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# Impact of chitosan-aloe vera gel with coconut oil coating on postharvest quality and antioxidant of 'Gopalbhog' mango at ambient storage

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All relevant data are within the paper and its Supporting Information files.

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The authors declare no conflict of interests.

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*Key words:* Antioxidant enzymes, coatings, mango, quality, storage.

**Abstract: Mangoes are valuable fruits because of their nutritional value and commercial significance. It ripens rapidly but deteriorates in quality while stored. Therefore, natural and biodegradable materials must be used in post-harvest management to reduce crop losses. *Aloe vera* (AVG), chitosan (CTS), and coconut oil (CO) either alone or in combinations were tested on mango postharvest features during 12 days' storage at ambient conditions (27±2°C and 80-85% RH). At the end of storage, coatings (AVG+CTS) reduced weight loss (20.02, 37.88%) and decay (9.52, 18.46%) compared to controls while enhancing fruit quality, especially firmness (3.21, 1.44 Kg cm$^{-2}$), ascorbic acid (9.25, 5.89 mg 100 g$^{-1}$), TSS (10.77, 19.5°Brix), acidity (0.46, 0.41%) and pH. Furthermore, coated fruits' total phenol content and antioxidant activity were substantially higher than those of uncoated fruits. Control fruits exhibited the least activity of CAT and POD enzymes during storage, while coated fruits had the lowest PPO activity. The coated fruit peels discoloured less after storage than the control fruits. CO treatment had a deleterious effect on various measures, possibly due to its high concentration. These findings suggested that the CTS+AVG coating may be efficient at the right dose to retain bioactive components and mango (cv. Gopalbhog) fruit quality after harvest.**

## 1. Introduction

Mango (*Mangifera indica* L.) is widely traded due to its versatility, taste, smell, and dietary content (Hossain, 2016). Its excellent nutritional value and abundance of vitamins and minerals make it extremely valuable (Athoo *et al.,* 2024). Bangladesh is the seventh-largest mango producer;

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production currently occupies around 123,997.70 hectares, yielding over 1,482,937.04 MT which contributes 34.33% of the area and 26.21% of the production of total fruit crops in Bangladesh (Bangladesh Bureau of Statistics, 2024). In Bangladesh, there is a huge number of mango varieties; among these is Gopalbhog. This variety is an early well-liked type grown primarily in the north. The fruits produced by this variety are attractive, clean, juicy, fibreless, sweet and weigh 200-300g and pest-free thus, they demand a premium price in the market.

Mangoes are climacteric fruits that mature, soften, and ripen quickly, and are prone to mechanical damage that causes significant postharvest losses (Lawson *et al*., 2019). Due to their climacteric nature, mangoes cannot be stored at room temperature for extended periods, as they mature between 2 and 10 days after harvesting (Kumar *et al.,* 2023), with shelf life varying from a few days at ambient temperature to up to three weeks in cold storage at 13°C. Fruit maturation involves a series of metabolic activities, including loss of weight, increased respiration, structural polysaccharide changes, chlorophyll degradation, carotenoids biosynthesis, starch hydrolysis to sugars, and fruit ripening to acceptable quality (Khanum *et al.,* 2020). A number of factors contribute to post-harvest losses, including the use of improper harvesting, handling and transportation equipment, unsuitable packaging materials, temperature control, rough handling of fresh fruits, and inadequate road infrastructure (Kefas *et al.,* 2024). A variety of fungi attacks mango fruits once they reach maturity and are harvested from the tree. Postharvest losses of mangoes in Bangladesh are estimated to be around 35% (Alom *et al*., 2019). Many harvested mangoes never reach consumers due to these losses (Giovannoni *et al.*, 2017). Less shelf life and postharvest monitoring have hampered mango deliveries to distant markets. Therefore, maintaining mango fruit quality and extending post-harvest life requires effective strategies. Mangoes' postharvest life is artificially prolonged by chemicals that harm the environment and human health. Recently, several treatments that are nontoxic and non-harmful have been employed to enhance the postharvest quality of mangoes, including edible coatings (Liu *et al.,* 2020; Perez-Vazquez *et al.,* 2023; Aaqil *et al.,* 2024), essential oils, or nanoparticles (Kanwar *et al.,* 2024).

Applying chitosan exogenously improves antioxidant activity, maintains firmness, reduces transpiration rate, and enhances fruit quality overall (Wang *et al.,* 2021). Being a naturally occurring compound with antibacterial capabilities, it delays fruit deterioration by making mangos more durable and preventing microbial attacks (Parvin *et al.,* 2023). Chitosan can form layers and is safe and recyclable (Kumar *et al*., 2021). It could treat mango fruit postharvest diseases as an antibacterial agent (Shah *et al.,* 2020). As stated by Silva *et al.* (2017), chitosan has already extended the shelf life of lemon, papaya, and mango following harvest. According to Eshetu *et al.* (2019), chitosan, either by itself or in combination, lowers respiration, softening of tissue, loss of weight, disease, and more.

*Aloe vera* is an environmentally safe postharvest treatment that researchers are interested in. It is frequently added to edible coatings to enhance their antibacterial and moisturizing qualities. Aloe vera gel improves fruit preservation by increasing coating flexibility and barrier properties (Ahmed, 2024). Researchers have extensively studied it as an edible covering material to enhance food quality and safety. However, studies indicate that Aloe vera gel, either by itself or mixed with other ingredients in edible coatings, can minimise lipid oxidation, slow respiration, soften cell walls, promote weight loss, and prevent fruit decay. This effect prolongs the shelf life of mangoes (Amin *et al*., 2021), table grapes (Ayyub *et al*., 2024), apples (Kaur *et al*., 2024), tomatoes (Tobing *et al*., 2023), and apricots (Farooq *et al*., 2023), while maintaining other quality characteristics.

Coconut oil, a tasty fruit coating, reduces respiration, transpiration, and ethylene production. It's rich in lauric acid. This acid may be endogenously converted to monolaurin, which has antimicrobial properties (Liberman *et al.,* 2006). In order to restrict respiration, transpiration, and microbial activity, coconut oil encircles stomata and lenticels (Bisen and Patel, 2012).

Hence, this study set out to analyze the impact of varying chitosan-aloe vera gel with coconut oil coating concentration on 'Gopalbhog' mango quality and shelf life at ambient storage. The aim of this study was to apply chitosan and *Aloe vera* gel as environmentally friendly preservation coatings for decreasing fruit softening, maintaining postharvest mango quality, and prolonging the commercial storage period.

## 2. Materials and Methods

*Fruit material*

Mature 'Gopalbhog' mangoes (peel turned yellow at the bottom and green at the top) from the center of the plant canopy were collected from an orchard near the HSTU (Lat. 25°38'11.6664'' N and Long. 88°38'10.9592'' E) in Bangladesh. We used local producers' harvest stages fruits, which were uniform in size and shape, had no damage and/or microbial infection, and were attractive in colour (green peel and yellow from bottom to top when mature). Fruits were transferred to the laboratory within 2 hours. 72 physiologically mature mangoes (4 fruits per replication) were cleaned with a sodium hypochlorite solution (1% v/v) and dried at room temperature before use.

When mango peels turned yellow at the bottom and green at the top, they were harvested.

*Treatments and storage*

The following six treatments were randomly assigned to six lots of fruits (12 fruits each lot): Control (distilled water), *Aloe vera* gel (AVG 1:1 v/v), chitosan solution (CTS, 1.5% w/v), Coconut oil (CO 1:1 v/v), AVG+CTS, and AVG+CO. Fruits were coated by brushing for five minutes, then air-dried for 2 hours at room temperature. Finally, treated fruits were stored at ambient conditions (27±2°C and 80-85% RH). Quality assessments were done every four days, from day 0 to day 12 of storage.

*Aloe vera gel extraction*

The picked *Aloe vera* leaves were peeled. The parenchyma, after being homogenised into a mucilaginous jelly, had to be filtered to get rid of fibrous materials (Song *et al*., 2013).

*Chitosan solution preparation (CTS)*

In 100 ml of 1% aqueous lactic acid (v/v), 1.5 grams of chitosan powder were dissolved in 1 ml of glycerin. To homogenize the solution, a magnetic stirrer was used for four hours at 25°C. The solution was filtered through three layers of muslin cloth.

*Preparation of chitosan-aloe vera gel coating (CTS+AVG)*

A magnetic stirrer was used to mix CTS and an AVG (1:1 v/v) at the ambient temperature for four hours.

*Preparation of coconut oil-Aloe vera gel coating (CO+AVG)*

In order to create a translucent liquid, CO and AVG (1:1 v/v) were pooled in a beaker and heated in a hot water bath.

*Weight loss*

Following the usual technique, the weight loss % was calculated:

Loss of weight (%)= [Initial fruit weight (g)- Fruit's weight on the observation day(g)]/[Initial fruit weight(g)] ×100

*Fruit firmness, TSS and pH*

Pressure testers measured fruit firmness in kg $cm^{-2}$. A 2 mm stainless-steel spherical probe entered the fruit sample. Three measures calculated the average stiffness. A digital refractometer calculated the TSS (°Brix). pH was measured with a Chinese digital pH meter (HI 2211 pH/ORP).

*Vitamin C*

Vitamin C was assessed as described by McHenry and Graham (1935) with slight modification. Briefly, Whatman No.1 filtered 5g of mango pulp with 5 ml of a 20% metaphosphoric acid solution. Five ml of filtrate was agitated with two drops of phenolphthalein solution in a small beaker and titrated with touching 2, 6-indophenol till pink.

Vitamin C (mg/100 g) = (Titrate × factor of dye (0.5) × prepared volume)/(Filtrate volume taken × weight of sample)

*Titratable acidity (TA)*

To test titratable acidity (citric acid %), 5 ml of the juice was titrated with NaOH (0.1 N) and phenolphthalein until it turned bright pink (pH = 8.0).

*Color*

We used a CR-2000 Japan chroma meter to quantify the color of the mango skin on two different sides of the fruit. The results were shown as L* values (positive means brightness, negative means darkness), a* values (negative means green, positive means red), and b* values (negative means blue, positive means yellow).

*Decay incidence*

The following equation is used to identify rotten fruits:

Decay (%) = (Number of decayed fruits )/(Number initial fruits ) ×100

*Total phenolic content (TPC)*

Total phenolic compounds (TPC) were determined using the method described by Singleton and Rossi (1965) with a few adjustments. Methanol (10 ml) was used to extract and strain 1 g of fruit pulp. An aliquot (1 ml) was mixed with 0.5 ml of Folin-Ciocalteu reagents (Sigma Aldrich) and 7.5% (w/v) aqueous $Na_2CO_3$. Distilled water was added to bring the volume up to 10 ml. The samples were vortexed for 35 minutes at ambient temperature, then centrifuged for 10 minutes at 4000 rpm. Absorbance at 765 nm was checked using a UV 1800 Shaanxi, China spectrophotometer. The TPC was measured as mg of GAE (Gallic Acid Equivalent) per 100-gram fruit pulp.

*Antioxidant activity by DPPH scavenging*

Ten milliliters of methanol and a gram of fruit pulp were mixed to determine the antioxidant activity of the treatment. Whatman No. 1 filter paper was used to filter the mixture. After that, 0.1 ml of extract and 1.9 ml of DPPH solution (0.3 mM) were added to a Falcon tube, which was vortexed for half an hour. Trolox solutions (TE) were used to create the standard curve. A spectrophotometer (UV 1800 Shaanxi, China) was used to detect absorbance at 517 nm compared to a blank.

*Assaying enzymes*

The fruit pulp (0.2 g) was mashed in 3 ml phosphate buffer (100 mM, pH 7, and 4% polyvinylpolypropylene) and centrifuged at 12000 rpm for 15 minutes, aliquoted, and stored at 4°C for future use.

*Polyphenol oxidase (PPO)*

Enzyme extract (600 µl), 1200 µl phosphate buffer solution (100 mM, pH 7), and 600 µl catechol (100 mM,) were mixed together. Activity was validated as U $g^{-1}$ FW after 2 minutes of 410 nm absorbance.

*Catalase (CAT)*

The mixture included $K_2SO_4$ buffers (700 µl, 50 mM, pH 7), $H_2O_2$ (100 µl), and 100 µl of EDTA (100 µl, 2.5 mM). A spectrophotometer recorded absorbance at 240 nm for two minutes. U $g^{-1}$ FW referred to catalase activity.

*Peroxidase (POD)*

To observe the peroxidase activities, we used enzyme extract (100 µl), $H_2O_2$ (100 mM), guaiacol (20 mM), EDTA (2.5 mM), and phosphate buffer (600 µl, 100 mM, pH 7. Color development was measured at 470 nm absorbance for 2 minutes, and the results were shown as U $g^{-1}$ FW.

*Sensory evaluation*

The coated fruits and control were evaluated for sensory attributes, including color, flavor, texture, sweetness, appearance, and overall expression, using a nine-point Hedonic Scale. 1 - Extreme dislike, 2 - Dislike very much, 3 - Moderate dislike, 4 - Slight dislike, 6 - Like slightly, 7 - Like moderate, 8 - Like very much, 9 - Like extremely (Salehin *et al.,* 2025).

*Statistical analysis*

Data was evaluated using a completely randomized design with three replications and two factorial designs. Statistical Tool for Agricultural Research (STAR, Version 2.0.1; IRRI, Laguna, Philippines) and R (version 3.4.2; R Core Team, 2017) with one-way ANOVA were used to analyse the data. LSD estimated mean value differences ($P<0.05$). PCA found likely associations between variables.

## 3. Results

Water loss influences fruit postharvest quality. Storage times and treatments significantly reduced fruit weight. Figure 1A shows that fruits lost weight as storage time increased. Control fruits lost the maximum weight (29.24%) during storage, while AVG+CTS dropped the least (20.02%). CTS, AVG, CO, and CO+AVG treated fruits lost 26.80%, 29.37%, 35.31%, and 26.07%, respectively.

Storage duration and treatments considerably influenced firmness. Throughout the storage period, the firmness gradually decreased regardless of treatment. For control and CTS+AVG, initially, the mango firmness values were 5.36 and 5.9 kg $cm^{-2}$, which dropped significantly at 12 days of storage, reaching values of 1.44 and 3.21 kg $cm^{-2}$, respectively (Fig. 1B).

Storage times and coatings significantly affected the mango fruit's mean total soluble solid (TSS) content. Figure 2A shows that fruit TSS increased significantly with increasing storage periods. The control had the maximum TSS concentration (19.50°Brix), while CTS+AVG and AVG-treated fruits had the lowest (10.77 and 11.0°Brix, respectively) at the end of the storage.

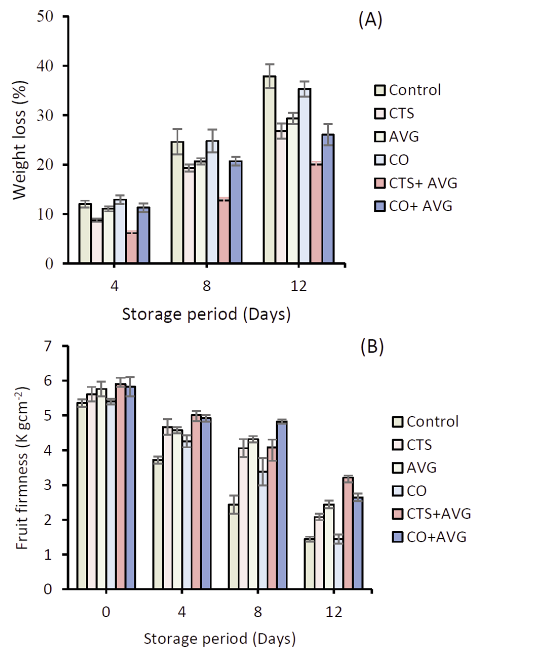


Fig. 1 - Mango weight loss (A) and fruit firmness (B) after 12 days of storage at 27±2°C and 80-85% relative humidity due to coatings and storage intervals. The vertical line shows the standard error of the means of three replicates. Control: Distilled water; CTS= Chitosan; AVG= Aloe vera gel; CO= Coconut oil; CTS+AVG= Chitosan+ Aloe vera gel; CO+AVG= Coconut oil+ Aloe vera gel.

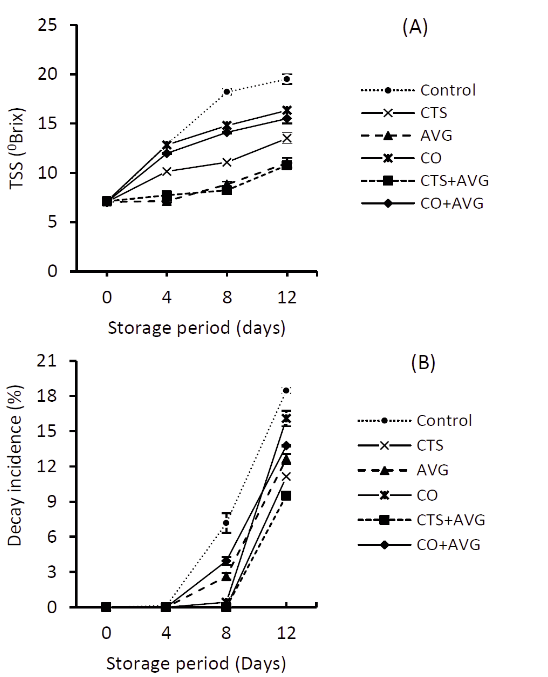


Fig. 2 - Mango TSS (A) and decay incidence (B) after 12 days of storage at 27±2°C and 80-85% relative humidity due to coatings and storage intervals. The vertical line shows the standard error of the means of three replicates. See Figure 1.

From figure 2B, it is observed that fruit degradation began after $4^{th}$ day of storage in the control group, whereas treated fruits began to deteriorate on the $8^{th}$ day of storage. Compared to the control fruit (18.46%), the mango fruits coated with CTS+AVG showed the least deterioration (9.52%) after 12 days of storage.

Color attracts customers' preferences. Coated treatments maintained color, whereas control fruits changed faster. Table 1 provides the color parameters L*, a*, and b*. All samples lost L* values during storage. Control and treated fruit differed greatly. The L* value of the control fruits was considerably lower (30.30) than that of the coated fruits during storage. Higher L* values (41.18) were recorded during storage for fruits covered with CTS+AVG.

After storage, control fruit exhibited higher a* values (-1.31) than coated fruits. The control and treated mangoes initially showed a rise in b* values, which decreased until the end of storage. However, the higher b* values (32.61) were found in CTS+AVG-treated fruits when compared to the control. Since fruit color affects product quality and fresh market value, customer approval is essential.

Mango fruit ascorbic acid content was significantly affected by storage and treatment. Due to physiological metabolism and ascorbic acid oxidation, treated and control mangoes lost vitamin C during storage (Fig. 3A). At 12 days, mean ascorbic acid was 7.56 mg 100 $g^{-1}$. CTS+AVG-treated fruits had a higher ascorbic acid level (9.25 mg 100$g^{-1}$), while control fruits had less (5.89 mg 100$g^{-1}$) after the storage compared to the other treatments.

Acidity decreased during storage. The mean acidity was 0.53% after 12 days storage. In figure 3B, the control had the least acidity (0.41%) while the CTS+AVG treatment had the highest (0.64%).

CTS+AVG-treated fruits exhibited a lower pH 3.39 while control showed higher $P^H$ value 4.65 at the end of storage (Fig. 3C).

During storage, treated and control fruits significantly lost phenolic compounds. At 12 days, CTS+AVG had higher phenolic content (126.34 mg 100 $g^{-1}$), compared to the control (84.13 mg 100$g^{-1}$) (Fig. 4A).

Figure 4B shows that there was a significant decrease in antioxidant capacity in treated and control fruits after storage. At the conclusion of storage, CTS+AVG fruit samples showed the highest DPPH activity (293.51 µmol $g^{-1}$), followed by CTS

Table 1 - Mango peel color (L*, a, and b) after 12 days of storage at 27±2°C and 80-85% relative humidity due to coatings and storage intervals

| Treatments | Storage periods (Days) | | | | Mean (Treatments) |
|---|---|---|---|---|---|
| | 0 | 4 | 8 | 12 | |
| **L*** | | | | | |
| Control | 43.09±3.29 def | 37.53±0.32 hi | 31.96±0.4 j | 30.30±0.35 j | 35.72 C |
| CTS | 45.33±2.73 cde | 43.35±0.32 def | 40.69±0.11 fgh | 37.35±0.41 i | 41.68 B |
| AVG | 50.40±0.55 ab | 45.40±1.07 cde | 42.77±0.20 def | 40.96±0.47 fg | 44.88 A |
| CO | 47.80±0.17 bc | 43.02±1.94 ef | 40.86±0.20 fg | 38.96±0.07 ghi | 42.66 B |
| CTS+AVG | 53.08±1.37 a | 43.44±0.63 def | 42.47±0.05 ef | 41.18±0.11 fg | 45.04 A |
| CO+AVG | 46.28±1.38 cd | 44.73±0.80 cde | 43.62±0.01 def | 40.82±0.26 fg | 43.86 A |
| Mean (Storage periods) | 47.66 A | 42.92 B | 40.59 C | 38.26 D | |
| **a*** | | | | | |
| Control | -7.73±0.58 hij | -4.23±1.27 cde | -3.91±0.35 b | -1.31±0.06 ab | -2.07 A |
| CTS | -8.04±0.13 jk | -7.10±0.66 ghij | -5.47±0.07 efg | -3.40±0.06 cd | -6.00C D |
| AVG | -8.57±0.45 jk | -6.13±0.15 fgh | -5.08±0.10 def | -3.00±0.03 c | -5.70 C |
| CO | -7.93±1.25 ijk | -6.07±0.32 fgh | -4.08±0.68 b | -2.74±0.42 a | -3.15 B |
| CTS+AVG | -9.55±0.54 k | -6.71±0.06 fghi | -6.02±0.29 fgh | -4.09±0.33 cde | -6.59 D |
| CO+AVG | -88.84±0.31 jk | -7.76±0.37 hij | -4.22±1.48 b | -1.53±0.33 ab | -3.82 B |
| Mean (Storage periods) | -8.44 D | -6.33 C | -2.63 B | -0.81A | |
| **b*** | | | | | |
| Control | 15.12±0.50 l | 20.57±1.67 k | 30.37±0.48 fcde | 28.26±0.53 efghi | 23.58 D |
| CTS | 25.41±0.58 ij | 27.09±0.73 ghij | 30.91±1.40 cde | 30.57±0.52 cdef | 28.49 C |
| AVG | 25.78±0.64 hij | 27.58±1.02 fghi | 30.90±0.13 cde | 30.12±0.37 cdefg | 28.59 BC |
| CO | 28.82±2.12 efgh | 32.25±0.78 cd | 36.17±1.60 ab | 33.13±0.58 bc | 32.59 A |
| CTS+AVG | 24.04±2.57 j | 28.64±0.90 efgh | 38.81±1.65 a | 38.95±0.09 a | 32.61 A |
| CO+AVG | 29.00±0.72 efg | 29.64±0.31 defg | 30.69±0.38 cdef | 29.77±0.29 defg | 29.77 B |
| Mean (Storage periods) | 24.69 D | 27.63 C | 32.98 A | 31.80 B | |

Values are means with three replicates ± SE. Means followed by different letters (s) indicate significant differences within the columns or rows. Control= Distilled water; CTS= Chitosan; AVG= Aloe vera gel; CO= Coconut oil; CTS+AVG= Chitosan+ Aloe vera gel; CO+AVG= Coconut oil + Aloe vera gel.

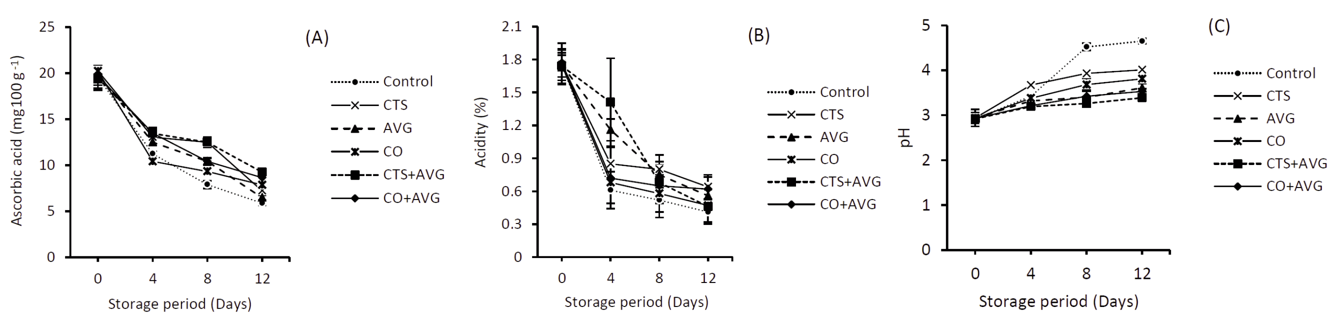


Fig. 3 - Mango ascorbic acid (A) acidity (B) and pH after 12 days of storage at 27±2°C and 80-85% relative humidity due to coatings and storage intervals. The vertical line shows the standard error of the means of three replicates. See Figure 1.

(244.29 µmol $g^{-1}$), AVG (276.12 µmol $g^{-1}$), CO (222.79 µmol $g^{-1}$), and CO+AVG (227.04 µmol $g^{-1}$). The control group had the lowest DPPH activity (182.65 µmol $g^{-1}$) compared to the coated groups, which may help the fruit generate antioxidant molecules and activate antioxidant defense enzymes.

Post-harvest treatments and storage durations significantly ($P< 0.05$) influenced mango fruit antioxidant enzymes. As demonstrated in figure 5A the control group had the highest polyphenol peroxidase (PPO) activity (7.17 U $g^{-1}$) after 12 days, while CTS+AVG-treated fruits had the lowest (3.95 U

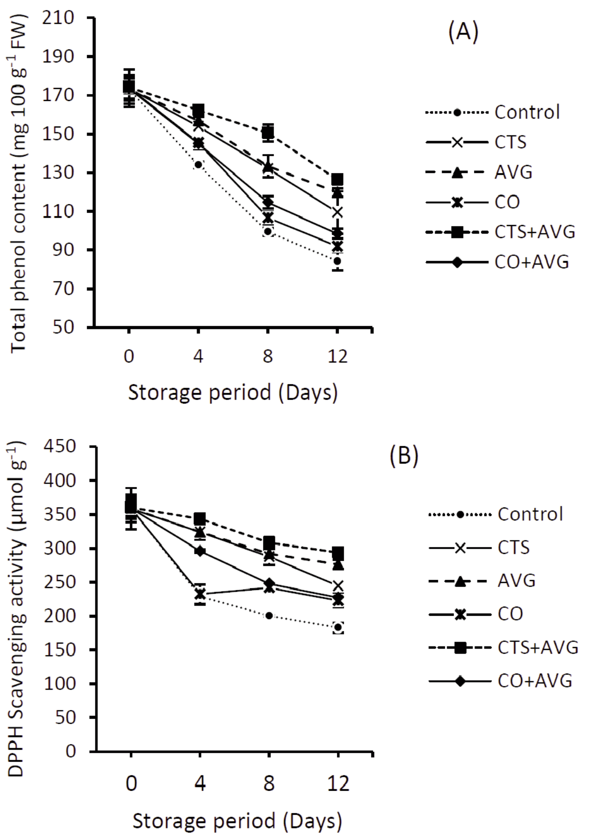


Fig. 4 - Mango total phenol content (A) and DPPH activity (B) after 12 days of storage at 27±2 °C and 80-85% relative humidity due to coatings and storage intervals. The vertical line shows the standard error of the means of three replicates. See Figure 1.

$g^{-1}$). As shown in figure 5B treated fruit samples and control-maintained catalase activity (CAT) throughout storage. After 12 days of storing, the CTS+AVG group had higher CAT activity (0.47 U $g^{-1}$) than the control group (0.33 U $g^{-1}$). Figure 5C shows the maximum POD activity (0.55 U $g^{-1}$) in CTS+AVG-treated fruits after 12 days of storage. POD activity at 12 days of storage was in CTS (0.48 U $g^{-1}$), AVG (0.51 U $g^{-1}$), CO (0.50 U $g^{-1}$), and CO+AVG (0.49 U $g^{-1}$) while the control (0.48 U $g^{-1}$) exhibited lower POD activity.

Mango fruits treated with CTS + AVG had superior overall impression (7.71) compared to the control (7.01). CTS + AVG improved the mango fruit's flavor (7.97), sweetness (7.33), taste (7.63) and color (7.90) at 8 days of storage (Fig. 6).

*Principal component analysis (PCA)*

PCAs examined biochemical properties and antioxidant enzymes after postharvest treatment.

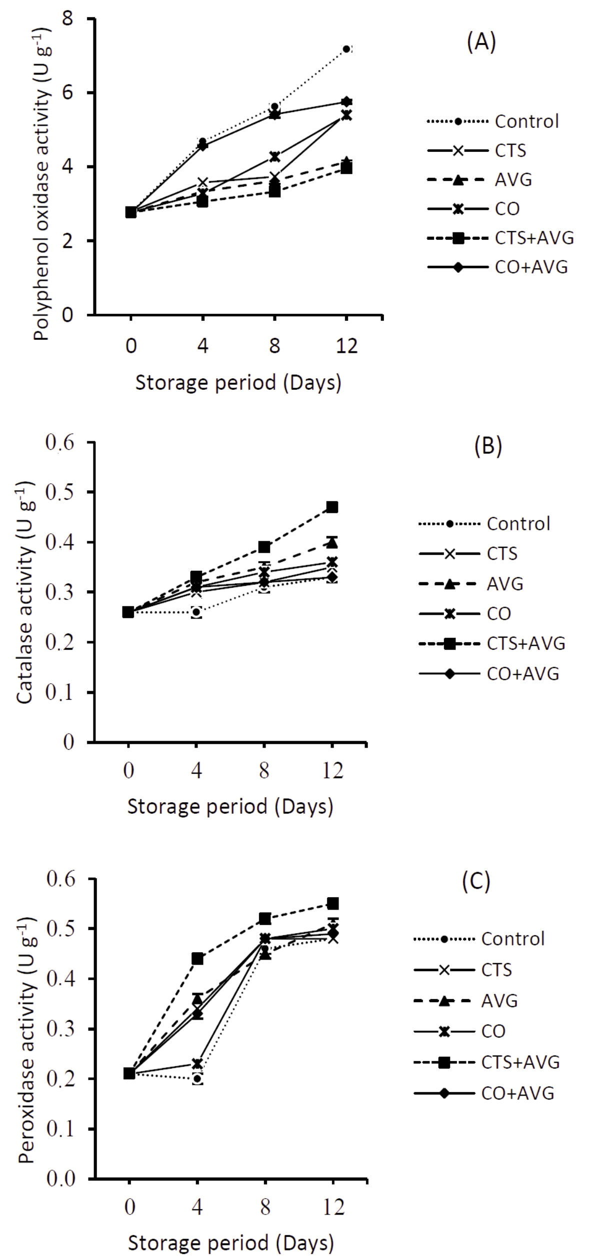


Fig. 5 - Mango PPO (A), CAT (B) and POD (C) activity after 12 days of storage at 27±2°C and 80-85% relative humidity due to coatings and storage intervals. The vertical line shows the standard error of the means of three replicates. See Figure 1.

Two PCAs explained 88.4% of PCA variation. PC1 (Dim 1) explained 80.1% of the dataset variation and PC2 (Dim 2) explained 8.3%. AA, TPC, DPPH, FF, L* values, POD, and CAT enzymes strongly connect with PC1, while TSS, WL, PPO enzyme, and a* values negatively correlate. PC2 was linked positively with b* values but negatively with TA and pH (Fig. 7).

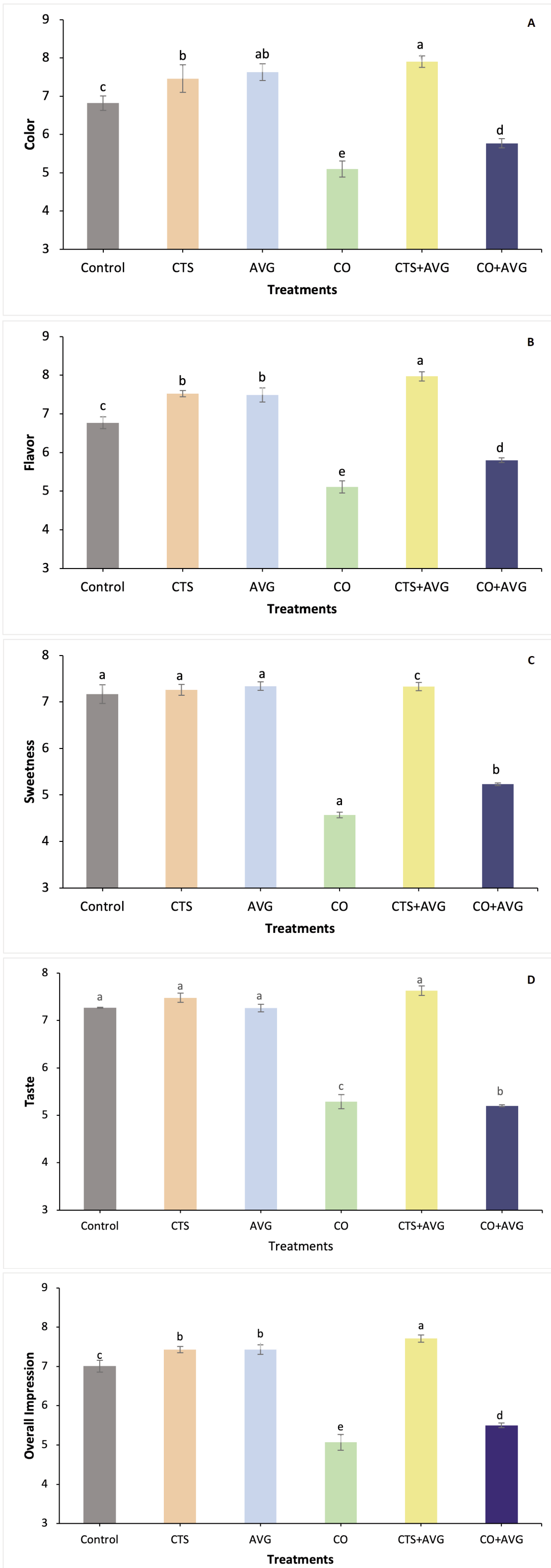


Fig. 6 - Mango color (A), flavor (B), sweetness (C), taste (D) and overall impression (E) at 8 days of storage at 27±2°C and 80-85% relative humidity due to coatings treatment. The vertical line shows the standard error of the means of three replicates. See Figure 1.

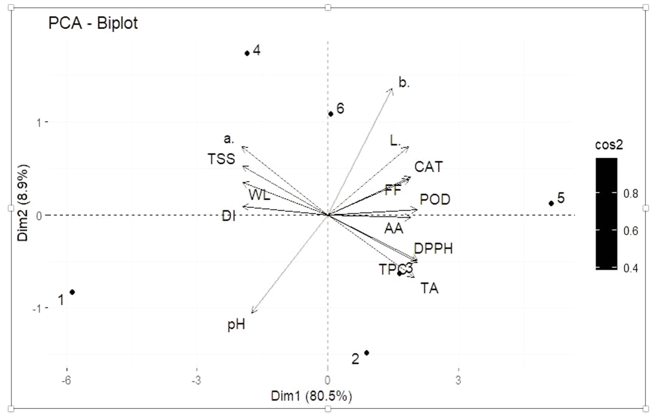


Fig. 7 - Principal component loading plot of physiochemical and antioxidant enzymes activities of mango fruit during storage.

## 4. Discussion and Conclusions

Mango ripening is associated with changes in color, texture, and flavor, resulting from modifications in the fruit's chemical composition. These include the conversion of starch to sugars, a reduction in acidity, and the generation of new volatile compounds (Taiti *et al.*, 2015). Fruit weight loss increases due to moisture evaporation and metabolic activity. Ncama *et al.* (2018) reported that water loss during postharvest storage leads to weight reduction, changes in texture and appearance, and shriveling. However, water loss can be reduced when fruit surfaces are covered with semipermeable edible coatings. Shah and Hashmi (2020) also discovered that CTS + AVG coatings reduce the weight of mango fruit.

CTS+AVG significantly maintained the firmness of mango fruits. According to Rukunuzzaman *et al.* (2025), mangoes treated with CTS + AVG decreased mango softening by reducing the breakdown of cell wall polymers, keeping the fruit firm. Our study also confirmed Rastegar and Atrash (2021) that CTS+AVG delayed mango fruit firmness.

Total soluble solids were significantly increased by moisture loss and the breakdown of carbohydrates into soluble sugars. However, edible coatings may limit respiration and exchange of gases in coated fruits by closing stomata, preventing an increased rate of TSS content (Chavan *et al.*, 2023). CTS+AVG-treated mangoes showed lower TSS during storage, as described by Yu *et al.* (2021).

The chitosan coating significantly decreased the frequency of disease-induced mango fruit deterioration while preserving fruit quality in agricultural commodities (Hasan *et al.,* 2020). Similar to this, AVG coating can prolong the shelf life of apricots by postponing microbial deterioration, whether it is applied alone or in conjunction with other treatments (Nourozi and Sayyari, 2020). In this study, the use of CTS either alone or in combination with AVG significantly decreased the incidence of mango fruit deterioration during storage.

Changes of color in climacteric fruits occur because of the alteration of chlorophyll to other pigments. Kaur *et al*. (2024) stated that CTS + AVG coatings slow down metabolic and pigment changes by regulating gas exchange in fruits while they are being stored. Due to the lower availability of oxygen and higher carbon dioxide in the internal microenvironment, it causes slower ripening (Paul *et al*., 2019).

The L* value decreased across all treatments, although it declined more slowly in treated fruits than in the controls. The lower a* values of the coated samples, which are more green than red throughout storage, may suggest a delay in mango fruit ripening. According to a previous study by Abdelshafy *et al.* (2023) and Begum *et al.* (2023), edible coatings can influence epidermal permeability, gas exchange, and oxidation. Seyed *et al.* (2021) found that mango fruits stored with *Aloe vera* gel and chitosan changed color less than control fruits.

Ascorbic acid, a powerful antioxidant, scavenges free radicals and reactive oxygen species during fruit ripening (Fenech *et al.,* 2019). The CTS + AVG coating in mango fruits might limit the permeability of oxygen and carbon dioxide on its surface and reduce the loss of ascorbic acid content. Our results were confirmed by Shah and Hashmi (2020), who reported higher levels of vitamin C in mango fruits treated with CTS+AVG.

Acidity presumably decreased due to widespread catabolisation of organic acids to sugars. A sudden reduction in TA indicated senescence in mango fruit (Shah and Hashmi, 2020). Seyed *et al.* (2021) found that *Aloe vera* gel with chitosan-treated mango fruits had the highest TA.

Fruit coated with CTS+AVG has the lowest pH. In line with our findings, Amin *et al.* (2021) discovered that CTS+ AVG reduces mango pH. According to Sogvar *et al.* (2016) who reported that strawberry's pH raised during storage in both control and *Aloe vera* gel-coated fruits; whereas control fruits had a higher pH value.

Retaining the fruit's nutritional quality (color, bitterness, astringency, acidity, and taste) during storage requires retaining phenolic chemicals, which decrease with ripening. Phenolic molecules, secondary plant metabolites, scavenge ROS to increase fruit antioxidants (Swallah *et al.,* 2020). An edible coating may reduce phenolic component oxidation in mangoes. Agreeing with Seyed *et al.* (2021), the current work determined that chitosan and Aloe vera gel coatings improve the phenolic retention of mangos during storage.

The treated fruits' antioxidant capacity, which is linked to total phenolic content, may boost the activity of DPPH scavenging. *Aloe vera* coatings-maintained antioxidant (DPPH) activity throughout storage (Khaliq *et al.,* 2019 a or b). Mango fruit treated with *Aloe vera* and chitosan during postharvest storage period showed improved DPPH scavenging activity, as reported by Begum *et al.* (2023).

The fruit's antioxidant system's genes for PPO, POD, and CAT increase throughout ripening, defending against ROS accumulation (Loay and El-Ezz*,* 2021, and Yu *et al.,* 2021). Most horticultural crops discolor when PPO oxidizes phenolic compounds, altering them to quinones. The coating reduced PPO activity, which may have activated defence-related enzymes to prevent browning of mango fruit and extend storage (Adiletta *et al.,* 2019). PPO and enzymatic browning may have been inhibited by fruit surface chitosan coating $CO_2$, $O_2$, and ethylene (Romanazzi *et al.,* 2018). These findings are consistent with previous findings in strawberry (Petriccione *et al.,* 2015), where chitosan coatings significantly reduced PPO activity and fruit discoloration. CAT activity reduces $O_2$ and $H_2O_2$. Shah and Hashmi (2020) discovered that mango fruit chitosan coating boosts CAT activity. POD, a fruit-specific oxyradical detoxifying enzyme, may reduce oxidative damage and a complex covering of chitosan and cinnamon oil increased POD activity in jujube, promoting storage disease resistance (Xing *et al.,* 2020).

According to these findings, using *Aloe vera* gel along with chitosan was the most effective way to mitigate decay symptoms and lessen the physicochemical alterations in mango fruit. Mangoes treated with AVG coatings, either separately or in combination, exhibited improved sensory quality, according to Khaliq *et al*. (2019 a, b).

This study presented that chitosan and *Aloe vera* coatings may increase mango storage life by minimizing weight loss, reducing postharvest deterioration and retaining ascorbic acid, titratable acidity, firmness, and peel color throughout storage. Mango fruit with coatings had higher total phenol and antioxidant levels than the control and ripened more slowly. These coatings may boost CAT and POD antioxidant enzymes and lower PPO during storage. Given human health concerns, edible coatings like chitosan-aloe vera may improve mango storage quality. Natural edible coatings of *Aloe vera,* chitosan, and coconut oil may affect antioxidant enzyme activity. In order to make mango fruit appealing to consumers and enhance its storability with edible coatings, further research is needed.

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