

[Research]

Effect of chitosan coatings on some quality indices of apricot (*Prunus armeniaca* L.) during cold storage

M. Ghasemnezhad*, M. A. Shiri, and M. Sanavi

Department of Horticultural Sciences, Faculty of Agriculture, University of Guilan, Rasht, Iran

* Corresponding author's E-mail: ghasemnejad@guilan.ac.ir

ABSTRACT

In this study, the effectiveness of chitosan coating treatment to control weight loss and maintaining fruit quality of apricot was investigated. Fruits were coated with 0.25%, 0.5% and 0.75% chitosan as well as distilled water (control). Following treatments, fruits were stored at 0°C and 80 ± 2% relative humidity for 25 days. The weight loss, total soluble solids (TSS), titratable acidity (TA), TSS/TA, pH, vitamin C, total phenolics and antioxidant activity (DPPHsc%) were followed at an interval of 5 days up to 25 days. Weight loss from all treated and untreated fruits increased over storage time. The weight loss of chitosan coated fruits was increased in comparison to untreated samples. There was no significant difference for total soluble solids (TSS), titratable acidity (TA), TSS/TA, pH, vitamin C in coated and uncoated fruits storage. Chitosan coatings significantly increased the content of total phenolics and antioxidant activity, as 0.5% chitosan showed maximum total phenolics (82.65 mg GAE/100g) and antioxidant activity (23.77 DPPHsc%). The chitosan coatings proved to induce the antioxidant capacity and also to sustain the total phenolic content.

Keywords: Chitosan coating; Apricot; Cold storage; Phenolic content; Antioxidant capacity.

INTRODUCTION

Apricot (*Prunus armeniaca* L.) belongs to Rosaceae family. It plays an important role in maintenance of human health, because the fruit contains carotene and lycopene pigments that protect the heart and eyes, as well as disease fighting effects of fiber that prevent digestive condition called diverticulosis and having antipyretic, antiseptic, emetic, and ophthalmic properties (Haydar *et al.*, 2007). It was found that apricot is fragile fruit having short storage life (3-5 days) at ambient conditions, 2-4 weeks at cold storage, depending on cultivar. The short storage life of this fruit is due to short time period from commercial ripening to the degradation process characteristic like senescence (Egea *et al.*, 2007; Agar & Polate, 1995).

Apricot fruits enriched different antioxidant compounds such as phenolics, vitamins and carotenoids. Phenolic

compounds demonstrated higher antioxidant activity than vitamins and carotenoids (Re *et al.*, 1999). They are able to scavenge reactive oxygen species due to their electron donating properties. The levels of phenolic compounds are different in apricot varieties (Akbulut & Artik, 2002, unpublished data; Macheix *et al.*, 1990).

Antioxidant content is an important parameter with respect to increasingly fruit and vegetable quality. There for, there are great interests to evaluate changes in antioxidant status during postharvest storage of horticultural crops (Fernando *et al.*, 2004). Postharvest storage can also affect phenolic compounds levels and antioxidant capacity in fruits (Holcroft *et al.*, 1999).

Generally, low storage temperatures are used to extend fruit postharvest life (Manning, 1996). Edible films and coatings can be used to help the fruit and vegetables

preservation because they provide a partial barrier to moisture, O₂ and CO₂. Also they can improve mechanical handling properties, carrying additives, avoiding volatiles loss and even contribute to the production of aroma volatiles (Olivas & Barbosa-Ca'novas, 2005). Chitosan coatings applied on fresh fruit, to reduce the moisture transfer, the oxidation and the respiration, that is important to prolong the shelf-life of such fruits (Debeaufort *et al.*, 1998). Due to increase in apricot production and export during the previous years, practical method of packaging and coating are necessary to improve the postharvest quality of apricots.

Little knowledge on changes in quality characteristics and postharvest life of apricot is available during cold storage. Therefore, this research has been carried out to study the effect of chitosan coatings on quality characteristics of apricot fruit during cold storage.

MATERIALS AND METHODS

Plant materials and treatments

Fruits of apricot (*Prunus armeniaca* L. cv. Darashti) at the commercially mature stage were harvested from an orchard in Tehran province, Iran. Fruits were selected for uniformity, shape, colour, and size, and any blemished or diseased fruits were discarded. The fruits (\approx 35 g) were randomly distributed into four groups prior to treatments. For the stock solution (0.75%, w/v) of chitosan, was prepared by dissolving purified chitosan (low molecular weight chitosan were purchased from Sigma Chemical Co.) in 0.5% (v/v) glacial acetic acid (Du *et al.*, 1997), under continuous stirring, and the pH was adjusted to 5.2 using 1 N NaOH. The stock solution was sterilized at 121 °C for 20 min, then made lower concentrations (0.5 and 0.25%) of chitosan solution were obtained by appropriate dilution with sterile distilled water. After dipping in different concentration of chitosan solution for one min. fruits were allowed to dry for 2h at 25 °C. Fruits were dipped in acidic solution without chitosan at pH 5.0 as control. Following treatment, apricots were stored at 0 °C and 80% \pm 2% relative humidity for 25 days and the

preferred characteristics were measured in 5 days intervals.

Weight loss

Apricots were weighed at the beginning of the experiment just after coating and air-drying, and also every five days interval during the storage period. Weight loss was expressed as the percentage loss of the initial total weight.

Total soluble solids (TSS), pH, Titrable acidity (TA), and TSS/TA

The pH was determined by pH meter (JENWAY - 3505), and titrable acidity (TA) (as malic acid) was determined by titration of 5ml filtrated juice by 0.1N NaOH up to pH of 8.3. Total soluble solid contents were determined by extracting and mixing one drop of juice from each fruit into a refractometer (JENWAY - 6405 UV/V).

Vitamin C measurement

To evaluate the vitamin C (Mazumdar & Magumdar 2003), 2 g fine powder of apricot tissue was homogenized in 10 mL (3%) metaphosphoric acid for 10 min. Then vitamin C was determined by titration of 10 ml filtrated sample by 2,6-dichlorophenolindophenol (DCIP) (0.86 mM) containing bicarbonate sodium (2.5 mM) and expressed as mg ascorbic acid /100gr FW.

Total phenolics content (TPC)

The total phenolics were determined by the Folin-Cicalteau method as described by Singleton *et al.* (1999), with minor modifications, based on colorimetric oxidation/reduction reaction of phenols. Polyphenols extraction was carried out by adding 10 ml methanol (85%) to 1g fine grind of apricot tissue. 250 μ l of sterile distilled water was added to 250 μ l of extract, and then 2.5 ml of diluted Folin-Cicalteau reagent (10%) and 2 ml of % 7.5 sodium carbonate were added. The samples were shaken for 1.5 to 2 hours. The absorbance of samples was measured at 765 nm by a PG Instruments ltd- T80+ UV/VIS spectrophotometer. Gallic acid was used for calibration curve. Results were expressed as mg gallic acid (GAE)/ 100 g FW.

Total antioxidant capacity

The antioxidant activity was measured by the scavenging of 2, 2-diphenyl-2-picrylhydrazyl hydrate (DPPH) radicals (Ismail *et al.*, 2009). In the presence of antioxidant, the purple color intensity of DPPH solution declined. The change of absorbance was detected using spectrophotometer (PG Instruments Ltd - T80+ UV/VIS) at 517 nm. Briefly, a 0.15 mM methanolic solution of DPPH was prepared. 2 ml of this solution was added to 1 ml of methylic extracts of apricot fruits. The control was prepared by adding 2 ml of DPPH to 1 ml methanol. The content of the tubes were mixed and followed to stand for 30 min (under dark condition) and absorbance was measured at 517 nm. The antioxidant activity is expressed in the form of the percentage of free radical scavenging.

Statistical analysis

Statistical analysis were made by one-way analysis of variance (ANOVA) followed by a LSD (least significant difference) comparison means test (SAS 9.1 2002-2003). Differences were regarded as significant when the p-values were less than 0.05. The results were expressed as means \pm SE. Each experiment was carried out in tetraplicate (n = 4).

Weight loss

Weight loss from all treated and untreated fruits increased during storage (Fig. 1). At the end of 25 days storage, the weight loss of fruit coated with 0.25% chitosan reduced at the last stage of storage (5.24 %). Higher chitosan concentration (0.5% and 0.75%) increased weight loss that compared to control (9.14 and 7.57 % respectively).

Fruit weight loss is mainly associated with respiration and moisture evaporation through the skin. The rate at which water is lost depends on the water pressure gradient between the fruit tissue and the surrounding atmosphere, and also the storage temperature. Chitosan coatings act as barriers, thereby restricting water transfer and protecting fruit skin from mechanical injuries, as well as sealing small wounds and thus delaying dehydration (Ribeiro *et al.*, 2007).

Chitosan coatings have been effective in controlling water loss from other commodities, including cucumber and pepper (El Ghaouth *et al.*, 1991a), longan fruit (Jiang & Li, 2001), banana and mango (Kittur *et al.*, 2001) and strawberries (Ribeiro *et al.*, 2007). High chitosan concentration may increase anaerobic respiration followed by higher fruit weight loss.

RESULTS AND DISCUSSION

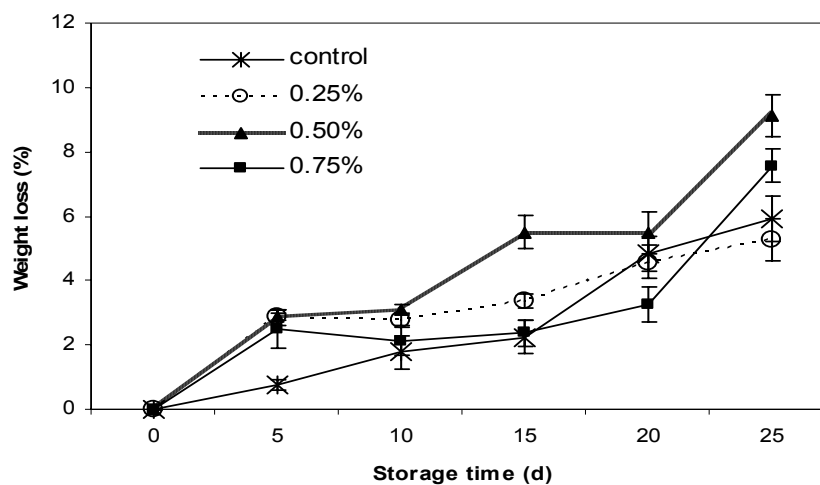


Fig 1. Changes in percentage weight loss of apricot fruits coated with 0.25%, 0.5%, 0.75% chitosan, and the control during storage at 0°C. Vertical bars indicate standard error (n=4).

Total soluble solids (TSS), pH, titrable acidity (TA) and TSS/TA

Total soluble solids (TSS) of apricot during its storage period are given in Fig 2. Generally, there was gradual decrease in TSS during storage. No significant differences were found between coated and control treatments for TSS. Data showed

that TSS contents of the fresh apricot were about 11.3% which was decreased to $\approx 8.56\%$ at the end of storage. The decrease in TSS contents during storage might be due to the respiration rate and conversion of sugars to carbon dioxide and H_2O (Saira *et al.*, 2009).

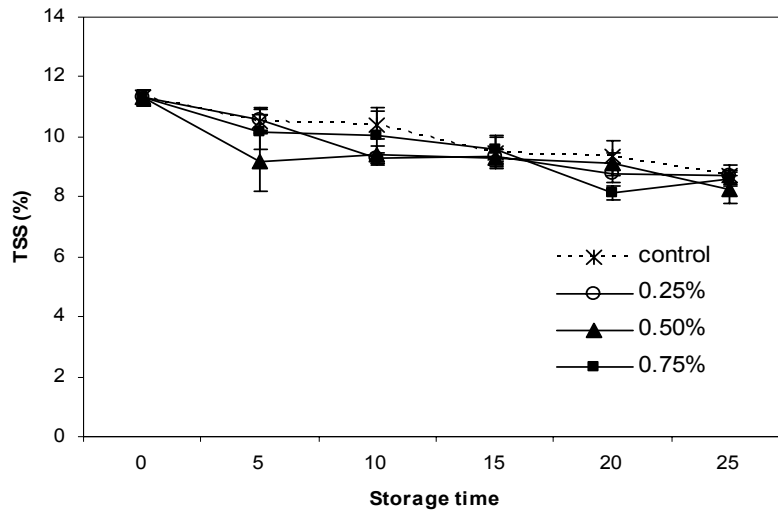


Fig. 2. Changes in TSS of Apricot fruits coated with 0.25%, 0.5%, 0.75% chitosan, and the control during storage at 0°C. Vertical bars indicate standard error (n=4).

The pH of apricot juice gradually increased during storage. There were no significant differences between treated and control fruits, although, the control and 0.25% chitosan showed higher pH at the end of 25 d storage (Fig. 3). This was probably

because the semi-permeable chitosan film formed on the surface of the fruit might have modified the internal atmosphere, i.e., the endogenous CO_2 and O_2 concentration of the fruit, thus retarding ripening (Lowings & Cutts, 1982; Bai *et al.*, 1988).

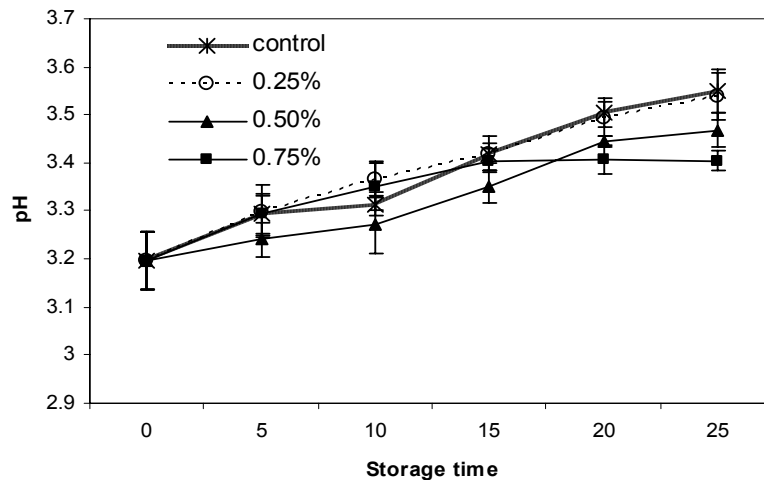


Fig. 3. Changes in fruit juice pH of apricot coated with 0.25%, 0.5%, 0.75% chitosan, and the control during storage at 0°C. Vertical bars indicate standard error (n=4).

Titrateable acidity is directly related to the concentration of organic acids present in the fruits. The results related to titrateable acidity of apricot during storage are shown in Fig. 4. No significant difference was found for TA in treated fruits with chitosan and

control. The decreasing acidity at the end of storage might be due to the metabolic changes in fruits or due to the use of organic acid in respiratory process that is compatible with those of Echeverria and Valich (1989).

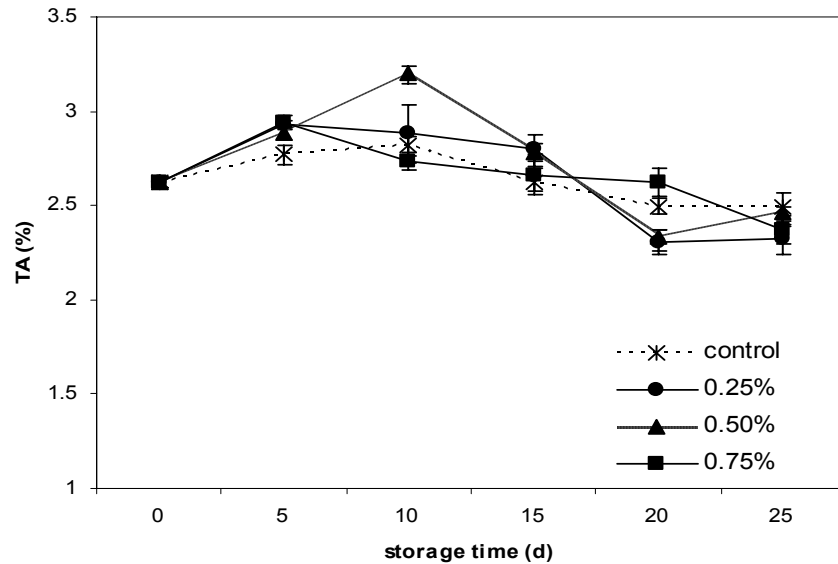


Fig 4. Changes in TA of apricot fruits coated with 0.25%, 0.5%, 0.75% chitosan, and the control during storage at 0°C. Vertical bars indicate standard error (n=4).

The TSS/TA decreased significantly along with increased storage time in both uncoated and coated fruits (Fig. 5). TSS/TA was 4.33 at fresh fruit and subsequently reached 3.47 at the end of storage time, with

no significant difference between storage times. The data also revealed that there was no significant difference in the TSS/TA between treatments.

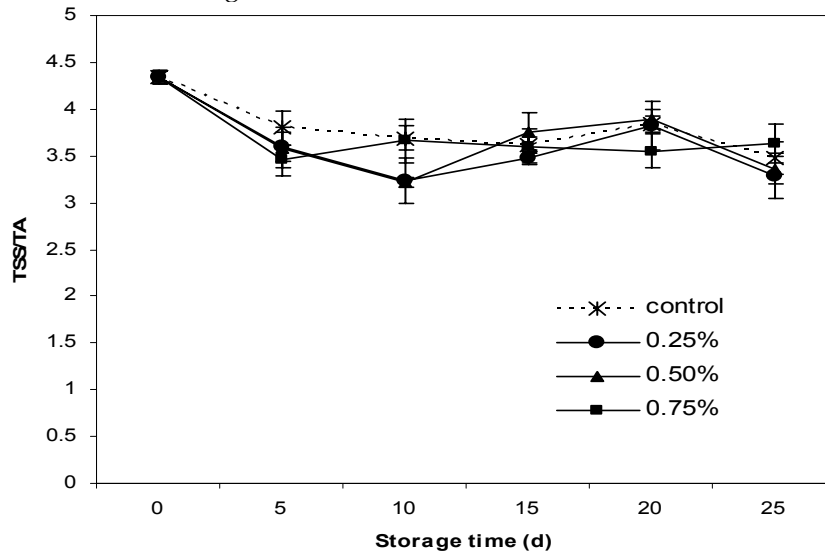


Fig. 5. Changes in TSS to TA ratio (TSS/TA) of apricot fruits coated with 0.25%, 0.5%, 0.75% chitosan, and the control during storage at 0°C. Vertical bars indicate standard error (n=4).

Vitamin C

The Vitamin C of samples increased slightly at the beginning of storage and thereafter declined to end of storage. Although treated fruits with chitosan showed higher vitamin C after 25 d than the

control fruits, but no significant difference was found among treatments (Fig. 6). Ascorbic acid is able to scavenge the superoxide and hydroxyl radicals, as well as regenerate α -tocopherol (Davey *et al.*, 2000).

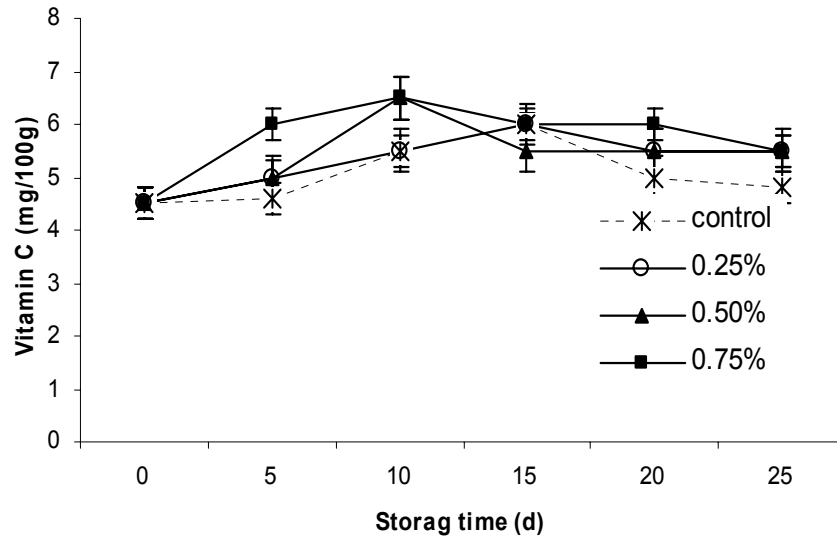


Fig. 6. Changes in vitamin C of apricot fruits coated with 0.25%, 0.5%, 0.75% chitosan, and the control during storage at 0°C. Vertical bars indicate standard error (n=4).

Total phenolic content (TPC)

The changes in the total phenolics content in apricot are shown in Fig. 7. The total phenolics content of all coated fruits was significantly higher than that of control. In all treatments, it increased first and thereafter declined at the end of storage. The highest phenolic content was found with 0.5% chitosan (69.8 mg GAE/100gr FW) and the lowest one was found in control (55.96 mg GAE/100gr FW) after 25 d storage.

Besides its antifungal activity, chitosan also has a potential of inducing defense-related enzymes (Bautista-Baños *et al.*, 2006) and phenolic contents in plants (Benhamou,

1996). In the present study it was found that the phenolic compounds in chitosan-treated apricot were higher than that of control. A 0.5% chitosan was the most active in increasing total phenolic compounds among all different treatments. The result is in compatible with Benhamou and Thériault (1992), and Liu *et al.* (2007), who reported that the production of phenolic compounds was induced in tomato plants and fruit treated with chitosan. The decreasing of phenolic compounds at the end of storage might be due to breakdown of cell structure in order to senescence phenomena during storage (Macheix *et al.*, 1990).

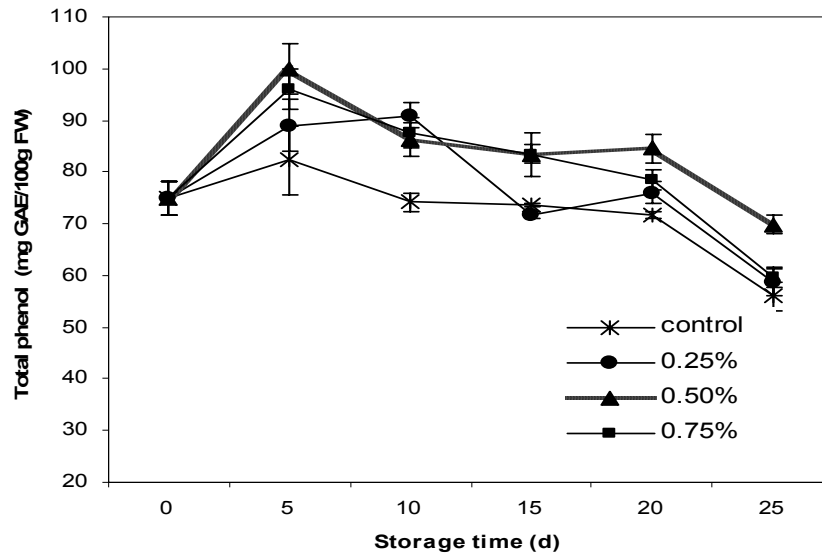


Fig. 7. Changes in total phenolics of apricot fruits coated with 0.25%, 0.5%, 0.75% chitosan, and the control during storage at 0°C. Vertical bars indicate standard error (n=4).

Antioxidant capacity

It was found that antioxidant capacity increased significantly ($P < 0.05$) during 15 days storage and thereafter decreased (Fig. 8). Coating fruits with 0.5% Chitosan was the most effective in the increase of total antioxidant capacity. Previous studies have

shown that there is a positive correlation between antioxidant activity and total phenolic content (Wang *et al.*, 1996; Rapisarda *et al.*, 1999; Wang & Lin, 2000). Therefore, the high total antioxidant capacity could be attributed to the high total phenolic content.

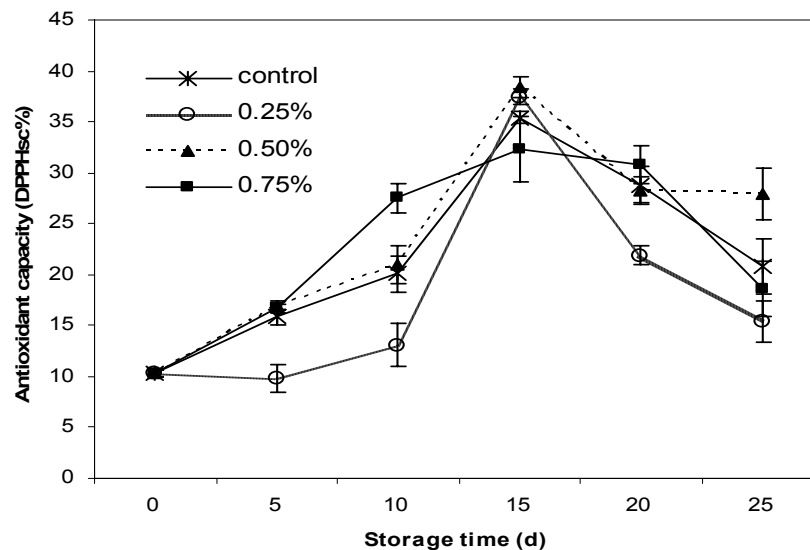


Fig. 8. Changes in total antioxidant capacity of fruits coated with 0.25%, 0.5%, 0.75% chitosan, and the control during storage at 0°C. Vertical bars indicate standard error (n=4).

Conclusions

The chitosan coatings proved to induce the antioxidant capacity and also sustain total phenolic content, but wasn't effective in reducing weight loss, even led to increased weight loss of apricot. There were no significant differences for total soluble

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