Pectin edible coatings enriched with essential oils of lemon and thyme to improve storage of black raspberry

Soma Abdi* and Davood Bakhshi

Department of Horticultural Science, University of Guilan, Rasht. Iran

Received: 25.05.2019 Accepted: 18.07.2019

ABSTRACT

The short-term postharvest durability of black raspberry is often due to containing a high level of water, high metabolic activity and sensitivity to fungi. In order to increase the quality and storage longevity of black raspberry fruit, the effects of different densities of improved pectin coating with lemon and thyme essential oils accompanied with edible pectin coating in 5°C for a period of 12 days has been studied. The experiment has been done with 6 different treatments including control without coating (distilled water) in three replications based completely randomized design which goes as follows: P2%+TE 0.15% (W/V), P2 TE 1 %+ (W/V), P2%+LE 0/15%(W/V), P2%+ LE0.1% (W/V). Fruit quality during storage was evaluated at 3-days intervals in terms of marketability, weight loss, anthocyanin content, vitamin C, TA and TSS. According to the results, coating fruits with pectin along with lemon essential oils oil delayed degradation of anthocyanin, vitamin C. All coating treatments have delayed the weight loss in the fruits by means of controlling losing fruit moisture in postharvest storage condition. The best result was gained in P2%+TE 0.15% treatment of a decrease in weight loss. Also the longest postharvest storage time belonged to treatment P2%+ LE 0.15%. Besides, the enriched pectin coating with lemon and thyme essential oils had a positive effect on preserving the quality of the appearance of the fruit in the storage period. Also the highest amount of vitamin C and anthocyanin for the mentioned treatment was resulted for a period of 12 days. According to the results, pectin coating, enriched by lemon and thyme essential oils is a good treatment for preserving the quality of shelf-life of black raspberry fruit.

Keywords: Anthocyanin, postharvest, weight loss, quality, storage


INTRODUCTION

Black raspberry (Rubus occidentalis) is of the Rosacea family (Marquina et al., 2002). Near a Valley in Oregon America, some remaining of the raspberry fruit has been found which belonged to 8000 AD. The local culture of the Indians in America is one of the oldest of its kind in using black and red raspberry and fruits of the similar nature in order to use their pharmaceutical and nutritious qualities (Hummer and Janick, 2007). Some undesirable reactions occur to fruits and vegetables structure because of decay and this leads to unfavorable changes in the taste, smell and color of their plant tissues (Valdez et al., 2017). Edible coatings are defined as a very thin layer of edible nutritious material on different types of food. The production of coatings has rapidly increased because of the customers insistence on and inclination for purchasing products which have preserved their freshness and quality. In this acceleration in production, there have definitely been harder attempts for more direct effects of these coatings on bettering the appearance of the products and higher rate of selling them. In fact, these materials are used as a solution for the too early expiration date of some of the

* For correspondence: S. Abdi (Email: rojhina.ab@gmail.com)
products (Ciolacu et al., 2014). The polysaccharide pectin coating is made of D-galacturonic acid units. Pectin coating the products with a soluble coating which has no color and no taste. Due to the hydrophilic nature of pectin, it has low functionally regarding losing the moisture, but it produces a very strong barrier for avoiding gas exchanges (Okunowo et al., 2013), apples are full of pectin when they are in there ripening stage (Mohnen, 2008).

The world demand for pectin in food industry is increasing day after day in a way that the total production capacity which used to be 45 to 50 million tons per year which has increased to 140-150 in 2011, and this is the indication of the world population increasing demand for this complex polysaccharide (Valdez et al., 2015). One of the most appropriate and applicable methods for increasing the maintenance of raspberry fruit and preserving it from tissue damage is applying coatings which are made from natural polymers (Kader, 2002). Of the important effects of pectin on plant cells are adhesion, mechanical power, the capacity for forming stabilizing gels and also the growth of plant cell walls (Lopes dA Silva and Rao, 2009). Pectin coating is used for keeping fruits and vegetables fresh and edible and the examples are as follows: cantaloupe (Oms-Oliu et al., 2008; Martiñon et al., 2014; Ferrari et al., 2013), avocado (Mafloonzad and Ramaswamy, 2008), nectarine (Ramirez et al., 2015), watermelon (Sipahi et al., 2013), papaya (Brasil et al., 2012), pear (Oms-Oliu et al., 2008), strawberry (Guerreiro et al., 2015; Trevino-Garza et al., 2015), apple (Moreira et al., 2015), raspberry (Guerreiro et al., 2015), peach (Ayala-Zavala et al., 2013) and Saputa (Menezes and Athmaselvi., 2016).

Recently, many producers and consumers have paid a lot of attention to using natural material which decrease the rate of corruption in food products and increase the shelf life of fruits and the products. Applying plant essential oils in postharvest diseases has emerged as a new method in the recent years. These compositions not only do not they have any side effects, but also increases the period of shelf life and storage period of the fruits due to the antioxidant qualities (Antunes et al., 2010). Using these natural antibacterial material in food compositions or coatings or their direct consumption can be a suitable replacement for chemical pesticides and fungicides (Min and Krochta et al., 2005). Lemon essential oils is counted as one of the most commonly used flavors of foods and drinks. Although its production is in a way that it does not lend itself to direct use in food products without optimization (Norsker et al., 2000), findings show that it is possible to use the citrus essential oils as a preventer of the growth of pathogens in postharvest diseases (Du plooy et al., 2009).

Thymol (Zataria multiflora) is an aromatic plant of the Lamiaceae family. This leaves and stems contain oil essential oils, tannins, saponins and antisepctic material. The main oil compositions of thyme plant has been studied by means of chromatography of GLC, chromatography of Citroen, nuclear magnetic resonance (NMR) an chromatography of liquid gas connected to assive spectrograph (GLC/MS) (Ebrahimzade et al., 2003; Mohagheghzade et al., 2000). Two important and active components of this plant are thymol and carvacrol. Thymol is a type of phenol and is used as stabilizer in pharmaceutical products. The curing and antinociceptive qualities of thymol and carvacrol (GLC/MS) (Ebrahimzade et al., 2003; Mohagheghzade et al., 2000). Two important and active components of this plant are thymol and carvacrol. Thymol is a type of phenol and is used as stabilizer in pharmaceutical products. The curing and antinociceptive qualities of thymol and carvacrol (GLC/MS) (Ebrahimzade et al., 2003; Mohagheghzade et al., 2000). Two important and active components of this plant are thymol and carvacrol. Thymol is a type of phenol and is used as stabilizer in pharmaceutical products.

Lemon (Citrus limetta) is from Rutaceae family. The chemical compositions out of analyzing lemon essential oils includes: α-pinene, β-pinene, Myrcene, Limonin, Terpineol, 1,8 cineole, Linalool, Citral, Trans-acetate and Geraniol acestate. The Limonin and Valencene present in Lemon essential oils have an antifungal and antibacterial quality and it is used as an additive to foods and flavor in food industry. Using enriched plant cuttings has been applied in different products such as thymol-pullulm of apples and tangerines (Gniewosz and Synowiec, 2011), Eugenol oil+citral oil+ pectin+Alginate coating on raspberry (Guerreiro et al., 2015), Citroen oil plus pectin coating in strawberries (Abdi et al., 2017), boil +gum Arabic plus cinnamon oils plus lemongrass coating on the mixture of bananas and papayas (Maqbool et al., 2011), bergamot+ chitosan Plus hard work Hydroxypropymethylcellululose essential oil on grapes (Sanches-Gonzalez et al., 2011), lemonen oil+origanum+ N-aclyated chitosan compactum oil+ Mentha oil piperita+ thymus vulgaris oil coating on strawberries (Vn et al., 2011), lemongrass oil +cinnamon oil + alginate in cantaloupe (Raybaudi-Massilia et al., 2008), London oil + chitosan coating in strawberries (Perdones et al., 2012), lemon and orange oils plus alginate coating in raspberries (Gmoes et al., 2017).

The purpose of this study is to examine the effects of pectin coatings enriched with lemon and thyme essential oils as edible coating on the shelf-life and physicochemical qualities of black raspberry in 5°C for period 12 days.
MATERIALS AND METHODS

Procurement of fruits

Fresh black raspberry fruits were brought from the local fruit market of Rasht town, Guilan and they were sorted for uniform size, shape, color and maturity stage. Fruits free from any physical injuries or diseases were selected.

Preparation of coating solutions

In order to solve pectin (Sigma-Aldrich Chemic, Steihein, Germany) in 100 minutes of distilled for 30 minutes was incessantly mixed in 70 °C, then 20% of Glycerol (as coating conditioner) was added to the pectin soluble. Producing lemon and thyme essential oils  (Essential oils Giah -Gorgan plant Essential oils company- Iran) was solved in one milliliter of ethanol, then it was added to the pectin in soluble (Dhanpal et al., 2012). Applying the treatments on the fruits took one minute and by dipped method, the treatments are as follows:

1. Treatment (control)
2. Two percent pectin (P2%)
3. 2% pectin + 0.1% lemon essential oils  (P 2%+LE1%)
4. 2% pectin+ 1.5% lemon essential oils  (P 2%+LE 0.15%)
5. 2% pectin+ 0.1% thyme (P 2% TE 0.1%)
6. 2% pectin+ 1.5% thyme (P2%+TE 0.15%)

Determination of quality parameters

Measuring three qualities was done every other 3 day, which means on the third, sixth, ninth and eleventh day. The grading method was done to evaluate the shelf-life indicator. Fruits the tabulated in 5 groups and they were graded 1 to 5 (Asghari et al., 2014). In order to evaluate the shelf-life of the fruits, appearance evaluation karma weight loss and observing the ostensible fungi corruption were used. For measuring the weight loss (Mir Muhammad et al., 2014) the total anthocyanin by means of absorption discrepancy in different pH (Giusit and Ronald, 2001), vitamin C by means of titration acidity (A.O.A.C, 2000 a.b), total acidity of titration method and solid soluble material by using refractor meter were measured.

Statistical analysis

The experiment was done in a separate way and in the form of a completely random plan by means of six treatments and 3 reputations and 10 samples for each repetition. The comparison of the average of the data was done by means of (SAS (3.1)) software and (Duncan's multiple-range test (p<0.05) test.

RESULTS AND DISCUSSION

Shelf life

The analysis of the results considered the sampling times of 3 and 12 day shelf life for all quality parameters measured. Based on the results, fruits treated with p2%+LE 0.15% coating had a better apparent condition in the way that on the 12th day, they still have kept in appropriate quality. Treatment p2%+TE 0.1% did not show any significant difference with p2%+TE 0.15% treatment. The shortest shelf-life belong to the control treatment. Also, treatment P2%+LE 0.15% increased the shelf life of raspberries for a period of 12 days (Fig. 1).
Pectin treatment showed resistance against weight loss due to existence of pectin coating, but because of the paucity of any kind of essential oils, it finally showed corruption in a higher degree. Generally the coatings prevent corruption and microbe pollution by means of disrupting the growth condition and micro organic activities such as water and oxygen activity and they do this by making physical obstacle on way of micro organic penetration into the product and antibacterial compositions (Ou et al., 2003). These coatings also prevent microbe growth on edible tissues in case of their emergence (Wu et al., 2010). Fruits which had coatings enriched with lemon and thyme essential oils had longer shelf life and this is due to the existence of mixtures such as Monoterpenes (such as limonene), Sesquiterpene hydrocarbons and originated derivatives (aldehydes (such as Citral)) ketones and acids accompanied with linear aldehydes, alcohols (such as linalool) and esters and non-volatile sector including hydrocarbons, fat acids, sterols, carotenoids, Coumarin wax and flavonoids (Espina et al., 2011). 31 GC/MS compositions have been recognized and derived from thyme essential oils which totally includes 96/67 essential oils and the most major mixtures already identified are 31/5% yhymol, 23/4% Para-siman, 13/94% Gamma-Terpinen, Linalool(3/38) and Carvakelol (2/66%) (Enomoto et al., 2001). Lemonon and thyme are the most salient mixtures of lemon and thyme essential oils and of their most outstanding qualities are antibacterial and antiviral qualities (Roy et al., 2007).

**Weight loss**

The results have shown that the highest amount of weight loss belonged to control. Treatments P2%, P2%+LE 0.1% and P2%+LE 0.15% did not show any significant difference on the 9 day. Treatment P2%+TE 0.1% ends in protecting the quality of the fruits by decreasing the weight loss amount. Also, the lowest amount of weight loss refers to the 12 day, treatment 0.47% or P2%+TE 0.15% (Fig. 2). Results showed that the weight loss in coated fruits by P2% coating and treatment P2%+TE 0.15% acted weaker than the usual level. In the way that by passage of time, raspberry fruits coated with thyme essential oils in 5°C could exhibit resistance facing weight loss.

This can happen due to the preventive role of essential oils against corruption added to its anti-bacterial qualities which ends in weight-loss. In postharvest period, the disconnection of irrigation path with the mother-plant and the increase in fruits and vegetables surfaces perspiration which is a physical activity ends in moisture loss of the product (Yossef, 2014). The results of this study and (Menezes and Athmasalvi, 2016, Velickova et al., 2013).
Anthocyanin

Results showed that the highest amount of anthocyanin on the 12 day belonged to control treatment (0.074 mg/g FW). In the experiment period, treatments (0.068 mg/g FW) P2%+LE 0.1%, (0.06 mg/g FW) + LE 0.15% and (0.059 mg/g FW) + P2% TE 0.1% did not show any considerable difference in anthocyanin level. Also, the lowest amount of anthocyanin belonged to the 9 and 12 days in treatment (0.052 mg/g FW) + P2%+TE 0.15% (Fig. 3). Raspberries are considerable source of compounds such as anthocyanins, flavonoids, chromogenic acids, flavonoids, Tannins and Procyanidins that have high biologic activities which protect body against cardiovascular diseases, cancer, inflammations, obesity and other kinds of chronic disease (Wu et al., 2010). The high amount of antioxidant activity of raspberry cultivars is due to the high level of compounds such as phenolic compounds, anthocyanin and Vitamin C (Dawidowicza et al., 2006). Various anthocyanins in raspberry fruit are Cyanidin-3-sophoroside, Cyanidin-3-glucorutinoside, Pelargonidin-3-sophoroside-Cyanidin-3-glucoside, Pelargonidin-glucorutinoside-Cyanidin-3-rutinoside, Pelargonidin-3-glucoside, Malvidin-3-glucoside, Delfinidin-3-glucoside (De Ancos et al., 1999). The amount of Anthocyanin increases at ripening period, but it takes up a decreasing manner after harvesting due to destructive processes and aging (Valero and Serano, 2010). It is of the essential oils to mention that the storage temperature has a high impact on the rate of this process, in a way that corruption takes place in 5°C at a lower rate. The increase in Anthocyanin in control fruits can be due to high amount of corruption in fruits and destroying the anthocyanin in chemical processes related to pathogens (Almeida et al., 2007). According to results, by passage of storage period and due to accretion in aging, anthocyanin level adds up, but this happens slower in fruits coated with lemon and thyme essential oils pectin in 5°C. There seems to a relation between fruit ripening and anthocyanin increase which is delayed by the enriched coating to some degree. The total increase of anthocyanin throughout the storage period is because of the phenolic compounds' biosynthesis in postharvest period and dehydration (Hassanpour, 2015). Hen et al, 2004 results accorded with the results of this study. They reported that anthocyanin synthesis accelerates by increase in in the aging process which ends in the strawberry fruit color turning red.
Vitamin C

According to the results of third day, the highest amount of vitamin belonged to treatment (P2%+ TE 0.15% 0.35mg 100g FW). Treatments P2%+TE 0.1%+ P2%+LE 0.15% did not have a significant difference with each other on the sixth day. Control treatment and P2% treatment did not any significant difference with each other on the ninth day. The lowest amount of vitamin C belonged to the control treatment (mg 100gFW 0/22) (Fig. 4). Vitamin C has a significant nutritious value in fruits and vegetable because of having antioxidant role, but it is very sensitive decomposition due to oxidation. In fact, the antioxidants present in foods, fruits and vegetable decrease the effects of free radical molecules in the body and as a result empower the body immune system (Erkan et al., 2008). Based on the results of the present study the treated fruits had more vitamin C
compared to control treatment, but there was insignificant difference other treatments. The decrease in vitamin C in control treatment causes a diminish in its antioxidant capacity. Reduction in Vitamin C level can be caused by environmental ascorbic acid oxidation. Primarily, because of Vitamin C oxidation to dehydrating ascorbic acid and in case of continuation of the reaction, changes to deactived dehydroascorbic, the path which is irreversible and consequently, an extreme decrease in this compound is amount at the shelf life period of raspberry fruit will be observed (Yossef, 2014). Reports indicate that the decrease in Vitamin C level in the storage period can be referred to respiration rate (Garcia et al., 1996). An increase in pH level as a result of enzyme activity, added to an increase of oxidation can end in Vitamin C decadence (Vargas et al., 2006). Preservation of Vitamin C in coated fruits can be the indicator of preserving the quality and nutritive value of the fruit. It seems that the treated samples showed less change in Vitamin C level because of controlling the amount of oxygen entering the cells and decreasing the amount of enzyme activity by means of the enriched pectin by lemon and thyme essential oils. Therefore, enriched pectin with lemon and thyme essential oils causes the preservation of Vitamin C in the storage period (Yossef, 2014). According to Amal et al. (2010), the amount of Vitamin C decreases in the storage period, but the amount of decrease in Vitamin C level in coating treatments in wheat and soy with thyme essential oils has been less than Calcium chloride.

![Figure 5](image1.png)

**Figure 5.** Effects of pectin enriched with thyme and lemon essential oils on black raspberry TSS

![Figure 6](image2.png)

**Figure 6.** Effects of pectin enriched with thyme and lemon essential oils on black raspberry TA
Based on the results, the highest amount of TSS belonged to the control. Treatment P2% had more TSS than treatment P2%+TE+LE. Also treatment P2%+TE0.15% had the lowest (6/02%) of TSS (Fig.5). According to the results, with the increase in storage period, the TSS increases, but this increasing trend slows down in treatment which have pectin coatings with lemon and thyme essential oils. The reason of increase in TSS amount in the storage period is the increase in fruits respiration eventuates in decadence of carbohydrates, changes in other material such as lowering of acids, increase of soluble pectin and phenolic compounds and initiation of fruit decadence. Furthermore, in present results, by applying the enriched pectin by lemon and thyme essential oils, the respiration intensity decreases the amount of TSS follows an even slower increasing course (Mali and Grossmann, 2003). Given that the amount of TSS and TA, determines the taste of raspberries, the abundance or paucity of these factors depends on the taste of different individuals (Abdi et al., 2017). Radi and colleagues, 2017, based on the analysis of gelatin coating with black and green Aloe Vera essential oils on oranges (fresh-cut) reported that the amount of TSS increases with the accretion of storage period, but this process had a lower speed in treated fruits. Also, results from similar experiments on Loquat fruit indicated an increase in the amount of TSS (Song et al., 2016).

The Total Acidity (TA)

The effects of the enriched pectin coating with lemon and thyme essential oils on the amount of TA have been exhibited on figure 6. Results showed that throughout the twelve days of the experiment, the highest amount of TA belonged to P2%+TL 0.15% and the lowest amount of TA belonged to control treatment. Treatment P2% (0.76$ and 0.68%) and control treatment did not have a significant difference with one another on the twelfth day. The other treatments had a decreasing trend on the third, sixth, ninth and twelfth day, but they did not have a significant difference in their level of TA (Fig. 6).

The decrease of TA correlates with fruit ripening. The amount of acid titration is in relation with fruit ripening and leads in a sour taste in fruits and vegetables and pectin coating with lemon and thyme essential oils slows this process down. ISO-citric is the dominant acid in raspberries. It was reported that the decrease on the eighth day in (fresh-cut) apples with sucrose, trehalose coating (Albanese et al., 2007) accorded with the results of the present study. Similar results were reported about the coating of chitosan on hawthorns, mangos and litchis (Yossef, 2014; Scollard et al., 2016; Chanthaphon et al., 2008).

Conclusion

Results of the present study showed that pectin coating with lemon and thyme essential oils treatment in the temperature of 5°C analyzed for all the qualities could be recognized as an appropriate treatment by keeping the quality. Given that raspberry fruit has a weak taste, and the smell of thyme affected that of the fruit, it is suggested that in order to preserve the quality of raspberries, a milder essential oils be used, otherwise the marketability of the product decreases. Finally, according to the results it can be claimed that the enriched pectin coating with lemon and thyme essential oils in the defined densities is recognized as a good treatment for preserving raspberries, but more research and analysis is required on the commercial level.

REFERENCES


Abdi and Bakhshi (Edible coatings to improve storage of black raspberry)


Scollard, J., McManamon, O., Schmalenberger, A., 2016. Inhibition of Listeria monocytogenes growth on fresh-cut produce with thyme essential oil and essential oil compound verbenone. Postharvest Biology and Technology.120, 61-68. doi:org/10.1016/j.postharvbio.2016.05.005.


Abdi and Bakhshi (Edible coatings to improve storage of black raspberry)


