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Effects of Chitosan Coating on the Biochemical Properties of Sweet Pepper (*Capsicum annuum* L.) in Cold Storage

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ABSTRACT

Bell pepper exports usually face limitations in storage, marketing, and delivery timing, which may result from rapid fruit ripening after harvest and microbial contamination. These adverse effects can highly reduce the qualitative properties of the fruit and exacerbate fruit spoilage. However, unique postharvest approaches can prevent these unwanted outcomes. Edible coating treatments can prolong shelf life after harvesting various fruits. In this experiment, we investigated the effects of chitosan as an edible coating at four levels (0, 0.5, 1, and 2%) and storage durations (0, 7, 14, 21, and 28 days). The treatments affected the postharvest quality of bell pepper (cv. 'California Wonder'). The experiment comprised four replications, using two factorial-balanced analyses of variance based on a randomized complete design (CRD). In measuring enzyme activity after 28 days of storage, the results showed that the chitosan treatment (2%) significantly reduced the activity of peroxidase (76.25%) and polyphenol oxidase enzymes (37.05%) compared to the control. However, it significantly increased antioxidant capacity, total phenol, flavonoids, ascorbic acid, ascorbate peroxidase, and catalase activities by 41.7, 21.5, 21.7, 32.25, 59.05, and 58.10%, respectively. Moreover, the results showed that different concentrations of chitosan, especially the 2% concentration, maintained the postharvest quality of bell pepper and delayed fruit aging compared to the control. According to the results, the edible chitosan coating can increase the shelf life of bell pepper fruits.

Introduction

Bell pepper, *Capsicum annuum* L., also known as sweet pepper, paprika pepper, or capsicum, is a strategic fruit species of the *Solanaceae* family, with excellent nutritional properties and high levels of ascorbic acid, antioxidants, and vitamins, which commonly appear as a vegetable ingredient or have applications in side dishes (Wahyuni et al., 2013). The fruits of this plant are botanically classified as berries and exist in different colors, including red, yellow, orange, green, white, and purple. Bell pepper is native to Mexico, Central America, the Caribbean, and northern regions of South America. They are cultivated in tropical and subtropical parts of the world. The global production of bell peppers was 36 million tons in 2020. China, Türkiye, and Indonesia had the highest production levels in the world based on recent data (Tiamiyu et al., 2023). Bell pepper is cultivated in subtropical regions of Iran, including Khuzestan, Bushehr, Hormozgan, South of Kerman, and Sistan Baluchistan on

farms. Nowadays, this plant is cultivated in almost all parts of Iran by greenhouse technology. Bell pepper trade had a value of 6 billion and thirty million dollars in 2022 (FAO, 2023). However, the fruit is perishable and vulnerable to flaccidity, wilting, shriveling, fungal infections, deterioration, and a limited shelf life (Tiamiyu et al., 2023).

Its postharvest storage, as in many other fruits and vegetables, is characterized by changes in the physiological and biochemical activities. These activities are usually followed by a decrease in the qualitative characteristics of fruits, such as moisture, texture, aroma, and taste (Jianglian and Shaoying, 2013). Thus, some postharvest treatments can increase the shelf life of this fruit.

Edible coatings are increasingly used as an ideal preservative method for storing fruits. Edible coatings, as thin layers of food materials, are used on the surface of fruits and are an alternative to protective wax coatings (Sharma et al., 2019). The most common edible coatings are starch and its derivatives, cellulose derivatives, pectin, whey proteins, plant-derived proteins, plant extracts, essential oils, wax, and chitosan (Lin and Zhao, 2007). Chitosan is an important edible coating with proven effects on the maintenance of fruit quality. It slows down weight loss and the deterioration of fruit color and textural changes, thus delaying fruit senescence and assisting in the maintenance of fruit appearance and overall quality (Velickova et al., 2013). In addition to being semi-permeable to respiratory gases, chitosan reduces respiratory and metabolic activities. Furthermore, it has antibacterial, antifungal, and antiviral properties that reduce the need for chemicals and increase food safety (Melo et al., 2020).

In a previous study, the effects of cellophane and chitosan coatings were evaluated on the quality and storage characteristics of bell pepper (cv. 'California Wonder') within timeframes of 14 and 28 days. The results showed that increasing the storage period caused a decrease in the quality of control fruits. However, the chitosan coating prevented weight loss, maintained firmness, and increased soluble solids, titratable acid, sugar-to-acid ratio, ascorbic acid, antioxidant capacity, total phenol content, catalase enzyme activity, and peroxidase activities, compared to the control. The cellophane treatment caused the highest fungal infection (27.6%) and suboptimal marketability (88.3%) compared to the chitosan treatments and co-treatment of the chitosan and cellophane. Co-applications of chitosan and cellophane better maintained the biochemical features and quality characteristics of the fruits than in other treatments (Mohammadi et al., 2018). In another relevant study, it was reported that edible chitosan-based coatings were able to reduce the percentage of chilling and rot by maintaining the quality characteristics of sweet pepper after prolonged storage (3 weeks) at 1.5 °C and then another three days at 21 °C (Kehila et al., 2021). Regarding the effects of edible coatings on the quality of biochemical fruits and storage life of bell peppers, it was reported that applying chitosan edible coating increased the activities of polyphenol oxidase (PPO), peroxidase (POD) while enhancing the phenolic content in fruits (Alpos and Bayogan, 2023). Considering the importance of bell pepper exports in terms of economic development, there is a constant need for new research on ways to prolong the storage life of bell peppers with appropriate coatings. Therefore, this study aimed to maintain bell pepper quality and shelf life in storage while using edible chitosan as a coating material.

Materials and Methods

This experiment was carried out in the laboratory of Physiology, Horticulture Department, University of Hormozgan, Bandar Abbas. Fresh bell pepper fruits (cv. 'California wonder') were harvested at the maturity stage from a greenhouse complex in Sar-Khoon village, Bandar Abbas County. The bell peppers were harvested in December 2019. Immediately after harvest, they were transferred to the laboratory to apply the treatments. Then, healthy and uniform bell peppers were selected. The treatments included different concentrations of chitosan (0, 0.5, 1, and 2%) with four replications per treatment. The various concentrations of this coating were prepared by dissolving the required amount of chitosan powder in 0.5% acetic acid and with heat. After the complete dissolution of chitosan, the uniform solution was prepared by raising the pH of the solution to 5.7 with 1 N NaCl according to guidelines by Xing et al. (2011) (Xing et al., 2011). The prepared solution was kept in a sterile space for 24 hours before applying the treatments. The healthy fruit bell peppers were immersed in each chitosan concentration (0, 0.5, 1, and 2% w/v) for 2 min. After applying the treatments, the fruits were dried at laboratory temperature and stored in plastic baskets for 0, 7, 14, 21, and 28 days without additional coating (10 °C and 95% relative humidity). The biochemical and enzymatic parameters were examined.

Ascorbic acid

To measure ascorbic acid, a

spectrophotometer was used, followed by an illustration of the ascorbic acid standard curve (Etemadipoor et al., 2020). One gram of fruit tissue was homogenized with 10 mL of distilled water, followed by filtration. A filtered solution (0.1 mL) was added to 1% metaphosphoric acid. Then, 1 mL of the solution was combined with 10 mL of colored 2, 6- dichloroindophenol (0.0025%). The mixture was shaken vigorously, and its absorbance was read with a spectrophotometer (Cecil, CE2501, UK) at 517 nm wavelength. The amount of ascorbic acid content was reported in mg per 100 g of fresh fruit tissues.

Total phenol

Total phenol content was measured by the Folin–Ciocalteu reagent method (Meyers et al., 2003). In this method, the methanolic extract was mixed with 125 µL of the Folin–Ciocalteu reagent (10%) and, after five min at 35 °C, 100 µL of 7% sodium bicarbonate solution was added. The absorbance of the reaction mixture was read by a spectrophotometer at 765 nm after 120 min of storage without light. On a standard gallic acid curve, the amount of total phenol was expressed in milligrams of gallic acid per gram of fresh tissue.

Flavonoids

To measure the total flavonoids content, 1.5 mL of methanol (80%), 100 µL of aluminum chloride solution (10%), 100 µL of 1 M potassium acetate solution, and 2.8 mL of distilled water were added to 500 µL of each extract. The absorption of the mixture was measured after 40 min at a wavelength of 415 nm, relative to the blank. The total flavonoid contents of the extracts were reported in mg equivalent to quercetin per gram of fresh weight (Chang et al., 2002).

Antioxidants capacity

The antioxidant capacity of the fruit tissues was determined by the free neutralization of DPPH (Miliauskas et al., 2004). For this purpose, 0.2 g of the fruit tissue was pulverized with liquid nitrogen in a porcelain mortar, and then 10 mL of pure methanol was added. After homogenization, it was centrifuged at 10,000 rpm. Then, 10 µL of the methanolic extract was mixed with 1,900 µL of 100 µM DPPH solution and left in the dark for 30 min to reach a uniform solution. The absorbance of the samples was read at 515 nm by a spectrophotometer, and the antioxidant capacity of the extracts was calculated as the percentage of DPPH inhibition.

Catalase (CAT)

Catalase enzymatic activity was measured by the rate of H_2O_2 decomposition and through a decrease of absorption at 240 nm, according to a method reported by Xing et al. (2011). Enzymatic extraction was performed using two grams of fruit tissue and 100 mM potassium phosphate buffer (pH = 7). To measure the CAT activity, the reaction mixture included 2.87 mL of 50 mM potassium phosphate buffer and 100 µL of enzyme extract. An enzyme unit was defined as the amount of enzyme required to decompose one micromole of hydrogen peroxide in grams of fresh weight per minute.

Ascorbate peroxidase (APX)

A relevant method (Nakano and Asada, 1981) was used for measuring the APX activity. The enzyme activity was determined by spectrophotometry based on the reduction of absorption at 290 nm. The enzyme activity was expressed by finding the equivalent of absorption per min as enzymatic units per milliliter of extract.

Peroxidase (POD)

According to In-Byung et al. (2007), 161 µL of guaiacol with 17 µL of H_2O_2 was added to the phosphate buffer to measure the POD enzyme activity. For each assay, 33 µL of the extract was added to 1000 µL of the buffer, and the absorption curve was read by a spectrophotometer at 470 nm.

Polyphenol oxidase (PPO)

The PPO enzyme was measured using a method by Kar and Mishra (1976) with some modifications. Accordingly, 0.0504 g of pyrogallol was dissolved in 20 mL of distilled water before being added to the phosphate buffer solution. The absorption curve was read at 420 nm using a spectrophotometer. The phosphate buffer was used as a blank solution.

Data analysis

The results were analyzed by SAS software based on a two-factorial-balanced analysis of variance and a complete randomized design (CRD). The LSD test was employed to make comparisons of mean values ($P \leq 0.05$).

Results

The analysis of variance showed significant simple effects of chitosan and time, and significant interactions of chitosan and time that affected all traits in bell pepper fruits ($P \leq 0.01$) (Table 1).

Table 1. Analysis of variance regarding the effects of different concentrations of chitosan (0, 0.5, 1, and 2%) in various durations (0, 7, 14, 21, and 28 days) on biochemical traits of bell pepper.

Sources of variation	D.f	MS							
		Ascorbic	**Flavonoids**	**APX**	**Phenol**	**DPPH**	**CAT**	**POD**	**PPO**
Chitosan	3	60.90**	0.449**	0.24**	0.694**	1.41**	0.456**	0.89**	0.274**
Time	4	58.05**	0.568**	0.16**	0.507**	1.25**	0.560**	0.37**	0.389**
Chitosan × Time	12	78.01**	0.599**	0.127**	0.699**	1.78**	0.866**	0.98**	0.447**
Error	60	9.32	0.033	0.0165	0.018	0.015	0.06	0.023	0.014
CV (%)	-	5.43	1.11	2.78	1.53	0.29	2.87	2.10	3.88

* ns is non-significant, * is significant at the 5% level, ** is significant at the 1% level.

Ascorbic acid

Based on the results of the analysis of variance, the simple effects of chitosan, time, and the interaction effect of chitosan and time were significant on the ascorbic acid content of bell peppers (P≤0.01) (Table 1). The ascorbic acid contents of the chitosan-coated fruits were significantly higher than the control, especially after 21 and 28 days of storage (Fig. 1). The ascorbic acid contents of the control fruits decreased during storage, and a maximum decrease occurred after 28 days of storage. However, the reduction in ascorbic acid content was slight in the treated fruits with chitosan coating concentrations of 0.5, 1, and 2% after 14, 21, and 28 days of storage. The chitosan coating concentration of 2% significantly maintained the ascorbic acid contents at the highest level after 21 and 28 days of storage (Fig. 1). The differences in ascorbic acid content reduction among the treated fruits of 2% and 1% coating concentrations were 14.08% and 24.95% between 21 and 28 days of storage, respectively (Fig. 1).

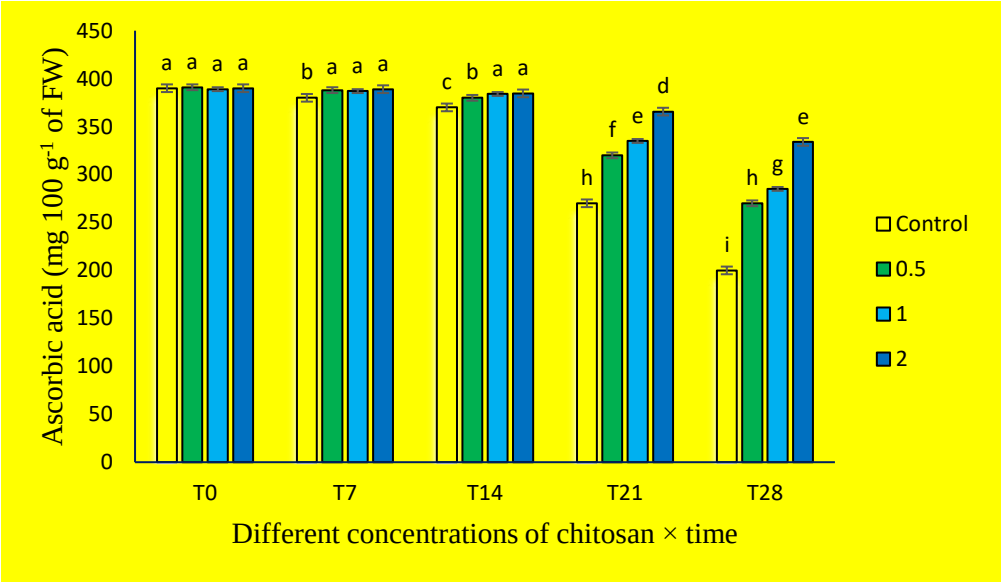

Fig. 1. Comparison of the mean effect of different concentrations of chitosan (0, 0.5, 1, and 2%) through different durations (0, 7, 14, 21, and 28 days) on ascorbic acid in bell pepper fruits. Mean values with similar letters had no significant difference (P≤0.05).

Total phenol

The analysis of variance showed that the simple effects of chitosan and time and the interaction of chitosan and time were significant on the phenol content in bell pepper fruits (P≤0.01) (Table 1). The phenol contents of the treated fruits with different concentrations of chitosan coating (0.5, 1, and 2%) were significantly increased than the control fruits after 14, 21, and 28 days of storage (Fig. 2). With the increase in chitosan coating concentration (0.5, 1, and 2%), the phenol contents significantly increased after 21 and 28

days of storage. The results showed that chitosan coating (2%), through 28 days of storage, caused a significant increase in the phenol content in bell pepper fruits (37.037%) compared to the control (Fig. 2).

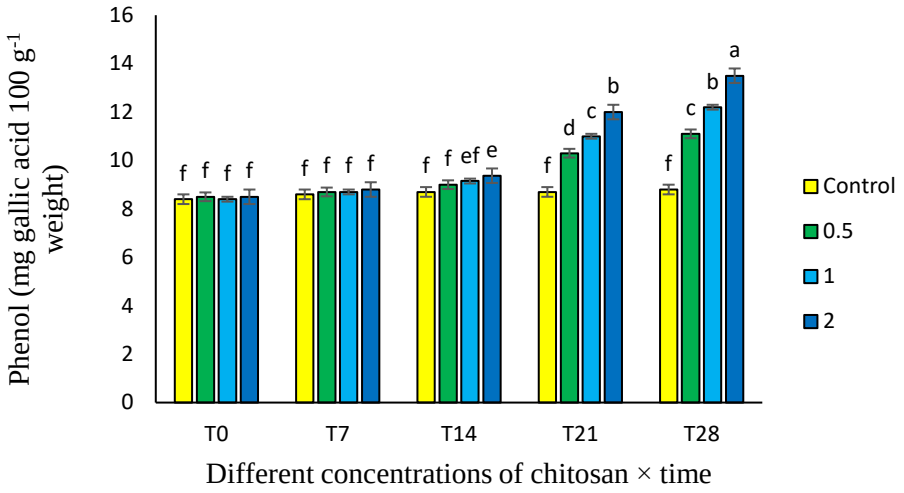

Fig. 2. Comparison of the mean effects of different concentrations of chitosan (0, 0.5, 1, and 2%) through different durations (0, 7, 14, 21, and 28 days) on the phenol content in bell pepper fruits. Mean values with similar letters had no significant difference (P≤0.05).

Flavonoids

According to the analysis of variance, the simple effects of chitosan and time and the interaction effect of the chitosan and time were significant (P≤0.01) on the flavonoid content of the bell pepper fruits (Table 1). The chitosan coating concentration of 0.5, 1, and 2% caused the flavonoid content of the bell pepper fruits to significantly increase after the 14, 21, and 28 days of storage. On the last day of storage, the flavonoid contents of the treated fruits with the different concentrations of chitosan coating were higher than on other sampling days of the storage. Treated fruit with the chitosan concentration of 2% had the highest flavonoid content (Fig. 3). At the chitosan concentration of 2% after 28 days, the treatment caused the flavonoid content to become significantly higher (256%) than that of the control group in its condition at the beginning of the experiment (Fig. 3).

Antioxidant activity

According to the analysis of variance, the simple effects of chitosan, time, and the interaction of chitosan and time were significant on the antioxidant activity (scavenging activity of DPPH radical) of the bell pepper fruits (P≤0.01) (Table 1). Through 14, 21, and 28 days of storage, the results showed that the fruits treated with the chitosan coating (2%) made the antioxidant activity (scavenging activity of DPPH radical) higher (32%) than that of the control group (Fig. 4). During the days of storage (7, 14, 21, and 28), the antioxidant activities (scavenging activity of DPPH radical) were significantly increased in the treated fruits with the chitosan coating concentrations (0.5, 1, 2%) than the control group (Fig. 4).

Catalase (CAT)

The results of the analysis of variance showed that the simple effects of chitosan, time, and the interaction of chitosan and time were significant on the catalase activity in the bell pepper fruits (P≤0.01) (Table 1). The chitosan coating retained catalase activity of the treated fruits significantly higher than that of the control fruits during storage (Fig. 5). Through 28 days of storage, chitosan (2%) caused the catalase activity to be significantly higher (39.13%) than that of the control (Fig. 5).

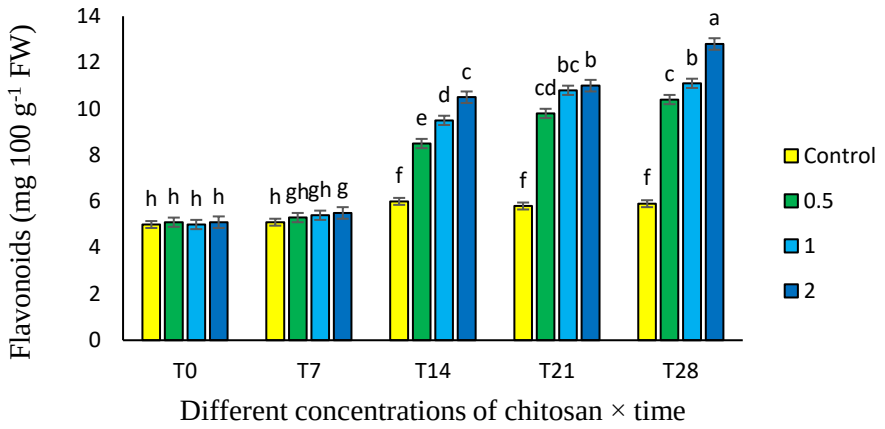

Fig. 3. Comparison of the mean effects of different concentrations of chitosan (0, 0.5, 1, and 2%) through different durations (0, 7, 14, 21, and 28 days) on the flavonoid content of the bell pepper fruits. Means values with similar letters had no significant difference (P≤0.05).

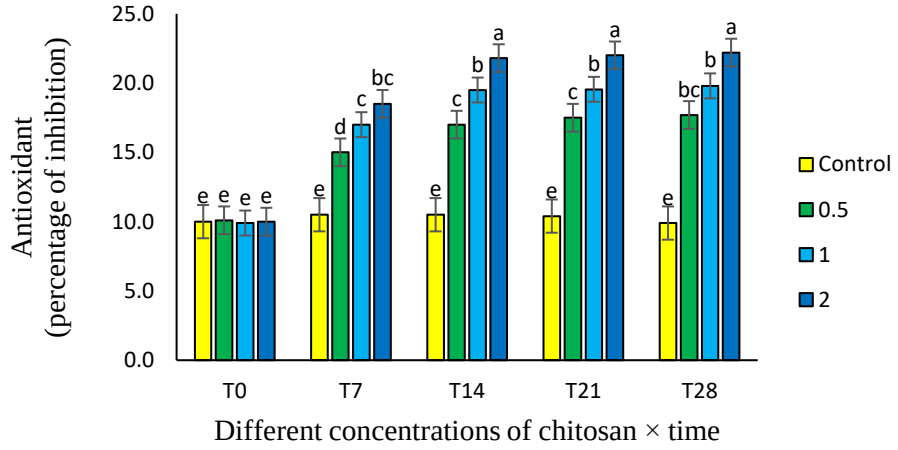

Fig. 4. Comparison of mean effects of different concentrations of chitosan (0, 0.5, 1, and 2%) through the different durations (0, 7, 14, 21, and 28 days) on antioxidant activity (scavenging activity of DPPH radical) of the bell peppers. Mean values with similar letters had no significant difference (P≤0.05).

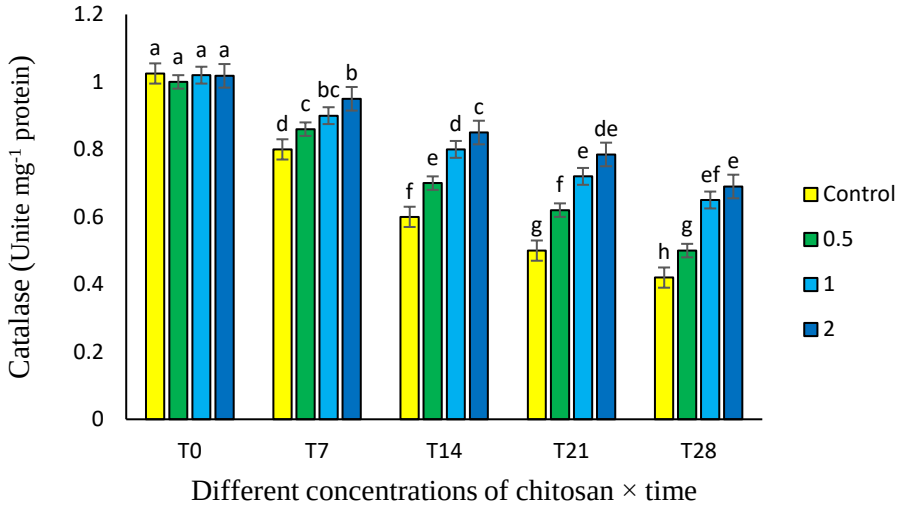

Fig. 5. Comparison of mean effects of different concentrations of chitosan (0, 0.5, 1, and 2%) through different durations (0, 7, 14, 21, and 28 days) on catalase activity in bell pepper fruits. Mean values with similar letters had no significant difference (P≤0.05).

Ascorbate peroxidase (APX)

Based on the results of the analysis of variance, the simple effects of chitosan and time and the interaction of chitosan and time were significant on the ascorbate peroxidase content of bell pepper fruits (P≤0.01) (Table 1). The results showed that the APX contents significantly decreased during the 0, 7, 14, 21, and 28 days of storage (Fig. 6). Also, the APX contents increased substantially in response to higher chitosan coating concentrations during the 7, 14, 21, and 28 days of the storage (Fig. 3). The chitosan coating (2%) caused a significant increase in APX (25.53%) after 28 days of storage compared to the control group (Fig. 6).

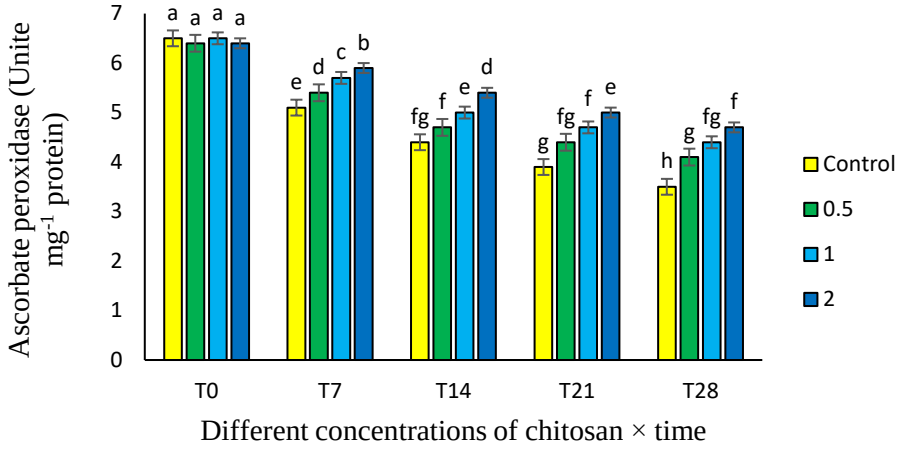

Fig. 6. Comparison of mean effects of different concentrations of chitosan (0, 0.5, 1, and 2%) through different durations (0, 7, 14, 21, and 28 days) on the ascorbate peroxidase content in bell pepper fruits. Mean values with similar letters had no significant difference (P≤0.05).

Peroxidase (POD)

The analysis of variance showed that the simple effects of chitosan, time, and the interaction of chitosan and time were significant on the peroxidase activity in bell pepper fruits (P≤0.01) (Table 1). The results showed that the peroxidase activity of the control and treated bell pepper fruits increased through storage (7, 14, 21, and 28) (Fig. 7). However, the peroxidase activity of the bell pepper fruits in the control group increased more significantly than the fruits treated with chitosan coating (Fig. 7). The increase in peroxidase activity of the bell pepper fruits treated with chitosan coating (2%) was significantly less than in the others (Fig. 7).

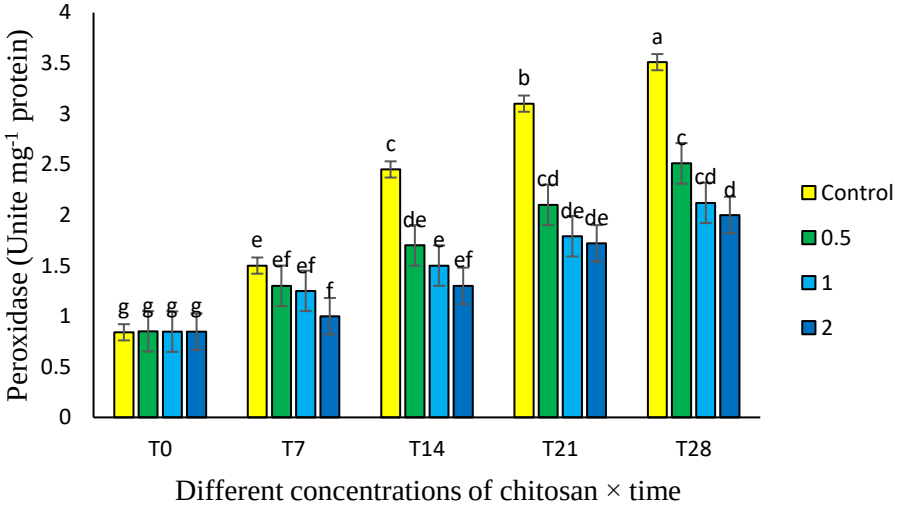

Fig. 7. Comparison of mean effects of the different concentrations of chitosan (0, 0.5, 1, and 2%) through different durations (0, 7, 14, 21, and 28 days) on peroxidase activity in bell pepper fruits. Mean values with similar letters had no significant difference (P≤0.05).

Polyphenol oxidase (PPO)

The analysis of variance showed that the simple effects of chitosan, time, and the interaction of chitosan and time were significant on the polyphenol oxidase activity in bell pepper fruits (P≤0.01) (Table 1). The results showed that the polyphenol oxidase activity of the control and treated bell pepper fruits increased during storage (7, 14, 21, and 28) (Fig. 8). However, the polyphenol oxidase activity of the control bell pepper fruits increased more significantly than the chitosan-treated fruits (Fig. 8). The increase in polyphenol oxidase activity of the bell pepper fruits treated with chitosan coating (2%) was significantly less than the other samples (Fig. 8).

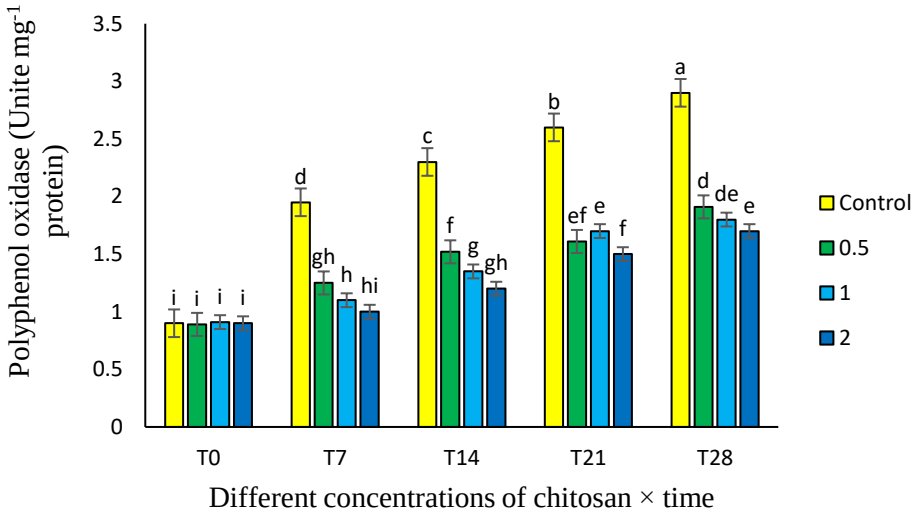

Fig. 8. Comparison of mean effects from the different concentrations of chitosan (0, 0.5, 1, and 2%) through different durations (0, 7, 14, 21, and 28 days) on the polyphenol oxidase activity in bell pepper fruits. Mean values with similar letters had no significant difference (P≤0.05).

Discussion

Chitosan is a natural, biodegradable, edible surface coating and eco-friendly biopolymer that has applications in preserving the postharvest quality of bell pepper fruits (Kumar et al., 2021a, b). The semi-permeable chitosan film on the bell pepper fruit surface regulates the exchange of gases and reduces transpiration, thus reducing water loss (Kumar et al., 2021a, b).

Ascorbic acid is more sensitive to oxidation and decomposition than other nutrients during storage. A possible reason for the decrease in ascorbic acid during storage is its auto-oxidation, which occurs spontaneously in the presence of oxygen (Sogvar et al., 2016). Chitosan coating seems to reduce ascorbic acid oxidation by reducing the amount of available oxygen, which is why coated fruits usually have higher levels of ascorbic acid than the control group at the end of storage. This finding is consistent with a previous report by Jiang and Jiang (2005).

The ascorbic acid content reduction differences of the treated fruits with the chitosan coating concentration 2 and 1% were 14.08% and 24.95% between 21 and 28 days of the storage, respectively, compared to the control. A decrease in gas exchange, including the one in the amount of oxygen entering the fruit, occurred by the coating layer of chitosan, which led to lower oxidation, less acids, phenols, and other compounds such as ascorbic acid (Xing et al., 2011). Therefore, better preservation of phenolic compounds and ascorbic acid occurred because of the chitosan treatments. It was also associated with a reduced level of cellular oxidation. Previous studies indicated that chitosan increased phenolic compounds in tomato and bell pepper fruits by inducing relevant enzyme activities (Liu et al., 2007; Xing et al., 2011). Oxidation or loss of AsA may be caused by several factors – including exposure to oxygen, metals, light, temperature, and alkaline pH (Taheri et al., 2020). The most important antioxidant compounds in bell pepper fruits are ascorbic acid and phenols. Their preservation enhanced the antioxidant capacity of the fruits during the postharvest period (Sudarshan et al., 1992).

The current study showed that catalase activity in the treated fruits remained significantly stable because of the chitosan coating compared to the control fruits during storage. Antioxidant compounds, including catalase, can increase naturally in plants because of stress conditions. This compound prevented damage to plant

tissues by removing free radicals (Xu et al., 2009). Therefore, by dissecting the fruit tissue from the mother plant and increasing the stress intensity during storage, we end up with lower storage materials and antioxidant precursors. As a result, the contents of antioxidant enzymes and other compounds in the fruit tissue decrease during storage, compared to the time at harvest. In this study, similar to previous research by Xing et al. (2011), the chitosan treatment reduced the intensity of stress on fruits and preserved catalase and other antioxidant compounds, including ascorbic acid and total phenol content, as well as antioxidant capacity, compared to the control.

In the present study, the increase of the peroxidase activity and the polyphenol oxidase activity of the treated bell pepper fruits with chitosan coating 2% was significantly less than the others. Browning of the flesh bell pepper during the days of storage was caused by enzymatic oxidation of phenolic compounds by POD and PPO. PPO activity increases in response to cell damage, intracellular compartmentation disruption, and release of phenolic substrates from vacuoles during fruit storage. The chitosan coating could reduce the cell damage, intracellular compartmentation disruption, and release of the phenolic substrates from vacuoles during the storage days of the fruits in this experiment.

In the present study, chitosan increased the antioxidant activity. Through 14, 21, and 28 days of storage, the results showed that the treated fruits with the chitosan coating (2%) made the antioxidant activity (scavenging activity of DPPH radical) higher (32%) than that of the control group. Chitosan (150 mg L^{-1}) reportedly induced the highest antioxidant activity in *Curcuma manga* seedlings (Abraham et al., 2011). In general, chitosan seems to increase plant resistance to oxidative stress and reportedly stimulates plant growth by increasing the activity of antioxidant enzymes and reactive oxygen species (ROS) (Yen et al., 2009).

In previous research, Alpos and Bayogan (2023) determined the effects of chitosan coating on sweet pepper postharvest quality and antioxidant properties at 5-day intervals. Shriveling was significantly delayed with 1.5% chitosan after ten days following the treatment. Chitosan (1.5%) did not prevent the degradation of ascorbic acid and the DPPH scavenging activity but increased the total phenolic content by 51% after 15 days following the treatment compared to the control. They suggested that a high chitosan coating concentration can have preservative effects in postharvest management (Alpos and Bayogan, 2023).

Mohammadi et al. (2018) studied the effects of dipping in chitosan solution and coatings to improve the quality of sweet pepper storability during cold storage. Treatments with cellophane and chitosan maintained ascorbic acid, antioxidant activity, total phenol, and catalase and peroxidase enzyme content better than control (Mohammadi et al., 2018). Also, Mohammadrezakhani and Pakkish (2015) showed that the peroxidase enzyme content increased in grapefruits of the control group during storage (Mohammadrezakhani and Pakkish, 2015). Functional molecules with edible chitosan-based coatings and alginate have a synergistic role by maintaining antioxidant potential and increasing antioxidant activity. Specific enzymes usually reduce browning activity and cause antimicrobial properties in fresh fruits and vegetables. All these properties help maintain the appearance of fruits and vegetables, decelerate aging in plant cells, and extend fruit shelf life (Nair et al., 2020). Our results showed that chitosan-based coating acts as a physical barrier and regulates the movement of gases and water vapor (Hasan et al., 2020) while enhancing anti-stress and antioxidant properties in fruits.

Conclusion

Bell pepper fruits are nutritionally high in value and are valuable sources of minerals and metabolites. Consuming these fruits has a special place in the human diet, but the rapid loss of fruit moisture can shorten their postharvest shelf life. Even low concentrations of edible chitosan-based coatings effectively maintained fruit quality in this research. Therefore, the commercial use of chitosan coating (2%) can extend the shelf life at storage and increase economic productivity in bell peppers.

Conflict of Interest

The authors indicate no conflict of interest in this work.

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