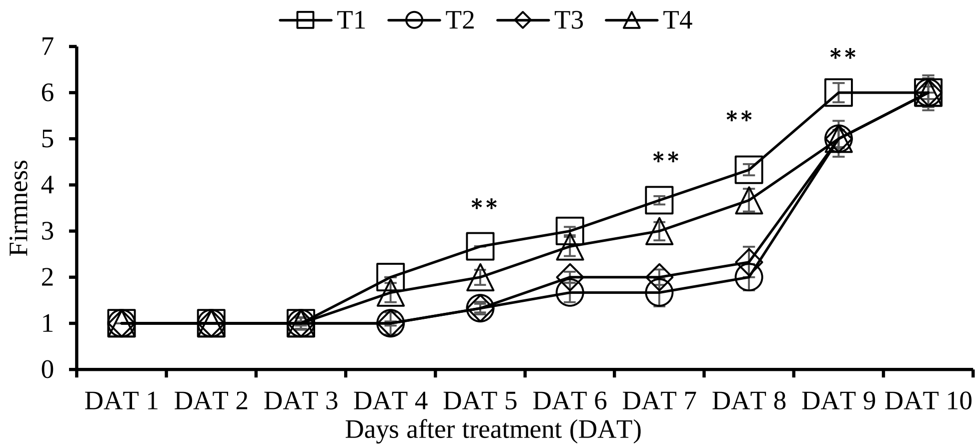

Fig. 1. Effects of chitin nanofiber on firmness of mango. T1= Control, T2= CNF 0.1%, T3= CNF 0.3%, T4= CNF 0.5%. Firmness was measured hedonically based on a scale of 1-6, in which 1 = Hard green, 2 = Sprung, 3 = Between sprung and eating ripe, 4 = Eating ripe, 5 = Over ripe, 6 = rotten. The error bar represents the mean ± SE (standard error) of three measurements. ** means significance at a 1% probability.

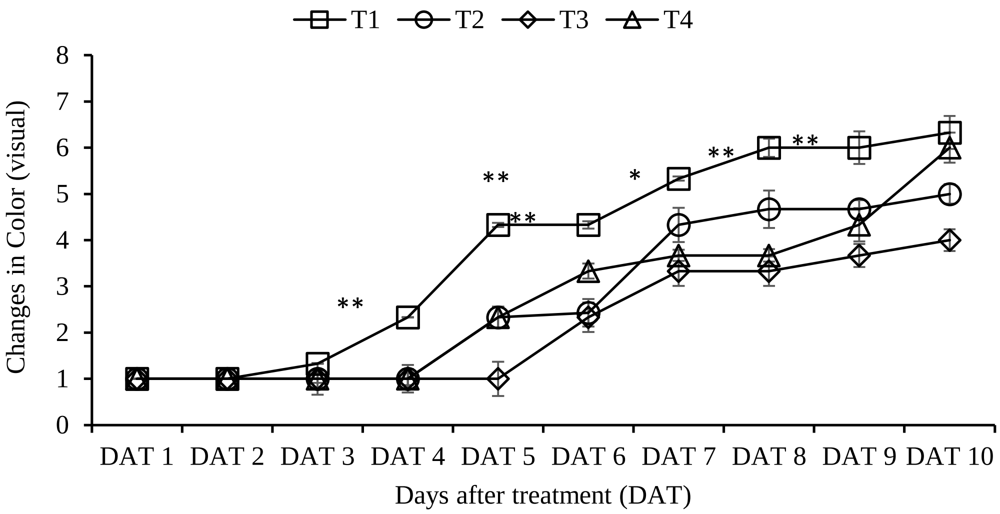

Fig. 2. Effect of chitin nanofiber on the visual color of mango. T1= Control, T2= CNF 0.1%, T3= CNF 0.3%, T4= CNF 0.5%. Color was measured visually using a numerical rating scale of 1-7, where 1 = green, 2 = breaker, 3 = up to 25% yellow, 4 = 25-<50% yellow, 5 = 50-<75% yellow, 6= 75-100% yellow, and 7= blackened. The error bar represents the mean ± SE (standard error) of the three measurements. *, ** mean significance at 5% and 1% probability, respectively.

Changes in fruit skin color

Visual color

A statistically significant difference (P < 0.01) was observed in the color change of mango among the treated and untreated mangoes (Fig. 2). Uncoated control fruits showed faster color change (4.33, 4.33, 5.33, 6, 6, 6.33) than CNF 0.3% treated fruits (1, 2.33, 3.33, 3.33, 3.67, 4) on DATs 5, 6, 7, 8, 9, and 10, respectively. The most noticeable changes during fruit storage are green to breaker color changes of mango peel. Therefore, color change indicates degradation of chlorophyll. As a result of color change, pulp becomes softer, and fruits produce a characteristic aroma. From our study, CNF 0.3% treated fruits required longer periods to reach different stages of ripening compared to the other treatments. Similarly, chitosan coating also delayed the color changes of mangoes (Hasan et al., 2020). The green color of mangoes turned yellow through chlorophyll breakdown as the process of ripening advances (Doreyappy-Gowda and Huddar, 2001).

Table 2. Color coordinates (L*, a*, b*, C*, h°) of mango as influenced by chitin nanofiber (CNF) at different days after treatment (DAT).

Treatments	DAT 1	DAT 3	DAT 5	DAT 7	DAT 9
	L*				
Control	42.67[b]	43.00[b]	44.77[a]	47.57[ab]	48.57[a]
CNF 0.1%	46.33[a]	43.73[b]	46.27[a]	50.00[a]	48.57[a]
CNF 0.3%	43.77[b]	44.27[ab]	44.27[a]	46.20[b]	48.63[a]
CNF 0.5%	45.97[a]	47.17[a]	47.67[a]	50.33[a]	46.90[a]
P	0.0067	0.0654	0.6784	0.0279	0.5564
	a*				
Control	-8.18[a]	-7.13[a]	-6.07[a]	-3.79[a]	-2.10[a]
CNF 0.1%	-7.13[a]	-6.60[a]	-3.43[a]	-2.67[a]	-1.18[a]
CNF 0.3%	-8.13[a]	-6.36[a]	-4.67[a]	-3.41[a]	-3.34[a]
CNF 0.5%	-8.72[a]	-7.23[a]	-7.20[a]	-5.75[a]	-4.47[a]
P	0.4562	0.9496	0.6227	0.9034	0.6851
	b*				
Control	17.61[a]	18.10[a]	20.76[a]	26.14[a]	28.53[a]
CNF 0.1%	19.15[a]	19.07[a]	22.81[a]	26.57[a]	29.11[a]
CNF 0.3%	18.25[a]	19.81[a]	20.76[a]	24.53[a]	27.28[a]
CNF 0.5%	19.10[a]	20.60[a]	23.14[a]	24.80[a]	26.073[a]
P	0.7790	0.2550	0.9109	0.7201	0.5351
	C*				
Control	19.42[a]	19.52[b]	21.80[a]	26.77[a]	28.99[a]
CNF 0.1%	20.85[a]	21.28[ab]	23.85[a]	27.32[a]	29.69[a]
CNF 0.3%	20.13[a]	21.31[ab]	22.47[a]	25.69[a]	28.32[a]
CNF 0.5%	20.94[a]	24.90[b]	27.72[a]	27.35[a]	26.58[a]
P	0.7450	0.2031	0.5730	0.9073	0.5471
	h°				
Control	114.93[a]	111.40[a]	106.63[a]	99.03[a]	90.13[a]
CNF 0.1%	111.10[a]	110.07[a]	102.13[a]	96.07[a]	92.67[a]
CNF 0.3%	114.13[a]	109.07[a]	103.87[a]	99.23[a]	98.70[a]
CNF 0.5%	112.83[a]	108.33[a]	98.83[a]	96.23[a]	94.83[a]
P	0.7942	0.9545	0.8186	0.9521	0.6727

Data presented as the mean of three measurements where an L* is lightness; a* is redness or greenness; and b* is blueness or yellowness. C* represents chroma mean color saturation, and h° represents hue angle. The mean values were separated by Tukey's HSD Test at 5%. The mean is not statistically different among the treatments if a column has similar letter(s).

Subjective color of mango

Lightness (L*) of mango gradually increased over time, irrespective of the treatments (Table 2). On DAT 7, significant variation *(P* < 0.05) was recorded where the maximum L* value was found in CNF-coated fruits, which means lightness of yellow color (most luminous). Nunes et al. (2007) also found an increased L* value of mango if coated with chitosan at postharvest. The value of a* indicates the amount of green or yellow color, and a* is more negative in CNF 0.5% coated mango than the control, indicating greener mango peel (Table 2). The shifting of a* value towards positive means more redness and ripening. Similarly, a more negative a* value was obtained if mangoes were treated with nano-chitosan (Ngo et al., 2021). Though there were no significant variations among the treatments, changes in b* values were slow at 0.5% CNF treatment than the control. However, a significant change in b* values were reported for nano-chitosan coated mangoes (Ngo et al., 2021). A progressive increase in the C* value was recorded, though nonsignificant (Table 2). However, the C* value of bananas increased initially, and declined later (Al-Dairi & Pathare, 2024). The C* might not reduce after a certain period due to varietal differences or environmental conditions. The hue angle (h°) of the mangoes decreased gradually, which is an indication of ripening (Table 2). The maximum h° (98.70) was obtained from CNF 0.3% treated mangoes, and the minimum was recorded for control (90.13). CNF coating showed the highest retention of h°, indicating a delay in the ripening process. Similarly, the ripening of mango is retarded by pectin/nano-chitosan treatment (Ngo et al., 2021).

Table 3. Effects of chitin nanofiber (CNF) on total soluble solid (TSS, °Brix), titratable acidity (TA %), and vitamin C content (mg 100g-1) of mango at different days after treatment (DAT).

Treatments	DAT 4	DAT 6	DAT 8	DAT 10
	TSS (°Brix)			
Control	8.2667^{c}	15.667^{b}	27.000^{a}	25.667^{a}
CNF 0.1%	10.167^{b}	8.0000^{c}	15.333^{b}	15.000^{c}
CNF 0.3%	13.567^{a}	16.333^{a}	27.667^{a}	21.000^{b}
CNF 0.5%	10.233^{b}	16.333^{a}	9.3333^{c}	11.667^{d}
P	0.0000	0.0000	0.0000	0.0000
	TA (%)			
Control	0.4233^{a}	0.3300^{a}	0.1800^{a}	0.3100^{a}
CNF 0.1%	0.4067^{a}	0.2633^{b}	0.1667^{a}	0.1933^{b}
CNF 0.3%	0.3633^{a}	0.2500^{b}	0.2533^{a}	0.1933^{b}
CNF 0.5%	0.4567^{a}	0.2400^{b}	0.1767^{a}	0.1800^{b}
P	0.8286	0.0708	0.4735	0.0001
	Vitamin C (mg 100g^{-1})			
Control	19.67^{b}	21.00^{b}	15.78^{b}	12.33^{b}
CNF 0.1%	34.33^{a}	32.00^{a}	29.33^{a}	24.33^{a}
CNF 0.3%	30.67^{a}	28.33^{ab}	24.00^{ab}	22.33^{ab}
CNF 0.5%	29.67^{ab}	25.67^{ab}	22.33^{ab}	20.00^{ab}
P	0.012	0.04	0.03	0.02

The data represent the mean of three measurements. The mean values were separated by Tukey's HSD Test at 5%. The mean is not statistically different among the treatments if a column has a similar letter(s).

Chemical attributes

The TSS content of mangoes increased gradually, and declined later (Table 3). Moreover, a rapid increase of TSS was observed in control and CNF 0.3% coated fruit. In contrast, the TSS value in 0.5% CNF steadily increased during storage. At DAT 10, the minimum TSS was recorded in 0.5% CNF (11.667 °Brix) followed by 0.1% CNF (15 °Brix), and the maximum for the control (25.67 °Brix). Similar TSS content was observed if mangoes coated with chitosan and cinnamon oil (Yu et al., 2021). TSS content fluctuated in the present study, and the similar fluctuation was reported for the nano-chitosan and pectin/nano-chitosan coated mangoes (Ngo et al., 2021).

Generally, TA follows a decreasing trend after harvest. CNF coating had no effect on TA content (Table 3). However, numerically a higher TA (0.25%) was recorded for 0.3% CNF, and lower (0.11%) from the control. Similarly, the 'Amropali' mango had the highest TA content if treated with chitosan oligosaccharides (Nitu et al., 2025). TA influences fruit flavor and storage quality because of organic acid content (Yu et al., 2021).

The CNF (0.1%) retained higher vitamin C (34.33, 32, 29.33, and 24.33 mg/100g) than the control on the 4th, 6th, 8th, and 10th DAT, respectively (Table 3). Similarly, the vitamin C content of mango was higher than the control if coated with pectin/nano chitosan, may be by forming a thin film, which delayed physiological and biochemical processes (Ngo et al., 2021). Similarly, the vitamin C content of uncoated fruit was the lowest while the maximum retention was observed for chitosan-treated mangoes (Parvin et al., 2023). However, vitamin C content decreased gradually for all treatments; as time elapsed, fruits began to deteriorate, and vitamin C declined.

Incidence and severity of disease

The onset of the disease started from DAT 5 for mangoes. On the 8th, 9th, and 10th days after storage, significant variation (P < 0.05) was recorded among the coated and uncoated mangoes. The highest disease incidence (100%) was recorded for untreated mangoes, and the lowest incidence (62.5%) was observed for 0.3% CNF (Fig. 3). CNF film creates a physical barrier to the oxygen and carbon dioxide, and serves as antimicrobial agent that may reduce disease incidence in mangoes (El Knidri et al., 2020; Jayaprakash et al., 2021). Mangoes treated with chitosan also exhibited low disease incidence (Munira et al., 2024; Parvin et al., 2023).

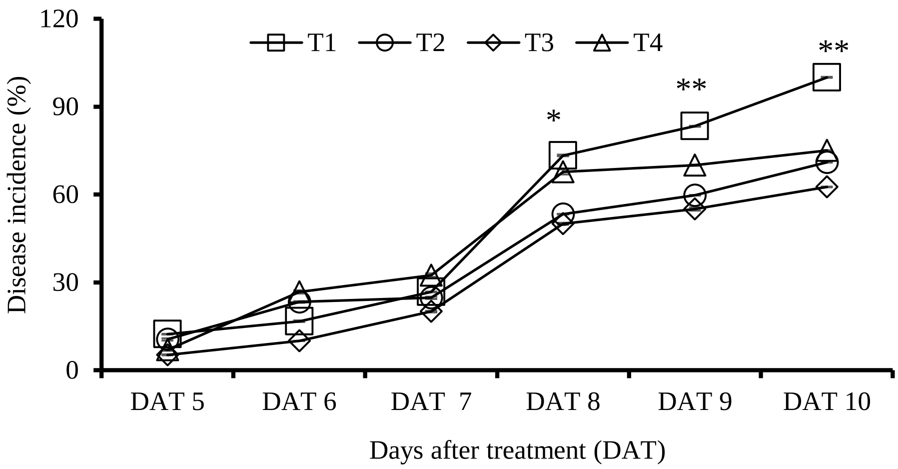

Fig. 3. Effects of chitin nanofiber on disease incidence of mango. T_1= Control, T_2= CNF 0.1%, T_3= CNF 0.3%, and T_4= CNF 0.5%. The error bar represents the mean ± SE (standard error) of three measurements. *, ** mean significance at 5% and 1% probability, respectively.

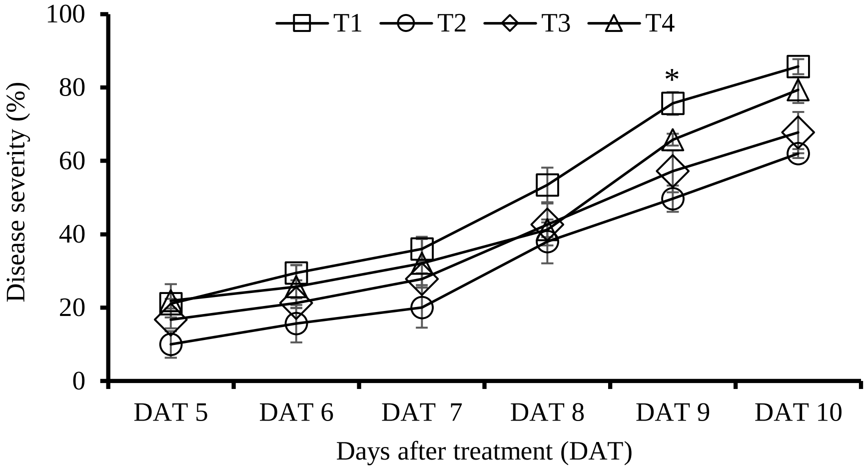

Fig. 4. Effects of chitin nanofiber on disease severity of mango. T_1= Control, T_2= CNF 0.1%, T_3= CNF 0.3%, and T_4= CNF 0.5%. The error bar represents the mean ± SE (standard error) of three measurements. *, ** mean significance at 5% and 1% probability, respectively.

The disease severity of mango gradually increased over the time (Fig. 4). The highest (85%) and the lowest (62%) disease severity were recorded from control and 0.1% CNF, respectively. Lower disease severity was reported if mangoes were treated with chitosan and 1-MCP (Wongmetha and Ke, 2012). Antimicrobial properties of CNF may reduce the severity of diseases in mangoes (El Knidri et al., 2020; Jayaprakash et al., 2021).

Shelf Life

Chitin nanofiber extended the keeping period of mangoes at storage. The highest shelf life (8.5 days) was obtained in mangoes coated with CNF 0.3%, followed by CNF 0.5% (8.33 days) at ambient conditions. The lowest shelf life was calculated from the untreated fruits (6.02 days) (Fig. 5). CNF (0.3%) prolonged the storage life of mangoes by 2.48 days than control. Similarly, irradiated chitosan also extended the shelf life of mangoes (Abbasi et al., 2009). Moreover, chitosan and chitosan with cinnamon oil prolonged the shelf life of mangoes (Yu et al., 2021; Parvin et al., 2023).

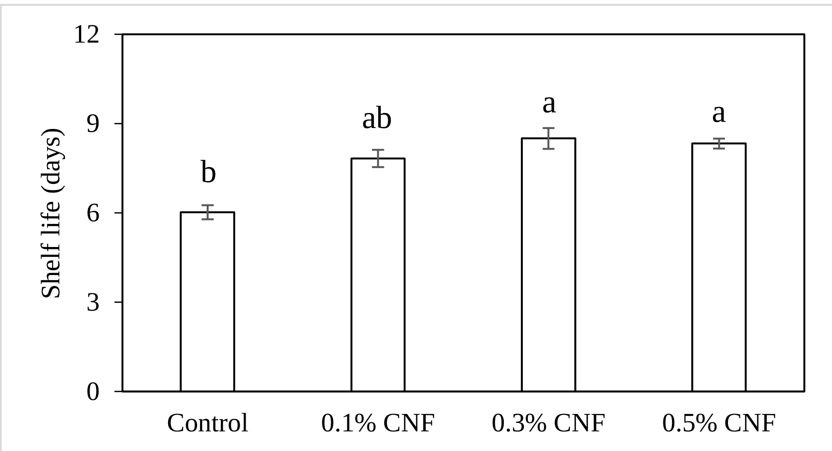

Fig. 5. Effects of chitin nanofiber on the shelf life of mango. The error bar represents mean ± SE (standard error). The treatment means are separated by Tukey's HSD Test at a 5% probability.

APPENDICES

Appendix I. Daily maximal and minimal room temperatures (°C) and relative humidity (%) at afternoon 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	30.5	80
7/31/2022	30.9	29.3	89
8/01/2022	30.1	29.2	88
8/02/2022	30.1	29.6	85
8/03/2022	29.7	29.1	85

CONCLUSION

Chitin nanofiber retains postharvest quality and prolongs the shelf life of mangoes. CNF (0.3%) coating decreases disease incidence by 37% and prolongs the shelf life of mangoes by 2.48 days compared to the control. CNF (0.1%) also retains 12 mg more vitamin C and decreases disease severity by 23% than untreated fruits. Therefore, CNF can be used for postharvest mango preservation. However, as the effectivity of the treatment varies due to varied concentrations, further research is required for other mangoes and different fruits. Moreover, the procedure of CNF extraction should be simple and economical.

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Credit author statement

Shirazoom Munira: Methodology, Investigation, Analysis, Writing – preliminary draft; Md. Yamin Kabir: Supervision, Conceptualization, Analyzing, Writing – draft, review & editing, Fund acquisition.Shamim Ahmed Kamal Uddin Khan: Conceptualization, Co-supervision; Md. Iftekhar Shams: CNF preparation and supply.

Conflict of interest

The authors at this moment hereby declare that there is no conflict of interest.

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