Application of Pectin Coating Containing Essential Oil for Increasing Quality of Strawberry Fruit

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ABSTRACT

Edible coatings and essential oils increase quality of product during storage due to their ability to control gas and moisture exchange and antimicrobial properties, respectively. The study was carried out using a factorial design with two factors include time (4 level) and treatment (6 level) in a completely randomized design with three replication. To evaluate the effect of coating on shelf life and quality of strawberry fruits, 2 concentrations (0.5 and 1%) of lemon and orange peel essential oil along with pectin was used. After fruit immersion in coating solution for 1 min, fruits were storage at temperature of 5 °C and relative humidity of 75±1 % evaluate shelf life, biochemical characteristics such as total soluble solids, total acidity, pH, antioxidant activity and weight loss. According to the results, with an increase in storage time, all evaluated characteristics showed an upward trend. The highest shelf life (24.23 days) observed in pectin with 1% lemon essential with a 12day of increase observed compared to the control. The results show that the control treatment accounted for the highest amount of soluble solids and total acidity during the period of storage. Moreover, the pectin enriched in two concentrations of lemon essence (0.5% and 1%) decreased significantly fruit weight loss. At the mid time of storage period, there were no significant differences in soluble solids between pectin enriched in 0.5 and 1% orange essence (6.48 and 6.53% respectively). In addition, during the period of storage, the pectin enriched in 1% orange essence showed less weight loss and soluble solids in comparison to the control. At the end of storage time, pectin with lemon essence illustrated the higher antioxidant activity than pectin with orange essence treatment. At this time, the highest amount of total acidity and the lowest amount of pH (0.75% and 6.76, respectively) observed in the pectin enriched in 1% lemon essence. In general, the results showed that 1% lemon essential oil had higher effects on preserving fruit quality and appearance than orange essential oil and essential-free pectin treatments. Therefore, use of essential oils for their antimicrobial properties coupled with edible coatings can be used as an effective treatment for strawberry fruit post-harvest technology.

Keywords: Essential oils, Postharvest, Shelf life, Strawberry, Total soluble solids


INTRODUCTION

Strawberry (Fragaria × ananassa) is one of the unique small fruits in the temperate zone, which is known as an important and commercial product (Rahman et al., 2014). It is belong to the Rosaceae family, with a short postharvest life so quickly becomes soft which is mainly due to fungal decay (Balogh et al., 2005). Same as other small fruits, strawberry has high content of bioactive compounds such as anthocyanin, phenolic acid, flavonoids, tannins and vitamin C (Da Silva Pinto et al., 2011). Edible coating is a thin layer of edible material that use on the surface of products. They are a suitable substitute for protective coating wax (Zahid et al., 2012). Edible coating material increase products shelf life, quality, health and physical characteristics stability by creating a semi-permeable barrier to water, oxygen and carbon dioxide between fruits and atmosphere. Suitable coating should pass a certain amount of gas, to prevent an aerobic respiration (Jabeen et al., 2015; Valdés et al., 2015). They can be polysaccharides, proteins, lipid or combination of them (Tanada-Palmuand Gross, 2005). Pectin is one of the most important components of cell wall with high molecular weight, which made from the combination of

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poly galactronic acid with local methyl ester (Willats, Knox, and Mikkelsen, 2006). Pectin tends to form strong films but poor resistant to water (due to natural hydrophilic characteristic). The ability of pectin to form strong and insoluble gels with dual cations, improve its poor resistant to water (Da Silva Pinto et al., 2011). Therefore application of edible coating cause less microbial growth and delay the senescence process. Pectin has other application in food industry (e.g Jam, jelly with low sugar, dessert, ice cream with fruit jelly, concentrated juice, vegetable and canned fruit) (Valdés et al., 2015). In addition, it is used to enhance fresh cut fruit shelf life such as cantaloupes (Oms-Oliu, Soliva-Fortuny, and Martín-Belloso, 2008), mango (Moalemiyan et al., 2012), avocado (Mafroonazad and Ramaswamy, 2008), nectarine (Ramirez et al., 2015), watermelon (Sipahi et al., 2013), pear (Oms-Oliu et al., 2008), papaya (Brasil et al., 2012), strawberry (Treviso-Garza et al., 2015), raspberry (Guerreiro et al., 2015) and peach (Ayala-Zavala et al., 2004). Essential oils are terpene compound with low molecular weight than water whish have special smell, antioxidant and antibacterial properties (Belletti et al., 2007). Recently essential oil as an antibacterial natural material has been used significantly to preserve foods against pathogen and other degenerative agents in postharvest food and industry (Caillet et al., 2006). Essential oils with hydrophobic properties are able to penetrate to mitochondria and cell content leakage because of dissolving lipids of bacteria cell wall (Lopez-Romero et al., 2015). Researches show that citrus essential oil can be used as a pathogen growth inhibitor in postharvest disease (Fisher and Phillips, 2006). Citrus essential oil due to their natural origin, no harm to human and environment and lack of resistant to pathogen can be used as an alternative substitute for chemical pesticides. Result of chromatography showed limonene as a main composition of citrus oil and make ups 84.2% of oil. Linalool (4.4%) and myrcene (4.1%) are in the next ranks. Limonene, β-pinene and γ-terpinene are the main compound of orange shell that prevents microorganisms’ growth (Chanthaphon et al., 2008). Lemon essential oil because of their antioxidant activity inhibits peroxidase activity in leafy vegetable and prevents enzymatic browning (Mousavizadeh and Sedaghatoor, 2011). Result shows sour lemon essential oil (250 μL/L) can control fungal decay in nectarine (Lazar-Baker et al., 2011). In a research, pectin (1%) and calcium lactate (0.5%) were used on fresh-cut cantaloupe. Pectin (1%) increased fruit shelf life to 14 days at 5°C and kept quality and sensory profile (Ferrari et al., 2013).

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Used chitosan coating enriched with lemon essential oil on strawberry at 5°C. They reported, application of lemon essential oil reduced fungal decay and fruit decay delayed for 7 days (Perdones et al., 2016). Result showed bacterial population reduced significantly in all treatment (Sanchis et al., 2016). Pectin coating reduced decay on fresh-cut apple and decreased Phenylalanine enzyme (Moreira et al., 2016). Yossef (2014) showed pectin edible coating reduced weight loss, microbial degeneration and firmness changes of fruit. Pectin application on fresh-cut melon at 4°C was reported by Cristiane et al (2013). Isela et al (2016) reported pectin coating enriched with Mentha pulegium essential oil reduced fungal decay and increased antioxidant activity of tomato. With respect to effect of edible coating and essential oils in preserving fruit quality, present research was designed to investigate the interaction between citrus (orange and lemon) essential oil and pectin on strawberry shelf life and quality at 5°C.

MATERIALS AND METHODS

Plant material and treatments

Fruit of strawberry (Fragaria × ananassa) cv. Paros at a commercially mature stage were harvested at a local orchard in Sanandaj (Kurdestan) and transported within 2 h to the laboratory of Ilam University. Fruit with abnormal shape and physical damage were removed, and then other fruits were washed with distilled water to remove surface microorganism and dust. Treatment included control (distilled water, without covering), (1% w/w) pectin, pectin + 0.5% and 1% orange essential oil and pectin + 0.5% and 1% lemon essential oil. After drying in room temperature, fruits were transformed to 5°C to evaluate fruit...
traits. Each treatment had 3 replication and 20 fruits were in each reapplication. Measurements were carried out in harvest day, third, sixth, ninth and twelfth day after harvest. Pectin (Merck- Germany), lemon essential oil (including limonene, β-bisabolene Gorgan- plant essential - Iran) and orange essential oil (including limonene, β-pinene, α-pinene, decanal, linalool, Gorgan- plant essential_ Iran) were used to prepare treatments.

**Preparation of pectin (1%, w/w)**

1 gr pectin was dispersed in 100 ml distilled water, solution was mixed monotonously for 30 min at 70 °C. To increase pectin elasticity 0.02 % glycerol was added to the solution (Norsker et al., 2000). Other treatments made by adding 0.5 and 1 ml lemon and orange essential oil, that were solved in ethanol (70 %) (46%). After reducing temperature of solution, selected strawberries were dipped in the solution for 1 min.

**Measurements**

To evaluate durability, weight loss, fungal decay sign and fruit firmness were measured (Rahman et al., 2014). Acidity, pH and TSS were analyzed following AOAC method (AOAC, 2000 a, b). To measure weight loss, fruits were weighted daily, then fruit weight loss was calculated using under equation (Mir Muhammad et al., 2014):

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\text{Fruit weight loss (\%) = primary weight – secondary weight/ primary weight*100}
\]

Antioxidant activity was determined using UV-visible spectrophotometer (CECIL- UK). 2 g fruit tissue was added to 40 ml water/ethanol (Merck- Germany) (1/1 w/w). Solution was centrifuged 15 min in 4000g. 0.1 ml of upper extract was added to 9 ml DPPH (Sigma- USA) 0.03 mg of DPPH dispersed in 1-lit methanol). Extract absorption was measured at 517 nm. Finally, antioxidant activity was calculated using under equation (Kelebek et al., 2009):

\[
\text{Antioxidant activity (\%) = DPPH absorption – sample absorption/ DPPH absorption * 100}
\]

**Statistical analysis**

The experiment was a factorial as a completely randomized design (including 2 covering agent in 3 level and 4 time). All data were subjected to analysis of variance using SAS (3.1). The treatment means were tested for significant difference using the Tukey at p< 0.05.

**RESULTS**

**Shelf life**

The shelf life value of fruit was shown in Fig 1. Where the highest shelf life was observed when lemon essential oil incorporated into the pectin. The shelf life in this treatment was 23.24 days, which was 12 days more compared to control. Pectin + 0.5% and 1% orange essential oil increased shelf life 16.84 and 17.09 days compared to control (5.39 and 5.64 respectively). In addition, pectin increased shelf life 5.75 days compared to control, that did not have significant difference with pectin + 1% orange essential oil. It seems lemon essential oil was more efficient than orange essential oil (Fig 2.).

According to the result, the highest shelf life was observed when 1% and 0.5% lemon essential was incorporated to pectin. It can be because of semi-permeable lemon essential oil and pectin covering. Pectin changes CO2 and O2 concentration around the fruit and delays fruit ripening. Pectin application is reported on many fruit and vegetable such as carrot, papaya, tomato avocado and apple (Mohnen, 2008). Also lemon essential oil decrease Botrytis decay due to high concentration of limonene. In a research lemon and orange essential oil application decreased fungal decay until 40% (at 5 °C and 20 days) (Lombardo et al., 2016).
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**Figure 1**- Effect of different treatments on shelf life of strawberry on 12 day  
*(P= Pectin, OE= Orange Essential, LE= lemon Essential)*

**Total soluble solids**

Data analysis showed significant effect of time and treatment on TSS (Table 1). According to the result, the highest TSS belonged to the interaction of third day and control treatment (6.6%). Fruit TSS curves showed upward turn from harvest day to the last measurement day. Totally TSS increased by time passing, but this increase was slower in pectin and citrus essential oil. So, at the end of storage the lowest TSS was observed in pectin + 0.5% orange essential oil (6.98%) (Fig. 3).

It seems TSS increasing is because of respiration during storage period. Starch coating reduce TSS consumption in fruit compared to non-coated strawberries because of respiration decrease by reducing gas exchange (Mali and Grossmann, 2003). Other reasons for TSS increase are degradation of carbohydrate, other material changing such as acids, increasing soluble pectin and fruit corruption (Oms-Oliu et al., 2008). Fruit TSS increasing and titratable acid reducing during fruit ripening is one of the fruit maturity indicators (Mali and Grossmann, 2003). Result of present research is according to the other research about pectin, chitosan coating on strawberry fruit (Treviño-Garza et al., 2015).
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Figure 2- Effect of different treatments on strawberry shelf life during storage (P= Pectin, OE= Orange Essential, LE= lemon Essential).
The data includes mean ± of SE of 3 replications. Dissimilar letters show significant difference at P <0.05

Total acidity

The result of variance analysis showed the main effect and interaction between time and treatment for total acidity was significant (P < 1%) (Table 1). Total acidity decreased during storage period. Based on mean comparison the highest total acidity (0.85%) was observed in pectin + 1% lemon essential oil in the first stage of storage, which reduced in comparison with harvest day. There was no significant difference between pectin and pectin + 1% orange essential oil in the middle stage of storage (0.76% and 0.71% respectively). In the end of storage period the highest and lowest total acidity belong to pectin + 1% lemon essential oil (0.75%) and control (0.4%) respectively. Also there was no significant difference between pectin + 0.5% lemon essential oil and pectin + 1% orange essential oil (Fig. 4).

Total acidity (Fig.4) decreased during storage period at 5 °C and this decrease in control treatment was very severe. However, pectin + citrus essential oil reduce decreasing trend. Acidity decreasing links to its consumption in Krebs cycle and acidity decrease reflect fruit ripening. Citric acid is a predominant acid in strawberry that its concentration depends on the variety (Thanaraj et al., 2009). Some of researcher have expressed that total acidity decreasing is due to respiration and citric acid converting to other material during storage period (Rapisarda et al., 2008). Our results are consist with Oms-Oliu et al (2008) and Treviño-Garza et al (2015) that are about cut-cantaloupe coated with 2% pectin and strawberry coated with 3.5 % pectin at 4 °C for 15 days.
Figure 3: Effect of interaction between different times and treatments on strawberry total soluble solids during storage (P= Pectin, OE= Orange Essential, LE= lemon Essential). The data includes mean ± of SE of 3 replications. Dissimilar letters show significant difference at P <0.05.

Figure 4: Effect of interaction between different times and treatments on strawberry total acidity during storage (P= Pectin, OE= Orange Essential, LE= lemon Essential). The data includes mean ± of SE of 3 replications. Dissimilar letters show significant difference at P <0.05.
pH

The result showed the main and interaction effect between time and treatment for pH were significant (P < 5%) (Table 1). Result showed highest pH was observed in control at the early stage of storage (6.98%). In the middle of storage period ant at the end of experiment the lowest pH were observed in pectin + 1% lemon essential oil (6.12% and 5.97 % respectively). In addition, there was no significant difference between pectin and pectin + 0.5% and 1% orange essential oil. pH changing trend may be as a result of biochemical changing that in control treatment was more than pectin + lemon essential oil. pH increasing during storage period can be as a result of organic acid oxidation. In the present research, citrus essential oil + pectin decreased pH-changing trend. In a research 1% pectin did not have significant effect on raspberry pH at 0.5 °C for 7 days (14). 1.5 % pectin application at 27 °C to 34 °C increased strawberry jelly shelf life for 6 months, and increased pH slightly (Hernandez-Munoz et al., 2008).

![Figure 5](image)

**Figure 5-** Effect of interaction between different times and treatments on strawberry pH during storage(P= Pectin, OE= Orange Essential, LE= lemon Essential). The data includes mean ± of SE of 3 replications. Dissimilar letters show significant difference at P <0.05.

Antioxidant activity

Analysis of variance showed main effect and interaction between treatment and times were significant for antioxidant activity (P < 1%) (Table 1). Antioxidant activity reduced during storage period but changing trend in control was more than coated fruit. There was no different between pectin and pectin + 0.5% and 1% orange essential oil in the middle of storage period. Pectin + 0.5% and 1% lemon essential oil had the highest antioxidant activity at the end of storage period (Fig. 6). During storage, antioxidant activity decreases due to cell protection against the damage caused by free radicals. Pectin coating decrease respiration rate and free radical production by moisture maintenance and CO₂ and O₂ exchange control. The antioxidant activity maintenance promoted by using chitosan was also observed by Perdones et al. (2016).
Weight loss

Analysis of variance showed main effect and interaction between treatment and time were significant for weight loss (Table 1). Result showed pectin enriched with citrus essential oil has been successful in reducing weight loss from harvest day to twelfth day (Fig. 7). According to obtained result the highest weight loss was observed in control (3.48%) and pectin + 1% orange essential oil (3.34%). There was no significant difference between pectin and pectin + 0.5% and 1% orange essential oil in the middle of storage period. The lowest weight loss was obtained from pectin + 1% lemon essential oil (2.23%) (Fig. 7). Fruit weight loss during storage period is an important factor affecting product quality. So losing a significant amount of water and fruit weight caused fruit decay in the storage first weeks. One of the important aims of covering is controlling the weight loss. The use of pectin, sorbitol, and mono glyceride in mango showed that 1% pectin increased fruit shelf life more than 2 weeks, kept microbiological, chemical and sensory profile of fruit and decreased weight loss during 6 months storage (Moalemiyan et al., 2012). Present results are matched with Pagliarulo et al (2016) and Colla et al (2006) who reported enriched cover decreases weight loss.
Figure 7: Effect of interaction between different times and treatments on strawberry weight loss during storage (P= Pectin, OE= Orange Essential, LE= lemon Essential) The data includes mean ± of SE of 3 replications. Dissimilar letters show significant difference at P <0.05.

CONCLUSION

Obtained result from present study showed enriched pectin with lemon essential oil was more effective way to increase strawberry shelf life and storage time compared with control. Pectin + lemon essential oil increased strawberry shelf life 12 days more than control. Also pectin enriched with orange essential oil was the lower level than combination of pectin and lemon essential oil. Finally, to use pectin and citrus essential oil, it is suggested that use them in the form of edible coating or sterile gas. So, they can be use in controlled atmosphere storage in the commercial level. Micro capsulation technique to prevent gas escape and heat effect is globally investigating. This technique increases essential oil effect and crop shelf life.

REFERENCES

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