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Extended Abstract

Effect of *Ulva flexuosa* Wulfen Seaweed and Shirazi Thyme (*Zataria multiflora*) Extracts on Qualitative Characteristics of Washington Navel Orange under Sorage Period

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Abstract

In recent years, in order to improve qualitative characteristics of horticultural products, the researchers have considered the use of organic substances. This experiment was conducted to evaluate the effects of different concentrations of *Ulva flexuosa* Wulfen seaweed (endemic of Persian Gulf) and Shirazi thyme extracts on postharvest characteristics of Washington Navel orange under cold storage for 60 days (the qualitative characteristics were evaluated with 15 days interval). The results indicated that fruit weight loss, fruit decay, TSS (total soluble solids) content increased and juice %, titratable acid and ascorbic acid contents decreased at the end of storage period. Postharvest quality of Washington Navel fruits significantly improved when fruits were immersed in seaweed and Shirazi thyme extracts. On the other hand, seaweed extract was more effective in improving these characteristics of orange compared to Shirazi thyme. At the end of storage time, the most effective treatment was 0.94 g/l of seaweed extract, so that the maximum reduction in percentage of fruit decay was observed in this concentration. Also the highest (35.49) fruit juice percentage and the least (3.26%) weight loss were obtained in the concentration of 3.75 g/l of seaweed extract. Therefore, the results of this study showed that seaweed extract could be used as an active bioactive compound to improve qualitative postharvest characteristics of orange fruits.

Keywords: Fruit postharvest quality, Seaweed Extract, Shirazi thyme, Washington Navel orange

Introduction

Over the recent years, the novel approaches have focused on the identification of effective organic compounds that preserve postharvest fruit quality and increase storability, thereby maintaining the marketability, and providing high-quality products for consumers (Nabti, Jha, & Hartmann, 2017). It was indicated that the natural seaweed extract could improve fruit quality and shelf life of avocado, pear, and orange fruits (Blunden, Jones, & Passam, 1978; Kamel, 2014; Omar, 2014). It has recently been noted that extract of *Ulva flexuosa* seaweed has a high antimicrobial and moderate antifungal properties (Mashjoor, Yousefzadi, Zolgharnain, Kamrani, & Alishahi, 2018).

The beneficial impact of these extracts is thought to be associated with compounds that may include, the betaines, oligosaccharides, polyamines, polypeptides, cytokinins and/or other hormones (Ibrahim, 2013; Nabti *et al*., 2017; Norrie & Keathley, 2005).

The extract of Shirazi thyme, due to its secondary metabolites such as thymol and carvacrol, have anti-fungal and anti-parasitic properties and used as antiseptic (Safaei & Afiuni, 2012; Shabanpoor, Zolfaghari, Falahzadeh, & Alipoor, 2011; Zabetian Hosseini, Mortazavi, Fazli Bazaz, Koocheki, & Bolorian, 2011), therefore, could reduce the early fruits decay and thus increase their postharvest quality. In a study conducted by Tavalloli, Karimi, & Rahemi (2008) Shirazi thyme extract improves the postharvest characteristics of orange fruit. Ojnordi, Javanmard, & Asadollahi (2012) reported thatedible coating based on whey protein containing Shirazi thyme extract could improved quantitative and qualitative properties of peach fruits.

Therefore, the main objective of this study was to evaluate the effect of *Ulva flexuosa* Wulfen seaweed and Shirazi thyme (*Zataria multiflora*) extracts on qualitative characteristics of Washington Navel orange under cold storage period.

Materials and methods

Mature fruits of Washington Navel orange were harvested in December 2015, from a commercial orchard according. The fruits transferred to the research laboratory of the Faculty of Agriculture and Natural Resources of University of Hormozgan, Bandar Abbas, Iran. Fruits were picked, disinfected by immersion in sodium hypochlorite 1% for 3 min, washed with distilled water, and air-dried in the laboratory.

U. flexuosa samples were hand-picked from the coastal areas of the Persian Gulf, and thoroughly washed with seawater to remove the undesirable contaminations. In the laboratory, they were air-dried for three days. Following the method used by Salehi, Sonboli, Eftekhar, Nejad-Ebrahimi, & Yousefzadi (2005), maceration method was used to prepare extracts of Seaweed and Shirazi thyme (Salehi *et al*., 2005).

Orange fruits were divided into six groups and each group immersed in the extract treatments for 15 minutes. After drying, the fruits were packed in plastic bags. After that, the fruits were kept under cold storage (5 °C) at 85-90% relative humidity for 60 days under storage conditions. The measurements were taken five times, at 15 day intervals, specifically after 0, 15, 30, 45 and 60 days, counted from the onset of the storage.

Fruit weight loss was calculated by measuring the difference between the initial and the final weight, whereby the initial fresh weight was expressed as zero percentage. Fruit juice was extracted by the Match juice extractor (model JU-171, China), and subsequently weighed and calculated as the percentage of fruit weight for each treatment. Fruit decay was specified visually by counting the number of fruits with signs of decay (having either pathological or physiological disorders) and was expressed as a percentage of the initial number of fruits per each replicate for each treatment (Ayala-Zavala, Wang, Wang, & González-Aguilar, 2007).

In order to measure the ascorbic acid (Vitamin C) content, undiluted extracts were used for iodometric titration. Briefly, 2 mL of 1% starch solution and 1 mL of 100 gL^{-1} potassium iodide solution were added to 10 mL fruit extracts. Then, the samples were titrated with 0.002 $molL^{-1}$ previously standardized potassium iodate solution, until the mixture became dark blue and the color persisted for more than 60 s. Next, the amounts of potassium iodate and ascorbic acid contents were determined according to Suntornsuk, Gritsanapun, Nilkamhank, & Paochom (2002). To measure the fruit titratable acids content, sodium hydroxide solution 0.1 N and phenolphthalein pH indicator was used (Saltveit, 2005). Measuring the TSS began after extracting fruit juice, whereby the fresh fruit juice was analyzed by a digital refractometer (model DBR95, Huixia®, Taiwan).

This study was conducted as a factorial experiment, based on complete randomized design. The first factor included different concentrations of *U. flexuosa* (0.94, 1.88, 3.76 and 7.52 gL^{-1}) and second factor was Shirazi thyme extract (0.14 gL^{-1}). At the end of the experiment, the data were analyzed with SAS (V. 9.2, SAS Institute, Cary, NC). The mean values were compared via the least significant difference (LSD) at 5% level.

Results and discussion

Qualitative characteristics of Washington Navel fruit were significantly affected by extract concentrations and storage duration. Throughout the storage period, the percentage of fruit weight loss increased significantly. This is due to loss of fruit water content by fruit transpiration during storage and this depends largely on the storage duration (Rab *et al*., 2015). Seaweed and thyme extracts prevented the weight loss of orange fruits during storage period. On the 60^{th} day of storage, the lowest (3.27%) fruit weight loss was observed with 3.75 g L^{-1} of seaweed extract. Some researcher reported that extracts of green and red seaweeds and thyme extract as natural anti-transpiration prevents fruit water and thus fruit weight loss during storage period (Fan, Hodges, Critchley, & Prithiviraj, 2013; Omar, 2014; Pérez-Alfonso *et al*., 2012).

Seaweed and thyme extracts decreased fruits decay percentage compared to control significantly. At the end of experiment, the lowest (3.67%) decay percentage was observed in 0.94 gL^{-1} seaweed extract. Seaweed including *U. flexuosa* Wulfen and Shirazi thyme extracts due to their antifungal and antibacterial properties reduces the amount of fruit decay and therefore resulting in longer citrus fruits storage life (Demirel, Yilmaz-Koz, Karabay-Yavasoglu, Ozdemir, & Sukatar, 2009; Kamel, 2014; Nabti *et al*., 2017; Omar, 2014; Pérez-Alfonso *et al*., 2012; Safaei & Afiuni, 2012).

Fruit juice content decreased significantly through the storage period. Studies show that the loss of fruit juice in citrus is the result of water evaporation from the fruit surface (Rab *et al*., 2015). After 60 days of storage, the highest fruit juice content (35.49%) was measured in 3.75 gL^{-1} seaweed extract. These results corroborate the reports by Omar (2014) who indicated that treating orange fruits with seaweed extracts maintained higher percentages of the fruit juice.

All organic compounds improve ascorbic acid during 30 days of orange fruit storage. Extract of seaweed and Shirazi thyme contains antioxidant enzymes that prevent the ascorbic acid from breaking down (El-Motty, Shahin, El-Shiekh, & El-Abd-Migeed, 2010; Ibrahim, 2013; Nabti *et al*., 2017).

The highest amount of titratable acid (TA) was measured at the beginning of fruit storage. However, on the 30th day after storage, the TA content decreased significantly. TA reduction was related to the use of fruit organic acids as a substrate, during respiration and growth processes (Marsh *et al*., 2004; Tehrani, Sharif Hossain, & Nasrulhaq-Boyce, 2011).

Total soluble solids (TSS) increases with increasing storage time. Increasing the amount of TSS in citrus during the storage process is due to the hydrolysis of the cell wall with various enzymes (Echeverria, Burns, & Wicker, 1988). The application of seaweed extract was more effective than the thyme extract in improving soluble solids. Seaweed extract contains phytohormones which improves the qualities of fruit, including soluble solids (El-Motty *et al*., 2010; Ibrahim, 2013; Nabti *et al*., 2017).

Conclusions

The present study suggests that dipping Washington Navel orange fruits in seaweed and Shirazi thyme extracts increases the storage life by augmenting the ascorbic acid content and reducing the percentage of fruit decay. These extracts are able to ameliorate other features such as fruit juice and TSS percentage. In most cases, seaweed extract was more effective than Shirazi thyme. The results of this study suggest that seaweed extracts can be used as a

perfect natural compound – an alternative to chemical fungicides and plastic wraps – to improve fruit quality and storability of the Washington Navel orange.

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