Original article

Effects of essential oil treatments combined with hot water treatment on improving postharvest life of sweet cherry

Erdinc BAL[1]*

[1] Namik Kemal Univ., Agric. Fac., Dep. Hortic., Tekirdag, Turkey, ebal@nku.edu.tr

* Correspondence and reprints

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Effects of essential oil treatments combined with hot water treatment on improving postharvest life of sweet cherry.

Abstract – Introduction. Sweet cherry fruit is a very perishable commodity, because fruits decay and lose water rapidly after harvest as a consequence of their high respiratory rate. The objective of the present study was to evaluate the effect of the combination of hot water plus essential oil treatments and hot water treatment alone on the quality of '0900 Ziraat' sweet cherries during cold storage. **Materials and methods**. Fruits were divided into four groups and were treated by dipping into water at 24 °C for 30 s (control), dipping into water at 60 °C for 30 s, and dipping into water at 60 °C for 30 s plus either menthol treatment or thymol treatment. After treatments, all fruits were packed in polypropylene bags and stored at 0–1 °C temperature and 90–95% relative humidity for 45 days. Physical and chemical changes were determined at 15-day intervals during storage. **Results and discussion**. All of the postharvest treatments improved fruit quality characteristics compared with fruit of the control. According to the data, after 45 days of storage, combination treatments were found to be more effective in controlling decay. The treated fruits had higher total anthocyanin and total phenolic compounds. In control fruits, total anthocyanin and total phenolic compounds initially showed a slight increase, but their accumulation significantly decreased with time.

Turkey / *Prunus avium* / fruits / postharvest losses / keeping quality / heat treatment / essential oils

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Effets de traitements aux huiles essentielles associés à un trempage dans l'eau chaude sur l'amélioration de la vie post-récolte des cerises.

Résumé – Introduction. La cerise est une denrée très périssable, car ce fruit pourrit et perd de l'eau rapidement après sa récolte du fait d'un taux respiratoire élevé. L'objectif de notre étude a été d'évaluer l'effet du trempage des cerises dans l'eau chaude associé à des traitements aux huiles essentielles, ou du trempage dans l'eau chaude seule, sur la qualité des cerises '0900 Ziraat' au cours du stockage au froid. **Matériel et méthodes**. Les fruits ont été divisés en quatre groupes et ont été traités par trempage dans l'eau à 24 °C pendant 30 s (contrôle) ; par trempage dans l'eau à 60 °C pendant 30 s ; par trempage dans l'eau à 60 °C pendant 30 s associé soit à un traitement au menthol, soit à un traitement au thymol. Après traitements, tous les fruits ont été conditionnés en sacs de polypropylène et stockés à une température de 0–1 °C avec une humidité relative de 90–95 % pendant 45 jours. Les changements physiques et chimiques ont été déterminés à 15 jours d'intervalle au cours du stockage. **Résultats et discussion**. Tous les traitements effectués après récolte ont amélioré les caractéristiques de qualité des fruits par rapport aux fruits témoins. Selon les données, après 45 jours de stockage, les traitements combinés (eau chaude + huile essentielle) ont été trouvés plus efficaces pour contrôler la détérioration des fruits. Les fruits traités ont présenté plus d'anthocyanes totaux et plus de composés phénoliques totaux. Dans les fruits témoins, les anthocyanes totaux et les composés phénoliques totaux ont d'abord montré une légère augmentation, mais leur accumulation a significativement diminué au cours du temps.

Turquie / *Prunus avium* / fruits / perte après récolte / aptitude à la conservation / traitement thermique / huile essentielle

1. Introduction

Sweet cherry (*Prunus avium*) fruits have a high market value and consumers prefer to buy fruits of high quality based on their appearance, sensory quality and nutritive values. The postharvest storage period of sweet cherries is limited by such factors as water loss, softening, development of surface pitting, stem browning and decay [1]. The fruit deterioration rate is affected by different factors such as intrinsic characteristics of the product and storage conditions in terms of temperature, relative humidity, storage atmosphere composition, etc. [2].

Sweet cherries have a short shelf life of 7–21 days in conventional cold storage [3, 4]; postharvest deterioration occurs very quickly if adequate precautions are not taken to prevent it. There is a demand to develop sustainable postharvest treatments to enhance the storage life.

Modified atmosphere packaging (MAP) storage has been successfully applied in order to prolong the shelf life of sweet cherries [5, 6]. With MAP in cold storage, cherry storage life can be as long as 30–40 days [7]. However, traditional MAP is not enough to ensure quality and safety preservation to fulfill consumer demand [2]. Therefore, MAP storage must be combined with other new treatments.

In recent years, there has been increasing interest in the use of natural compounds and postharvest heat treatments. There is almost no evidence on the use of essential oils or their components in combination with MAP in fruits, apart from the previous work of a few authors [2, 8–10]. The advantage of essential oils is their bioactivity in the vapor phase, and the limitation of aqueous sanitation for several commodities makes them useful as possible fumigants for stored commodity protection [11]. The use of essential oils, however, may be limited by flavor, because effective antimicrobial doses may exceed acceptable levels from an organoleptic point of view [12].

Postharvest heat treatments have been proposed as possible methods for surface disinfection of fruits and keeping fruit quality during storage. Heat treatments have been found to successfully maintain fruit quality in sweet cherry [13, 14].

The objective of the present study was to evaluate the effect of hot water and essential oil treatments in combination for controlling postharvest decay and maintaining quality of sweet cherry during cold storage.

2. Materials and methods

The sweet cherries (*Prunus avium* L. cv. 0900 Ziraat) used in our study were grown in Tekirdag (Turkey) (lat. 40°59' N, long. 27°29' E; located in the coastal region of the Marmara sea); they were harvested at the commercially mature stage, sorted to eliminate damaged and unripe fruit, and selected for uniform size and color. The essential oils tested were menthol and thymol.

The experiment was conducted in a completely randomized design including four treatments and three replications (three packages for each replicate). Fruits were divided into four groups. The first group was dipped into water at 24 °C for 30 s (control); the second group was treated by dipping into water at 60 °C for 30 s; the third group, by dipping into water at 60 °C for 30 s followed by a menthol treatment; and the fourth group, by dipping into water at 60 °C for 30 s followed by a thymol treatment.

Consequently, after dipping in hot water, all fruits were placed on absorbent paper to remove the excess surface water and dried at room temperature. Then, cherries (average mass of 250 g) were put in polypropylene baskets (13 cm × 22 cm) and packed in polypropylene bags (13-µm thickness).

Treatments with menthol and thymol (99.5% purity and purchased from Sigma, Sigma-Aldrich, Madrid, Spain) were performed by placing 0.05 mL of each essential oil on a sterile gauze inside the basket [9], avoiding contact with cherries, and immediately sealing it to avoid vaporization.

All packages were stored at 0–1 °C and 90–95% RH for 45 days. Fruit samples were analyzed initially (0 days) and after (15, 30 and 45) days of storage. Before analyses, packages were kept opened for a while;

thus, the odor disappeared very rapidly due to evaporation at room temperature.

During the storage period, various chemical and physical analyses were performed such as weight loss (%), total soluble solids content (%), titratable acidity (as malic acid, TA) (%), total phenolic compounds (mg·100 g^{-1}), total anthocyanins (mg·100 g^{-1}), and stem quality evaluation based on percentage of the surface being brown and decay rate (%) (score 5 for 0% of brown surface on the stem, score 4 for 1–25% of brown surface, score 3 for 25–50% of brown surface, score 2 for 50–75% of brown surface, score 1 for 75–100% of brown surface). Total anthocyanin content of the appropriately diluted extracts was determined by the spectrophotometric method of Wrolstadt [15]. Total phenolic constituents of fruits were measured following the literature methods involving Folin-Ciocalteu reagent [16].

Experimental data were subjected to analysis of variance (ANOVA). Sources of variation were treatments and time of storage. Statistical analyses of the data were performed with the MSTAT-C program and the means were separated by the LSD test to examine if differences between treatments and storage time were significant at $p < 0.05$. Results were the mean ± standard error of three determinations for each of the three replicates ($n = 9$).

3. Results and discussion

The main causes of sweet cherry deterioration are weight loss, color changes, softening, surface pitting, stem browning and loss of acidity [17]. Modified atmosphere packaging can reduce water loss, which is an important factor in cherry spoilage [18]. In our study, weight loss remained at low levels and increased slowly in all the four groups of cherries during storage, but the percent of weight loss varied among the treatments (*figure* 1). Weight loss in sweet cherries with postharvest treatments applied was slower than those of the control; however, there was no statistically significant difference ($p < 0.05$) among these treatments. After 45 days of storage, the highest weight

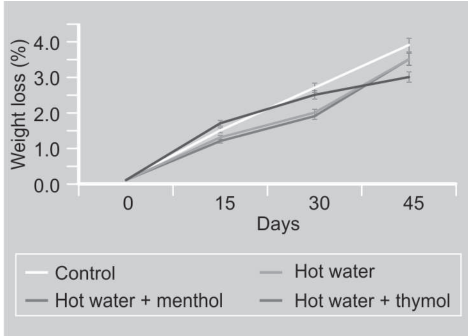

Figure 1.
Effects of essential oil treatments combined with hot water treatments on weight loss in sweet cherry (treatments × days LSD $_{0.05}$: not significant).

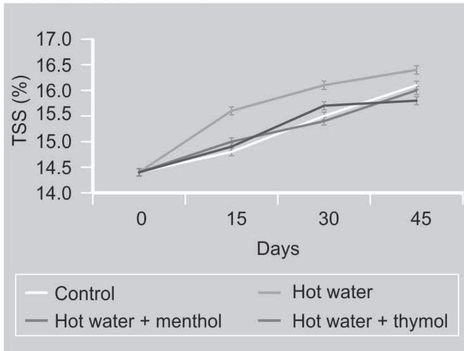

Figure 2.
Effects of essential oil treatments combined with hot water treatments on total soluble solids content (TSS) in sweet cherry (treatments × days LSD $_{0.05}$: not significant).

loss was determined for fruits in the control [(3.8 ± 0.4)%], while the least weight loss was observed for those dipped in hot water then treated with thymol [(2.9 ± 0.3)%]. Combined hot water and essential oil treatments were considered as successful in reducing weight loss. Heat treatments change primarily the resistance of the fruit epidermis and reduce the rate of water loss. However, the mechanism by which these essential oils led to a reduction in weight loss is still unknown [8].

The total soluble solids content (TSS) is an important characteristic, giving information about the quality of fruits. TSS of all the four groups of cherries was not significantly different at a level of $p < 0.05$ (*figure* 2). Depending upon the treatments, TSS of sweet cherries increased progressively with extended storage. Similar results were found on sweet cherries in the literature [1, 19]. The highest TSS was determined in fruits dipped in hot water without subsequent essential oil treatments [(16.4 ± 0.4)%], while the least TSS was observed in fruits dipped in hot water followed by a thymol treatment [(15.8 ± 0.3)%]. The increase in TSS may

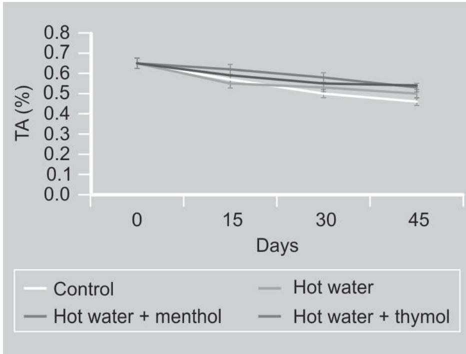

Figure 3.
Effects of essential oil treatments combined with hot water treatments on titratable acidity (TA) in sweet cherry (treatments × days LSD $_{0.05}$: not significant).

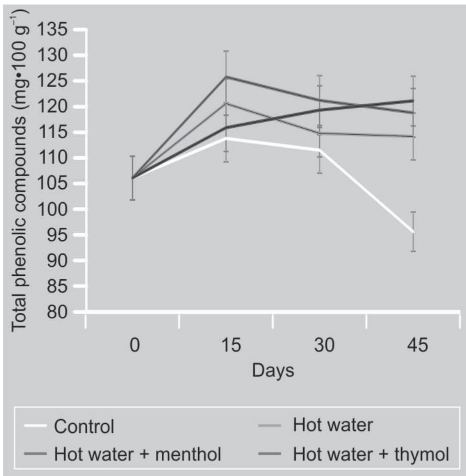

Figure 4.
Effects of essential oil treatments combined with hot water treatments on total phenolic compounds in sweet cherry (treatments × days LSD $_{0.05}$: 9.27).

result from an increase in concentration of organic solutes as a consequence of water loss.

Organic acids are substrates for the enzymatic reactions of respiration; a reduction in the acidity is expected [20]. In our study, it was found that there were no statistically significant differences ($p < 0.05$) among the treatments, and titratable acidity (TA) decreased slightly with extended storage in all treatments (*figure* 3). It is known that similar TA losses in sweet cherry occurred in many postharvest studies [8, 21, 22]. This could be due to utilization of acid in the respiratory process or by its conversion into sugars and salts. At the beginning of storage, TA of sweet cherry was 0.65%. TA content was higher in treated fruits than in fruits of the untreated control. The highest value of TA was detected in fruits dipped in hot water followed by a thymol treatment [(0.54 ± 0.02)%], then in those dipped in hot water followed by a menthol treatment [(0.53 ± 0.03)%] during the storage period.

In sweet cherries storage was found to have variable effects on the total phenolic and anthocyanin contents, which would depend on the cultivar and the storage conditions [22, 23]. According to our results, the total phenolic compound of all the four groups of cherries was significantly different at a level of $p < 0.05$ (*figure* 4). Treatments with hot water and essential oils had positive effects on the phenolic compounds of the sweet cherries treated compared with fruits of the control. This result is possibly due to the reduction of the activities of polyphenoloxidase by treatments. During storage, depending upon the treatments, total phenolic compounds initially showed a significant increase and then tended to decrease, except for fruits treated by thymol after dipping in hot water. It has been reported that, in sweet cherry, the total phenolic compounds generally decreased with storage at 1–2 °C [23]. At the end of the storage, in our study, the highest total phenolic compounds were determined in fruits treated by thymol after dipping in hot water [(121.1 ± 2.5) mg·100 g^{-1}], while the least total phenolic compounds were observed in sweet cherries in the control [(95.6 ± 4.0) mg·100 g^{-1}]. Reduction of total phenolic compounds in fruits of the control was faster than in those of the other treatments.

Anthocyanins are very important for fruit quality on account of their contribution to color and appearance. Generally, an increase in anthocyanins has been found during storage at low temperature in fruits such as sweet cherry [23], blueberries [24] and strawberries [25]. Similarly, in the current study anthocyanin values tended to increase. There were significant differences in total anthocyanin contents between treated fruit and control fruit ($p < 0.05$) (*figure* 5). The results of total anthocyanins revealed the same behavior in heat and combination treatments. Anthocyanin content at harvest was (33.7 ± 2.1) mg·100 g^{-1} and slightly increased in these treatments. However, in control fruits, total anthocyanins showed a significant increase [(45.2 ± 2.4) mg·100 g^{-1}] by 30 days and then rapidly decreased [(29.1 ± 1.5) mg·100 g^{-1}] at the end of storage. It is considered that the decrease in anthocyanin was parallel to the increase in the decay rate because breakdown of anthocyanins is directly related to postharvest browning and decay. A similar result was also reported in grape by Bal *et al.* [10].

Stem color is an important quality index, and one of the major limiting factors of cherry storage is stem browning. Consumers prefer fruit without brown and shriveled stems. In our study, hot water treatment and combinations with essential oils were effective on fruit stem quality. There were significant differences in stem quality between treated fruit and those of the control ($p < 0.05$) (*figure* 6). According to our results, at the end of the cold storage, minimum stem quality loss was recorded in fruit subjected to hot water treatment (score: 3.5 ± 0.3) followed by fruit dipped in hot water then treated with thymol (score: 3.2 ± 0.1) as compared with fruit of the control (score: 2.2 ± 0.2). The effect of dipping in hot water and combinations with essential oil treatments in delaying the loss of quality of stems could be attributed to its effect on the inhibition of water loss and, in turn, on stem desiccation and browning. Other previous reports on stem quality indicated that cherries and grapes were affected positively, after exposure to eugenol, thymol, menthol vapors and heat treatments [8, 9, 14].

Improvement of sweet cherry resistance against fungal attack can be a consequence of increases in biosynthesis of some protective proteins. Many authors indicated that the antimicrobial effects of essential oil constituents are dependent on their hydrophobicity and their partition in the cytoplasmatic microbial membranes [26]. On the other hand, the effect of heat treatment on fungal decay could be due to a combination of direct inactivation of the pathogen and to the induction of some kind of natural resistance in the fruit [27].

It was found that there were statistically significant differences ($p < 0.05$) among treatments (*figure* 7). According to our findings, physiological and fungal deterioration were seen from the 30th day of the applications. Hot water treatment in combination with essential oils was the most effective among postharvest treatments. These findings reveal that dipping in hot water and essential oil treatments have an antifungal function. High rates of decay were observed in control fruits, in which high rates of the breakdown of anthocyanins and oxidation of phenolics were determined. After 45 days of storage, the decay rate of control fruit was (40.8 ± 4.4)%. The lowest decay rate was determined in fruits dipped in hot water in combination with a menthol treatment

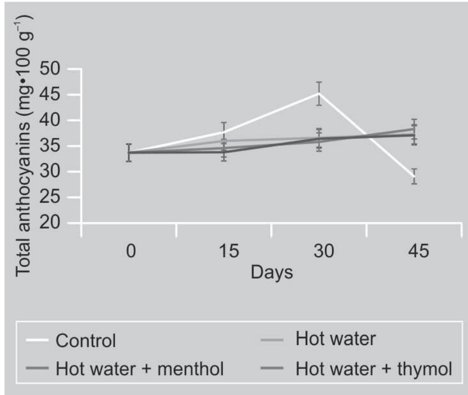

Figure 5.
Effects of essential oil treatments combined with hot water treatments on total anthocyanins in sweet cherry (treatments × days LSD $_{0.05}$: 3.27).

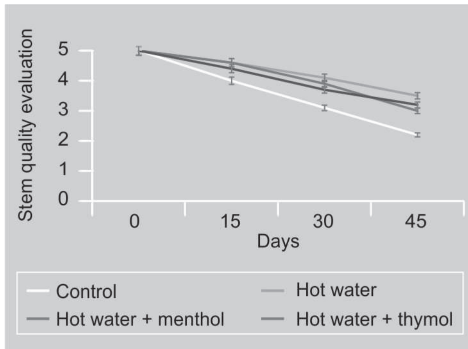

Figure 6.
Effects of essential oil treatments combined with hot water treatments on stem quality evaluation in sweet cherry (treatments × days LSD $_{0.05}$: 0.36).

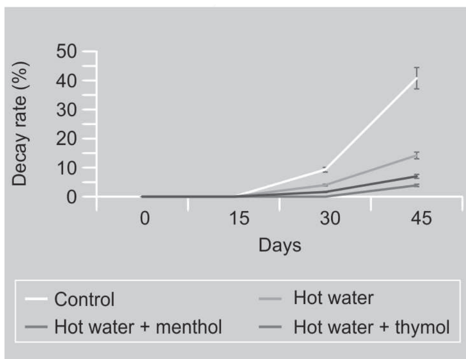

Figure 7.
Effects of essential oil treatments combined with hot water treatments on decay rate in sweet cherry (treatments × days LSD $_{0.05}$: 4.58).

[(3.9 ± 2.7)%]. Previous experiments using eugenol, thymol or menthol vapors revealed benefits due to reduced decay in cherries and grapes [8, 9]. Feng *et al.* [13] and Karabulut *et al.* [14] also reported a decrease in the decay rate in hot water-treated sweet cherries.

As a result, dipping in hot water combined with essential oil treatments is an effective method for prolonging storability of sweet cherry. In essential oil-treated fruits, the presence of the essential oils could not be detected. Most fruits treated by dipping in hot water combined with thymol or menthol treatments maintained quality for 45 days at 0–1 °C.

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Efectos de tratamientos a base de aceites esenciales asociados a una inmersión en agua caliente sobre la mejora de la vida postcosecha de las cerezas.

Resumen – **Introducción**. La cereza es un producto alimenticio muy perecedero, ya que este fruto se pudre y pierde agua rápidamente después de su cosecha, debido a una elevada tasa respiratoria. El objetivo de nuestro estudio fue evaluar el efecto de la inmersión de las cerezas en agua caliente asociada a tratamientos de aceites esenciales o el de la inmersión en agua caliente solamente, sobre la calidad de las cerezas '0900 Ziraat' durante el almacenamiento en frío. **Material y métodos**. Se dividieron los frutos en cuatro grupos y se trataron por inmersión en agua a 24 °C durante 30 s (control); por inmersión en agua a 60 °C durante 30 s; por inmersión en agua a 60 °C durante 30 s asociada a un tratamiento de mentol o a un tratamiento de timol. Después de los tratamientos, se envasaron todos los frutos en sacos de polipropileno y se almacenaron a una temperatura de 0–1 °C con una humedad relativa de 90–95% durante 45 días. Los cambios físicos y químicos se determinaron con 15 días de intervalo a lo largo del almacenamiento. **Resultados y discusión**. Todos los tratamientos efectuados postcosecha mejoraron las características de calidad de los frutos, en relación con los frutos testigo. Según los datos, después de 45 días de almacenamiento, los tratamientos combinados (agua caliente + aceite esencial) han sido considerados más eficaces para controlar el deterioro de los frutos. Los frutos tratados presentaron más antocianinas totales y más compuestos fenólicos totales. En los frutos testigo, las antocianinas totales y los compuestos fenólicos totales mostraron primero un ligero aumento, pero su acumulación disminuyó significativamente con el tiempo.

Turquía / *Prunus avium* / frutas / pérdidas postcosecha / aptitud para la conservación / tratamiento térmico / aceites esenciales