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Effect of Different Packaging Materials on Postharvest Quality of Fresh Fig Fruit

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ABSTRACT

The effect of different wrappers during postharvest on fresh fig fruits (*Ficus carica* L. 'Brown Turkey') was examined. The fruits were stored at 2ºC and were left unwrapped or wrapped with a 20 µm polyethylene film in plastic trays. The following treatments were evaluated: (1) without CO_2 and O_2 permeability (CC); (2) with Modified Atmosphere Packaging (MAP); (3) with additive potassium permanganate ethylene absorbent (AB) and; (4) unwrapped or control treatment (T). Quality attributes such as: weight loss (% PF), firmness (kg), total soluble solids, TSS (Brix), juice acidity (pH), CO_2 and C_2H_4 concentration and other volatile compounds were measured. Weight loss at 21 days was 1.4 and 1.5% for AB and CC, respectively. In the MAP treatment, the weight loss was 5.9%, while T had the highest weight loss (18%). Firmness decreased as weight loss increased in each treatment. In all the treatments, the chromatographic profiles showed the presence of acetaldehyde, ethyl acetate, hexanal and ethanol. However, in T there was a greater than in ethyl acetate. After 21 days, there was no statistical difference in pH between the treatments, but when analyzing the SST, the T treatment showed the lowest value. The MAP treatment resulted in better internal and external appearance and the fruits of T had a significant loss of quality.

Key Words: *Ficus carica*; Firmness; Total soluble solids; Respiration; Organic volatile; Visual appearance

INTRODUCTION

The common fig (*Ficus carica* L.) is a traditional fruit in western Asia. Its historical origin is presumably southern Arabia (Stover *et al*., 2007) or the eastern part of the Mediterranean area including Turkey and Iran where wild forms of fig trees can be observed (Khoshbakht & Hammer, 2006). Fig cultivation has come to be the most common in areas near the Mediterranean Sea. The fig is a nutritious fruit, richer in fiber, potassium, calcium, iron and is free of sodium, fat and cholesterol (Stover *et al*., 2007). Additionally, figs are an important source of vitamins, amino acids, and antioxidants (Solomon *et al*., 2006). Fig varieties with dark skin contain higher levels of polyphenols, anthocyanins and flavonoids, together with higher antioxidant activity compared to fig varieties of lighter skin (Solomon *et al*., 2006).

Given the fact that figs are highly perishable, which limits storage for long periods, and in order to expand the potential markets, most of the production is used for drying. Figs are climacteric fruits and are slightly sensitive to ethylene action on stimulating softening and decay severity, especially if kept at 5ºC or higher temperatures (Gözlekçi *et al*., 2008). Very little research has been done to identify the optimum environmental conditions for extending postharvest life of fresh figs. However, low temperatures, from 0 to 2ºC and a high relative humidity (90 to 95% RH) are recommended. The most important cause of deterioration is the incidence of microbial molds and rots that take advantage of the easily damaged epidermis and the high content of sugar in figs. The use of SO_2 can be a potential tool to control postharvest rots and, therefore, increase the market life of fresh figs (Cantín *et al*., 2011). The use of controlled atmosphere (CA) delayed the growth of microorganisms. For example, CA combinations of 5-10% oxygen and 15-20% carbon dioxide are effective in decay control, firmness retention, and reduction of respiration and ethylene production rates (Thompson, 2010). Modified Atmosphere Packaging (MAP) utilizes polymeric films of different vegetables (Thompson, 2010). Fruits and vegetables are physiologically active organs in which the interaction of the packaging material with the product is important (Bahri & Rashidi, 2009). If the permeability (for O_2& CO_2) of the packaging film is adapted to the products respiration, an equilibrium modified atmosphere will be established. Also, the film barriers used to reduce the transpiration rate of the product (Ullah *et al*., 2006). In comparison to CA, modified atmosphere packaging (MAP) constitutes the best way to preserve food, without diminishing the attractiveness of traditional packaging and

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at lower cost. Flavor is influenced by stage of ripeness, and overripe figs can become undesirable due to fermentative products. Also, the extended storage in MAP can result in loss of characteristic flavor. Currently, there are very few experiments in figs postharvest (D'Aquino *et al*., 1998). The aim of this study was to investigate the effect of different wrappers in fresh fig fruits during postharvest.

MATERIALS AND METHODS

The fig fruits (cv. Brown Turkey) were harvested from a commercial orchard with five years-old plants when the skin had a purplish brown color and the flesh was light pink (Fig. 1). The fruits were transported to the laboratory within 2 hours they were randomly assigned to each treatment and the initial weight of each fruit was determined with an electronic balance (Ohaus Pioneer®, sensitivity: 0.001 g to 0.1 g). The fruits were stored at 2ºC and the treatments consisted of comparing the effect of different wrappers on fresh fig fruits to maintain postharvest quality, by using polymers: (1) Polyethylene Terephthalate, PET, without CO_2 and O_2 permeability (Conaplat S.A., Argentine; http://www.conaplat.com.ar/) (CC); (2) polyethylene MAP (Xtend® MA/MH, StePac Ltd., Israel, http://www.stepac.com/); (3) polyethylene with additive potassium permanganate ethylene absorbent (Absorber®, Conaplat S.A., Argentina) (AB) and; (4) unwrapped or control treatment (T). The experimental design was a randomized complete block, using 15 plastic trays per treatment, and 10 fruits per tray. At weekly intervals, 5 trays were randomly removed from each treatment to assess postharvest quality. Data were subjected to analysis of variance and means were separated by LSD at the 0.05 level.

Weight loss was measured as percentage of the initial weight (WL%). Fruit firmness (resistance to compression & penetration) was determined with an automatic penetrometer (Marconi®, http://www.marconi.com.br/) fitted with a cylindrical plunger of 4 mm diameter and a convex tip in unpeeled fruits. The force (kg) required to compress the fruit at constant speed of 5 mm min^{-1} was recorded. Fruit pulp (25.0 g) was ground in a mortar and the juice was collected with a plastic pipette. A few drops of the sample were utilized to measure the Total Solid Soluble (TSS) in a Digital Brix Refractometer (Hanna 96801) and a pH meter was used to measure the juice pH (Hanna 84432). The concentration of CO_2 and C_2H_4 was measured by extracting the gas from each tray with a pump (Gastec CV100), using calibrated tubes for carbon dioxide (810-2H) and ethylene (810-172). A gas sample was extracted with a syringe from five fruits per treatment. The volatile compounds were thermally desorbed into the gas chromatograph (CG, Hewlett Packard 5890 series II with FID detector) by quickly heating at 250ºC for 5 min, taking as reference the ASTM standard D6520-06.

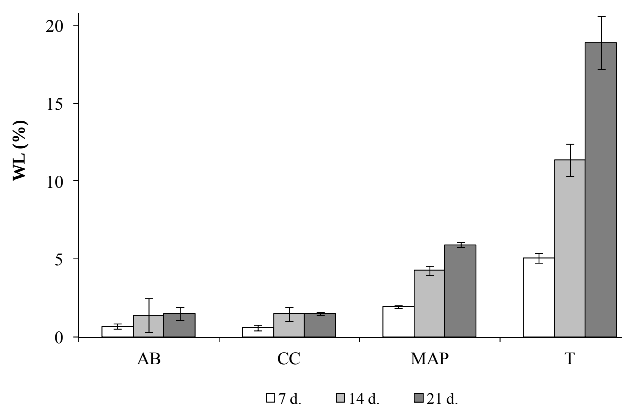
Table I: Effect of different treatment on total soluble solid (TSS) (Brix) and pulp acidity (pH) of the fruits for different days after harvest (DAH)

Treatments	DAH					
	7		14		21	
	TSS	pH	TSS	pH	TSS	pH
AB	9.9 ab	5.0 a	10.9 a	5.3 a	11.0 a	5.3 a
CC	10.3 a	5.3 a	10.7 a	5.1 ab	11.0 a	5.2 a
MAP	8.9 b	5.0 a	10.5 a	4.9 b	10.4 ab	4.7 a
T	10.1 ab	5.1 a	11.6 a	5.1 ab	8.8 b	5.1 a

Note: Letters a, b, and c indicates the significant different mean values in the same column ($p \leq 0.05$)

Fig. 1: Maturity stage of figs when were harvested (0 DAH), corresponding to the commercial maturity
This stage is considered when the fruit flesh gave slightly when touched and when the skin had a color purplish brown (a) and the flesh was light pink in color (b)

Fig. 2: Relationship between weight loss (WL, %) in each treatment and the days after harvest (DAH)
Vertical bars represent the standard deviation

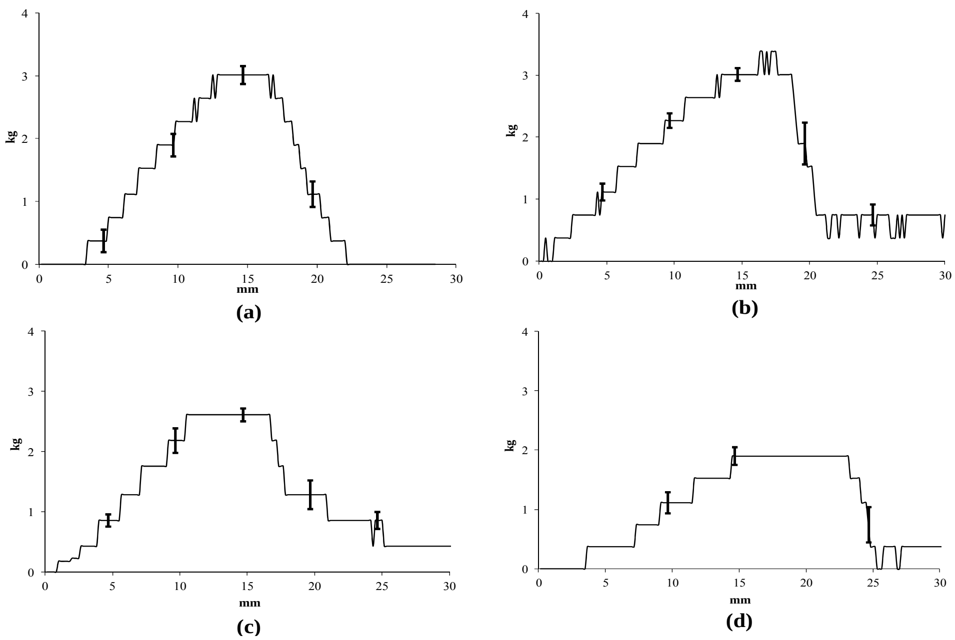


RESULTS AND DISCUSSION

Fruit weight loss (WL %) since the beginning of the experiment (Fig. 2) was mainly due to water loss, which is produced by a difference in vapor pressure between the fruits and surrounding air. The wrappers in some treatments are barriers to movement of water vapour and can help in the maintenance of high relative humidity (RH) and fruit turgor (Kader & Zagory, 1988).

Fig. 3: Force/deformation curves obtained the end of experiment (21 DAH) during a penetration test on unpeeled figs, using traction machine (Marconi®, cylindrical probe with a 4 mm diameter convex tip, penetration speed of 5 mm min-1, depth of 30 mm)

Note: a) AB; b) CC; c) MAP and; d) T. The standard deviation is shown by vertical bars on some values

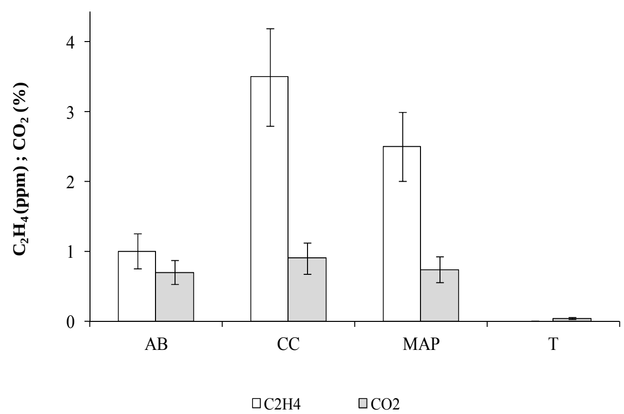


The weight loss was higher in T than in the other treatments, reaching approximately 19% in 21 days (Fig. 2). The AB and CC treatments had the lowest weight loss. The fruits of the MAP treatment showed a higher weight loss than the ones in the treatments with wrappers (CC & AB), possibly due to higher permeability of this polymer to water vapor. Although, the principles of modified-atmosphere packaging (MAP) of fresh produce are well known, the method (commercial distribution) is limited because of the difficulties in controlling in-package atmosphere and humidity during commercial shipments (Aharoni *et al*., 2008).

The values of the Total Soluble Solid (TSS) and pH for each treatment are shown in Table I. In general, the Brix values for this variety were lower than those measured by Crisosto *et al*. (2010). Also, a similar range of Brix values in fresh fig have been reported in Italy (Chessa, 1997) and in Turkey (Aksoy *et al*., 2003; Küden *et al*., 2008). Possibly, these lower values of TSS were caused by the location of the commercial orchard since there is lower integral radiation in this region than in the others. After 7 days, the measured values of TSS were lower in the AB and MAP treatments, probably due to a lag effect in post-harvest maturity by the action of ethylene absorbent (AB) or the control of fruit respiratory rate in MAP. After 14 days there were no statistical differences between the treatments and no increase in the TSS values in T, although the greater weight loss in this treatment (Fig. 2) should have increased the concentration of sugars. Towards the end of the experiment, at 21 d, the concentration of TSS in T was lower than in the other treatments, possibly due to the absence of a barrier to decrease the respiratory rate of these fruits (Table I). The pH measured values were virtually not affected by the treatments (Table I).

Fig. 4: Carbon dioxide and ethylene concentrations in the fig fruits in each treatment in the 21st day (21 DAH)

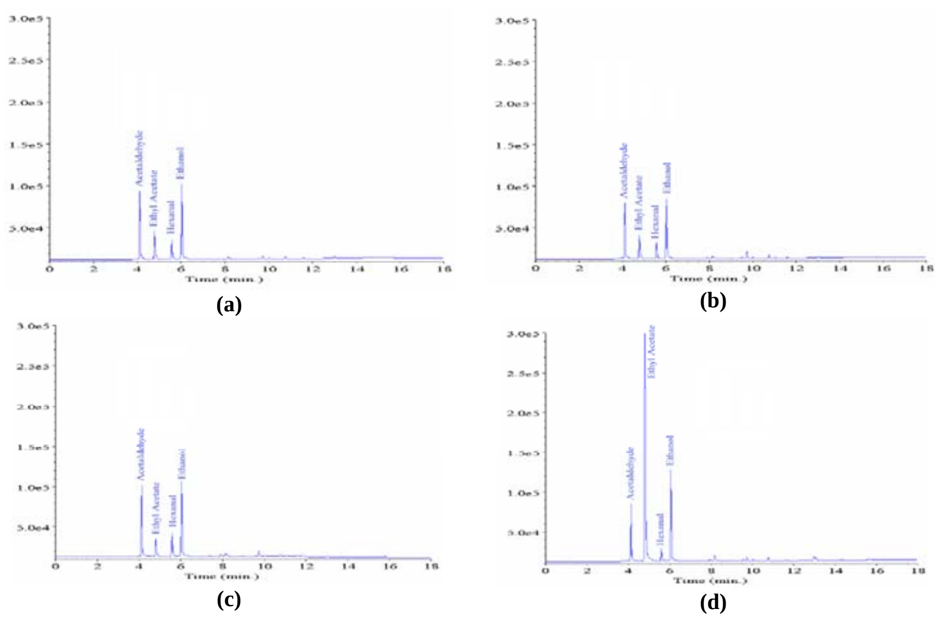
Vertical bars represent the standard deviation



The average values of the measurement of fruit firmness are presented in Fig. 3 indicating continuous variations of fruit firmness from the epidermis to 30 mm deep in the pulp. The fruits in treatments AB and T were the ones with the highest and lowest firmness, respectively (Fig. 3). Although, the firmness reached in the CC and AB treatments was similar, the fruits showed a pronounced softening of the pulp beyond 18 mm in depth. The fruits in

Fig. 5: Gas chromatography (CG) analysis of volatile compounds in the 21st day (21 DAH) with four components identified of each chromatographic peaks; from left to right: acetaldehyde, ethyl acetate, hexanal and ethanol

Note: a) AB; b) CC; c) MAP and; d) T



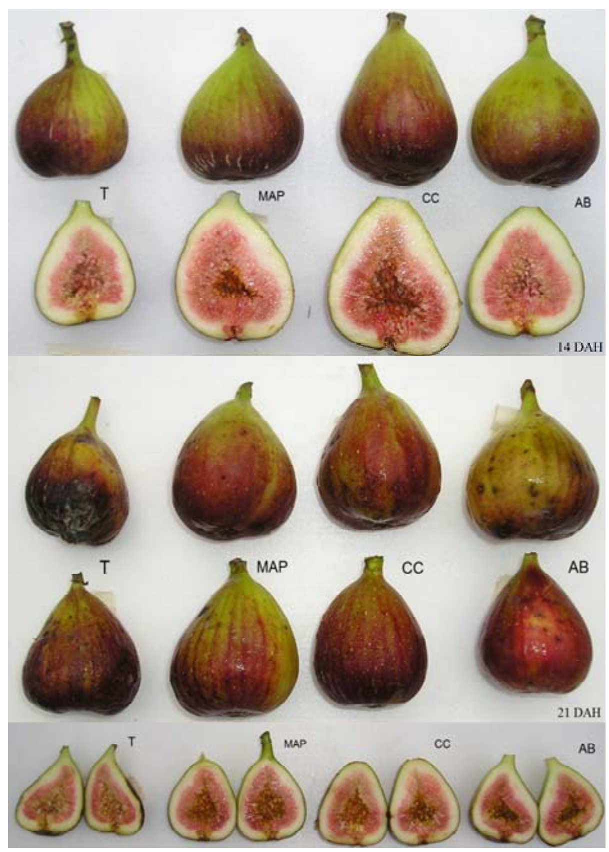
the MAP treatment had lower firmness than in the ones in AB. However, the fruits were firmer than in the CC treatment beyond 20 mm in depth.

Measurement of the concentration of ethylene (C_2H_4) and carbon dioxide (CO_2) at 21 days after harvest is shown in Fig. 4. In the T treatment, the presence of C_2H_4 in the air could not be detected, while the concentration of atmospheric CO_2 corresponds to the storage atmosphere because the fruits were left unwrapped. The additive ethylene absorbent in the polymer of the AB treatment reduced the C_2H_4 concentration (Fig. 4). In the MAP treatment, the CO_2 concentration was lower than in the CC treatment, indicating the selective permeability of the polymer to CO_2 (Exama *et al*., 1993). A similar unexpected situation, as regards the concentration of CO_2, was also observed in the AB treatment. Unlike previous treatments, theC_2H_4andCO_2concentrationsinCC were higher (Fig. 4).

The volatiles produced by the figs in each treatment at 21^{st} day are shown in Fig. 5. Only four volatiles were detected, by using gas chromatography: acetaldehyde, ethyl acetate, hexanal and ethanol; however, in T there was a higher increase in ethyl acetate (Fig. 5d). Possibly, the loss of organoleptic quality (off-flavor) in the fruits of the T treatment may be related to the increase of ethyl acetate, as it was found for the same volatile compound in strawberries (Larsen & Watkins, 1995).

Although the presence of various volatiles was measured in another study performed on figs (Jennings, 1977), hexanal was not found. Moreover, though usually modified atmosphere treatments produce an accumulation of acetaldehyde and ethanol (Thompson, 2010), this was not observed in this study. The increase in the emission of ethyl

Fig. 6: Internal and external visual appearance of the fruits in each treatment at 14^{th} (top image) and 21^{st} (bottom image) days after harvest (DAH)



acetate could be due to a mechanism of induced resistance, triggered by the phytopathogenic fungal infection (Dey *et al*., 1997). However, this relationship was not investigated in this study. Finally, the internal and external visual appearance of the fruits at 14 and 21 days after harvest (DAH) is shown in Fig. 6. At 14 DAH the visual appearance of the fruits of the MAP and CC treatments was slightly superior to the T and AB treatments (Fig. 6 top).

The fruits in T began to show symptoms of dehydration due to more than a 10% loss of its weight in water (Fig. 2), while in the AB treatment a few spots began to appear on the surface of the fruits. Finally, at 21 DAH decay of visual quality in the fruits of the T and AB treatments was evident (Fig. 6 bottom).The spots on the fruits of the AB treatment are visual symptoms of alternaria rot, caused by *Alternaria tenuis,* which appears as small, round, brown-to-black spots on the fruit surface (Montealegre *et al*., 2000). These visual symptoms were less marked in the fruits of CC and T. However, *Rhizopus* rot symptoms were observed in the T treatment, particularly in the fruit ostiole, and there were some early signs of *Endosepsis* (soft rot). This disease is caused by *Fusarium moniliforms* and it appears in the fig's cavity. It makes the pulp soft, watery and brown and sometimes it produces an offensive odor, possibly due to increased production of ethyl acetate (Fig. 5d).

CONCLUSION

Auto-modifying gas atmosphere using wrappers with selective permeability (MAP) produces a decrease in the respiration rate and thus further extends the storage life and quality appearance. The availability of absorbers of different gases, in particular ethylene, provides additional tools for maintaining a desired atmosphere within a package. However, the use of this type of film (AB) produced no beneficial effects in this study. Moreover, the postharvest diseases limit the storage period and marketing life of figs in the T and AB treatments. Weight loss at 21 days was 1.4 and 1.5% for AB and BC, respectively. In the MAP treatment, the weight loss was 5.9%, while T had the highest weight loss (18%). Firmness decreased as weight loss increased in each treatment. The fruits in the AB treatment were the firmest, followed by the CC and MAP treatments. In all the treatments, the chromatographic profiles showed the presence of acetaldehyde, ethyl acetate, hexanal and ethanol. However, in the T treatment there was a greater increase of ethyl acetate. At 21 days there was no statistical difference between the treatments in pH, but when analyzing the TSS, the T treatment had the lowest value. Finally, the MAP treatment resulted in better internal and external appearance and the fruits of the unwrapped T treatment had a significant loss of quality.

REFERENCES

Aharoni, N., V. Rodov, E. Fallik, R. Porat, E. Pesis and S. Lurie, 2008. Controlling humidity improves efficacy of modified atmosphere packaging of fruits and vegetables. *Acta Hortic.*, 804: 121–128

Aksoy, U., H.Z. Can, A. Misirli, S. Kara, G. Seferoglu and N. Sahin, 2003. Fig (*Ficus carica* L.) selection study for fresh market in western Turkey. *Acta Hortic.,* 605: 197–203

Bahri, M.H. and M. Rashidi, 2009.Effects of coating methods and storage periods on some qualitative characteristics of carrot during ambient storage. *Int. J. Agric. Biol.,* 11: 443–447

Cantín, C.M., L. Palou, V. Bremer, T.J. Michailides and C.H. Crisosto, 2011.Evaluation of the use of sulfur dioxide to reduce postharvest losses on dark and green figs. *Postharv. Biol. Tec.,* 59: 150–158

Chessa, I., 1997. Fig, *In*: Mitra, S. (ed.), *Postharvest Physiology and Storage of Tropical and Subtropical Fruits*, pp: 245–268. CAB International, Wallingford, UK

Crisosto, C.H., V. Bremer, L. Ferguson and G.M. Crisosto, 2010. Evaluating quality attributes of four fresh fig (*Ficus carica* L.) cultivars harvested at two maturity stages. *Hortic. Sci.*, 45: 707–710

D'Aquino, S., A. Piga, M.G. Molinu, M. Agabbio and C.M. Papoff, 1998. Maintaining quality attributes of ´Craxiou de Porcu´ fresh fig fruit in simulated marketing conditions by modified atmosphere. *Acta Hortic.,* 480: 289–294

Dey, P.M., J.B. Harborne and J.F. Bonner, 1997. *Plant Biochemistry*, p: 554. Academic Press, Oxford, UK

Exama, A., J. Arul, R. Lencki and Z. Li, 1993. Suitability of various plastic films for modified atmosphere packaging of fruits and vegetables: gas transfer properties and effect of temperature fluctuations. *Acta Hortic.*, 343: 175–180

Gözlekçi, S., M. Erkan, I. Karaşahin and G. Şahin, 2008. Effect of 1-MethylCycloPropene (1-MCP) on fig (*Ficus carica* cv. Bardakci) storage. *Acta Hortic.*, 798: 325–330

Jennings, W.G., 1977. Volatile components of figs. *Food Chem.*, 2: 185–191

Kader, A.A. and D. Zagory, 1988. Modified atmosphere packaging of fresh produce. *Food Technol.*, 42: 70–77

Khoshbakht, K. and K. Hammer, 2006. Savadkouh (Iran): an evolutionary center for fruit trees and shrubs. *Genet. Resour. Crop Evol.*, 53: 641–651

Küden, A.B., S. Bayazit and S. Cömlekcioglu, 2008. Morphological and pomological characteristics of fig genotypes selected from Mediterranean and South East Anatolia regions. *Acta Hortic.,* 798: 95–102

Larsen, M. and C.B. Watkins, 1995. Firmness and concentrations of acetaldehyde, ethyl acetate and ethanol in strawberries stored in controlled and modified atmospheres. *Postharvest Biol. Technol.,* 5: 39–50

Montealegre, J., J. Oyarzún, R. Herrera, H. Berger and L. Galletti, 2000. Identificación de hongos causantes de pudriciones en postcoseha de brevas e higos. *Bol. San. Veg. Plagas.,* 26: 439–443

Solomon, A., S. Golubowicz, Z. Yablowicz, S. Grossman, M. Bergma, H.E. Gottlieb, A. Altman, Z. Kerem and M.A. Flaishman, 2006. Antioxidant activities and anthocyanin content of fresh fruits of common fig (*Ficus carica* L.). *J. Agric. Food Chem.,* 54: 7717–7723

Stover, E., M. Aradhya, L. Ferguson and C.H. Crisosto, 2007. The Fig: Overview of an Ancient Fruit. *Hortic. Sci.*, 42: 1083–1087

Thompson, A.K., 2010. *Controlled Atmosphere Storage of Fruits and Vegetables*, 2nd edition,p: 460.CABI International, Wallingford, UK

Ullah, H., S. Ahmad, R. Anwar and A.K. Thompson, 2006. Effect of High Humidity and Water on Storage Life and Quality. *Int. J. Agric. Biol*., 8:828–831

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