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Shelf life Improvement and Postharvest Quality of Cherry Tomato (*Solanum lycopersicum L.*) Fruit Using Basil Mucilage Edible Coating and Cumin Essential Oil

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Abstract

The aim of this study was to improve tomato storability by testing the effect of a novel edible coating with basil mucilage, cumin essential oils and mixture of basil mucilage and cumin essential oil on tomato postharvest quality. A set of untreated control and treated fruits were stored at 20 °C and 80–90% RH for 9 days. The tomatoes were randomly sampled and their physico-chemical parameters were evaluated at the end of the period specified. As the storage progressed a general declining trend in the TSS was observed for all treatments except for tomatoes treated with essential oils. Titratable acidity significantly decreased as a function of storage time for all studied treatments. Basil gum coating treatments was the most effective of all coating showing a lowest weight loss after 9 days from storage. In our study, coating treatments has not made statistically great impact to maintain firmness. During the post treatment storage the tomatoes treated with basil gum displayed higher significant impact on 'L*' 'a*' and 'b*' (P<0.05) color rating values in comparison with other treated and untreated. In tomato samples treated with BGC+Cumin Essential oil, the 'a*/b*' ratio showed a decreasing trend with the progress in storage time and for other treatments the trends were in progressing manner. Sensory evaluation proved the efficacy of essential oils and combined BGC + Cumin Essential oil coating by maintaining the overall quality of tomato fruit during the storage period. The results suggest that by using basil gum as an edible coating, the weight loss can be delayed and the storage life of tomatoes stored at 20 °C can be extended.

KeyWords: Coating, Firmness, Oil, Quality, Tomato, Tss.

Introduction

Fruits and vegetables are highly perishable products particularly once they have been harvested. Being metabolically active, they tend to lose energy reserves through respiration and water through transpiration. In addition to the biochemical changes, there may be losses in quality through mechanical damage, pests and diseases, as well as physiological disorders induced by high or low temperatures or incorrect storage atmosphere. Improving the existing practices of handling and storage as well as developing techniques in order to maintain post-harvest quality has always been a challenge to the researchers (Debeaufort et al., 1998). In this regard, treating fresh fruits and vegetables with edible coating is an important approach that holds promise for the extension of storage life of fresh horticultural crops. The purpose is to extend the shelf-life of produce and to provide a barrier against hazards, retard moisture migration, reduce respiration rate and delay changes in textural properties. Essential oils are concentrated, hydrophobic liquid containing volatile aromatic compounds extracted from plants. They were previously reported to have biological activities (Lee et al., 2007) and have shown a potential to controlling postharvest quality. Cumin (*Cuminum Cyminum* L.) is an aromatic plant in the family Apiaceae. Its fruit, known as cumin seed is a lateral fusiform with abundant content of essential oils.

Tomato (*Lycopersicon esculentum* L) is both qualitatively and quantitatively a worldwide important vegetable, with an annual estimated production of 88 million tones. Under ambient conditions tomato ripens rapidly before becoming excessively soft and no longer marketable. Low temperature storage is effective in reducing the rate of these changes, delaying the ripening and control of postharvest decay while high humidity conditions protect the produce from water loss and shriveling. However, in the case of tomatoes, it is not possible to exploit low temperatures as the crop is susceptible to chilling injury (Morris, 1982). Edible coatings generate a modified atmosphere by creating semi-permeable barrier against hazards. Many studies have shown that coating treatment has the potential to be used as a protective treatment for reducing respiration, water loss and biochemical reaction rates. The role of coating treatment in extending postharvest qualities has been demonstrated in tomatoes (Asgar Ali et al., 2010; Zapata et al., 2008), apple fruits (El-Anany et al., 2009) and other fruits and vegetables. However, there is not yet any published study on the application of basil gum as an edible coating for developing storage life of tomato. The present work is planned to evaluate the impact during post-treatment storage of coated treated tomato to develop the characteristics associated with the optimum quality.

Material and Method

Plant material

Tomato fruits (*Solanum lycopersicum L.*) were obtained from Kajire Agro-industry (Khorasan Razavi, Mashhad), which were uniform in size, color and firmness. Tomatoes were surface disinfected by immersion in commercial bleach solution for 10 min, washed and dried under laminar flow hood. Then, fruits were sorted, divided and stored as coated with basil gum, cumin seed essential oils, basil gum + cumin seed essential oil and water as control in four equal lots.

Basil Gum Coating and other coating treatments

The basil seeds were carefully cleaned removing dusts, stones and chaffs. The gum extraction conditions were as follows: 50 ºC temperature, pH 7, 20 min soaking time and a water ⁄ seed ratio of 50:1. A soaking time of 20 min was selected based on Razavi et al. (2009).The seeds were rinsed with given volume of water in a short time and mixed with water (in a given ratio of water ⁄ seed) at a specific pH and temperature and enough time was given to reach the stage where the seeds were completely swelled (20 min agitation, 1000 rpm). Gum separation from the swelled seeds was done by passing the seeds through an extractor (Pars Khazar 700P, Rasht, Iran) with a rotating rough plate that scraped the gum layer on the seed surface. The separated gum was collected and the residual gums adhered to the seeds was subjected to immersion in water and the rotating extractor. This procedure was done four times. The collected gum from the different stages was mixed, filtered (by a cheese cloth) and dried by vacuum oven at 50 ºC. Finally, the dried extracted gums were then ground and packed in the plastic bags and stored under dry and cool conditions. Fruit were immersed in concentration of 10% basil gum coating solution for 2–3min and the coating solution was applied uniformly on the whole surface, while control fruit were dipped in purified water.

Mixed solution of cumin essential oil and basil seed gum was prepared adding pure cumin seed essential oil at 20% w/v to basil seed gum solution.

Total Soluble Solids (TSS)

The TSS of tomatoes was measured at room temperature using a hand held refractometer (Fisher Scientific Ltd., Ontario, Canada). The tomatoes from each treatment were ground in a blender and a drop of clear juice was placed in the chamber and the reading was expressed in ^{o}B. The machine was standardised using purified water before readings were taken. The readings were averaged for each replication value.

Titrable Acidity

The Titratable acidity of an aliquot was determined by titration against 0.1N NaOH until a pH value of 8.1 was reached. Titratable acidity is expressed in terms of citric acid as mg per 100 g of fresh fruit.

Weight Loss Percentage

Tomato samples (10 fruit per replication) were weighed at day 0 and at the end of each storage interval. The difference between initial and final fruit weight was considered as total weight loss during that storage interval and calculated as percentages on a fresh weight basis by the standard AOAC (1984) method.

Firmness/ texture

Fruit firmness was determined by measuring the amount of force (Kg) to puncture a hole in the fruit on each sampling day, using an Instron Universal Testing Machine with 6.00mm plunger tip interfaced with a computer. The machine was set for maximum compression with a speed of 20mm/min as in Zapata et al., (2008).

Color

Color was measured using computer vision system. The system comprised of a digital camera (Canon A550, Taiwan), image-capturing box and image analysis software (Clemex Vision Professional, PE4, Longueuil, Canada). A sample holder was placed at the bottom of the box which was covered with a white translucent background. The digital camera was fixed 25 cm above the sample. Lighting system consisted of two fluorescent lamps (Farhad lightening 10W, 0.09A, Mashhad, Iran) which were turned on for 10 min before image-capturing. Image processing and further operations were performed in Windows XP environment with Imagej software (version 1.4Og). Color space convertor from R*G*B* to L* a* b* was carried out using color space convertor plug-in, inside the program. Statistical parameters of L*, a* and b* values were extracted from converted image. The color of tomatoes was objectively determined in terms of the tristimulus color values L*, a* and b*, where, luminance (L*) forms the vertical axis, which indicates whiteness to darkness. Chromatic portion of the solids is defined by: a* (+) redness, a* (-) greenness, b* (+) yellowness and b* (-) blueness.

Overall acceptability

Sensory evaluation of the fruit for pulp colour, texture, flavor and appearance as a factor of overall acceptability was tested during the storage period using the method of Bai et al. (2003). Based on their consistency and reliability of judgment, a panel of seven judges with age ranging from 25 to 30 years was set up. Panelists were asked to score the difference between samples where 0–2 represented extreme dislike; 3–5 fair; 6–8 good; and 9 excellent.

Statistical Analysis

Data were analyzed using the General Linear Models procedure of the statistic 9.1 software package. Analysis of Variance (ANOVA) was performed to determine the significance of the main effects (treatment, storage time). Significant ($P<0.05$) differences between means were identified using the Least Significant Difference procedure.

Result and Discussion

Total Soluble Solids (TSS)

TSS is an indirect indication of the level of soluble sugars and therefore sweetness (Saltviet, 2005). According to the results total soluble solids of tomatoes was not found to be affected by any of coating treatments. However, as the storage progressed a general declining trend in the TSS was observed for all treatments except for tomatoes treated with essential oils (Table1). The increase in TSS is mostly due to the modification in structural carbohydrates, that is the cell wall composing substance such as pectin, hemicelluloses and also due to conversion of organic acids. The changes in TSS were significantly influenced by the duration of storage ($P<0.05$, Table1). In yet other studies gradual decrease in TSS of tomatoes with the storage time has been reported (Artés et al., 1998; Kagan-Zur and Mizrahi, 1993).

Titrable Acidity

Organic acids are the major taste components in tomatoes. In general, the levels of acids decline during ripening (Ulrich, 1970). Titratable acidity significantly decreased as a function of storage time for all studied treatments (Table 2). All the treatments applied were also found to be significant with basil gum. Combination of gum and essential oil showed statistically similar behavior during 6 day of storage in most of the other treatments. A significant reduction of titratable acidity of tomatoes following increase in storage period relates to their utilization in metabolic activity and decline in the level of reserve source of acids. Acids can be considered as reserve source of energy to the fruit and would therefore be expected to decline during the greater metabolic activity that occurs due to their utilization as respiratory substrates (Wills et al., 1989; Ulrich, 1970). This is prominently visible when we look at the acidity level of tomatoes at the start of the experiment. The results of the present study are in agreement with the outcome of Asgar Ali et al. (2010) who observed a lower titratable acidity in treated tomatoes than the control fruits.

Weight Loss Percentage

In order to determine any weight loss during the storage of the fruits, both treated and untreated fruits were weighed 0, 3, 6, 9 days after treatments. Weight loss percentage increased significantly with the prolongation of the storage period for all treatments (Table 3). Normally, the weight loss occurs during storage due to its respiration process, the transference of humidity and some process of oxidation (Ayranci et al., 2003). However, the all treatments significantly reduced the weight loss of tomatoes during storage compared to control (Table 3). In this study significant difference in weight loss of fruits was observed due to the effects of treatments and days of storage and interaction effects of treatments and day 6 and 9 of storage. However, basil gum coating treatments was the most effective of all coating showing a lowest weight loss after 9 days from storage. This reduction in weight loss was probably due to the effects of the coating as a semi-permeable barrier against O_2, CO_2, moisture and solute movement, thereby reducing respiration, water loss and oxidation reaction rates. A similar effect was observed by Ben-Yehoshua (1969) for oranges coated with wax and those of Banks (1984), who reported that sucrose ester-based coatings on banana fruit extended their storage life.

Firmness/ texture

The texture of tomato is a major quality feature. Texture in tomato is a function of the skin toughness, the flesh firmness, and the ratio of firm radial pericarp to the internal locular gelatinous material. The proportion of these tissue types influences the propensity toward firmness or softness in the fruit (Frenkel and Jen, 1989). Sufficient softening is necessary to lend the fruit's edibility and to release the cell content during chewing for the olfactory perception of the fruit aroma and flavor. It is commonly accepted that consumer preference is for firm fruit which do not lose juice during eating or slicing (Frenkel and Jen, 1989).

In our study, as revealed by the puncture test values of different coating treatment, it has not made statistically great impact to maintain firmness. However, in some reports coating treatments delayed the softening of whole tomato significantly during storage (Asgar Ali et al., 2010; Park et al., 1994). Our results showed a significant difference between applied coating treatments and control samples and between all day of storage (P<0.05, Table 4). There was a drastic decrease in the firmness of fruits after 3 day of storage in all treatments when compared to the firmness of tomatoes on the day just before the start of the experiment (Table 4). The peak values of puncture test forces were larger in Basil Gum Coating treated fruits than those seen for the others until 6 day storage. However, at the final storage time, Essential oils treated tomatoes were firmer in texture indicating a significantly higher puncture test (maximum load) values in tomatoes.

Generally, the firmness decreased with increase in the storage period. Similar observations with respect to firmness reduction during storage were made by Asgar Ali et al., 2010 that could arise from one of the three mechanisms: loss of turgor; degradation of starch; or breakdown of the fruit cell walls (Tucker, 1993).

Color

L*, a*, b*

Fruit color is probably the most important attribute that determines overall quality as it affects consumer perception. The average initial Hunter tristimulus 'L*', 'a*' and 'b*' color values for tomatoes on their arrival to the laboratory (day 0) were 34.4, 46.5, 41.6, respectively. However, during the post treatment storage the tomatoes treated with Basil Gum displayed higher significant impact on 'L*' 'a*' and 'b*' (P<0.05) color rating values in comparison with other treated and untreated (control samples). Also, the duration of storage was found to have significant influence on 'L*' 'a*' and 'b*' values after 6 and 9 days of storage (P<0.05).

The interaction of storage time and treatments for all color values showed significant outcome with higher effect of eesential oils after 9 day storage. The mean 'L*', 'a*' and 'b*' color values recorded for treated and control samples were close to each other (Table 5, 6, 7) (Having the reducing trends). A delay in color change due to treatments has been reported in tomato (Asgar Ali et al., 2010). In their study, coating of tomatoes with gum arabic delayed colour change, which was probably due to an increase in CO_2 and decrease in O_2 levels.

a*/b* ratio

The parameter a* is a very good measure of the degree of ripeness in tomato as it measures redness while the value of b* measures yellow discoloration (Artés et al., 1999). The ratio was found to be significantly affected by basil gum coating alone and simultaneous application of BGC and Essential oil (P<0.05). During 6 day of storage samples behaved significantly different with respect to 'a*/b* values among themselves (P<0.05) and statistically similar on 9 day of storage (Table 8)

In tomato samples treated with BGC+ Essential oil, the 'a*/b*' ratio showed a decreasing trend with the progress in storage time and for other treatments the trends were in progressing manner (Table 8). The ratio was much higher in control fruits compared to other treated counterparts on account of their bigger 'a*' values.

Sensory Evaluation

Both storage time and applied treatments affect the total acceptance of tomato fruit. As expected general acceptance of tomato fruits decrease during storage and scores dropped (Fig 1). Sensory evaluation of treatments coated with essential oils and combined coating with gum and essential oils revealed higher scores than untreated fruits and gum coating treatment until last days of storage. Another report (Asgar Ali et al., 2010) observes that compared with 10% gum arabic, control fruit and fruit treated with 5% gum arabic had lower scores for overall acceptability. Similar results were observed by El-Anany et al. (2009) when they treated 'Anna' apples with gum arabic coating.

Conclusion

The earliest application of edible coating in the field of post harvest technology of fresh fruits and vegetables has been emphasized mainly to control their quality parameters. In conclusion, the presented study indicated that basil gum coating treatments was the most effective of all coating showing a lowest weight loss and displayed higher significant impact on 'L*' 'a*' and 'b*' color rating values in comparison with other treated and untreated. Titratable acidity significantly decreased as a function of storage time for all studied treatments. However, TA, TSS and firmness were not found to be affected by any of coating treatments. In fact the objective firmness values were higher for the control fruits than the coating treated fruits. Sensory evaluation of treatments coated with essential oils and combined coating with gum and essential oils revealed higher scores than untreated fruits and gum coating treatment until last days of storage.

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Table1. Effect of different treatments on tomato fruit TSS during storage

Treatment	TSS			
	0	3	6	9
Control	7.3±0.4^{b}	7.97±0.05^{a}	6.7±0.6^{a}	6±4.3^{a}
Essential oil	7.43±0.2^{b}	6.3±1.4^{b}	7.23±0.23^{a}	8±0.01^{a}
Basil Gum Coating	7.1±1.08^{b}	6.6±1.45^{ab}	6.67±0.41^{a}	6±0.01^{a}
Gum+Essential oil	8.97±0.68^{a}	7.4±0.53^{ab}	6.4± 0.53^{a}	6.07±0.1^{a}

Means in the same column that do not share a common letter differ significantly ($p<0.05$).

Table2. Effect of different treatments on tomato fruit Acidity during storage

Treatment	Acidity			
	0	3	6	9
Control	0.94±0.01^{a}	1.01±0.07^{a}	0.71±0.0^{a}	0.76±0.01^{a}
Essential oil	0.72±0.09^{b}	0.44±0.04^{c}	0.48±0.0^{c}	0.46±0.05^{a}
Basil Gum Coating	0.68±0.03^{b}	0.75±0.09^{b}	0.6±0.03^{b}	0.6±0.09^{ab}
Gum+Essential oil	0.66±0.02^{b}	0.64±0.04^{b}	0.68±0.0^{b}	0.56±0.03^{b}

Means in the same column that do not share a common letter differ significantly ($p<0.05$).

Table 3. Effect of different treatments on tomato fruit weight loss during storage

Treatment	L*			
	0	3	6	9
Control	34.4±1.5[a]	30.4±1.7[a]	28.97±2.1[a]	22.6±1.[b]
Essential oil	26.9±1.7[b]	26.1±1.4[b]	26.3±2.1[b]	24.6±2.[a]
Basil Gum Coating	21.7±1.3[d]	26.5±1.7[b]	21.9±1.1[c]	21.1±1.[c]
Gum+Essential oil	25.4±0.89[c]	28.14±1.[ab]	25.2±0.84[b]	22.6±1.[b]

Means in the same column that do not share a common letter differ significantly (p<0.05).

Table4. Effect of different treatments on tomato fruit firmness during storage

Treatment	% Weight loss			
	0	3	6	9
Control	0[a]	9.37±0.01 [a]	11.76±0.05[c]	30.67±0.07[a]
Essential oil	0 [a]	5.71±0.01[b]	13.15±0.02[b]	21.14±0.04[b]
Basil GumCoating	0 [a]	5.71±0.03[b]	14.7±0.01 [a]	15.01±0.02[d]
Gum+Essential oil	0 [a]	2.94±0.06[c]	5.71±0.09[d]	18.94±0.01[c]

Means in the same column that do not share a common letter differ significantly (p<0.05).

Table5. Effect of different treatments on tomato fruit L* during storage

Treatment	Firmness			
	0	3	6	9
Control	0.87±0.1[c]	1.13±0.1 [a]	0.56±0.1 [b]	0.5±0.01 [b]
Essential oil	1.27±0.2[a]	1.13±0.2 [a]	1.1±0.1 [a]	0.83±0.05 [a]
Basil Gum Coating	1.26±0.1[a]	1.6±0.2 [a]	1.2±0.1 [a]	0.57±0.05 [b]
Gum+Essential oil	1.1±0.1[b]	1.2±0.4 [a]	1.13±0.2 [a]	0.73±0.15 [a]

Means in the same column that do not share a common letter differ significantly (p<0.05).

Table 6. Effect of different treatments on tomato fruit a* during storage

Treatment	a*			
	0	3	6	9
Control	46.5±1.6[a]	48.5±1.5[a]	44.3±2.7[a]	33.1±1.4[b]
Essential oil	41.7±1.4[b]	36.6±1.4[c]	34.6±1.7[c]	36.9±2.5[a]
Basil Gum Coating	37.4±1.7[d]	40.7±1.2[b]	33.8±0.83[c]	32.7±1.2[b]
Gum+Essential oil	39.24±0[c]	40.68±1.[b]	37.9±0.88[b]	33.3±1.6[b]

Means in the same column that do not share a common letter differ significantly (p<0.05).

Table 7. Effect of different treatments on tomato fruit b* during storage

Treatment	b*			
	0	3	6	9
Control	41.6±1.9[a]	41.9±2.[a]	37±2.7[a]	24.6±1.6[b]
Essential oil	33.6±1.7[b]	30.9±1.[c]	30.8±1.8[b]	29.8±2.6[a]
Basil Gum Coating	29±1.5[d]	32.5±1.[b]	27.4±0.9[c]	25.4±0.9[b]
Gum+Essential oil	31.4±1.04[c]	32.97±1[b]	30.03±0.96[b]	27.73±1[ab]

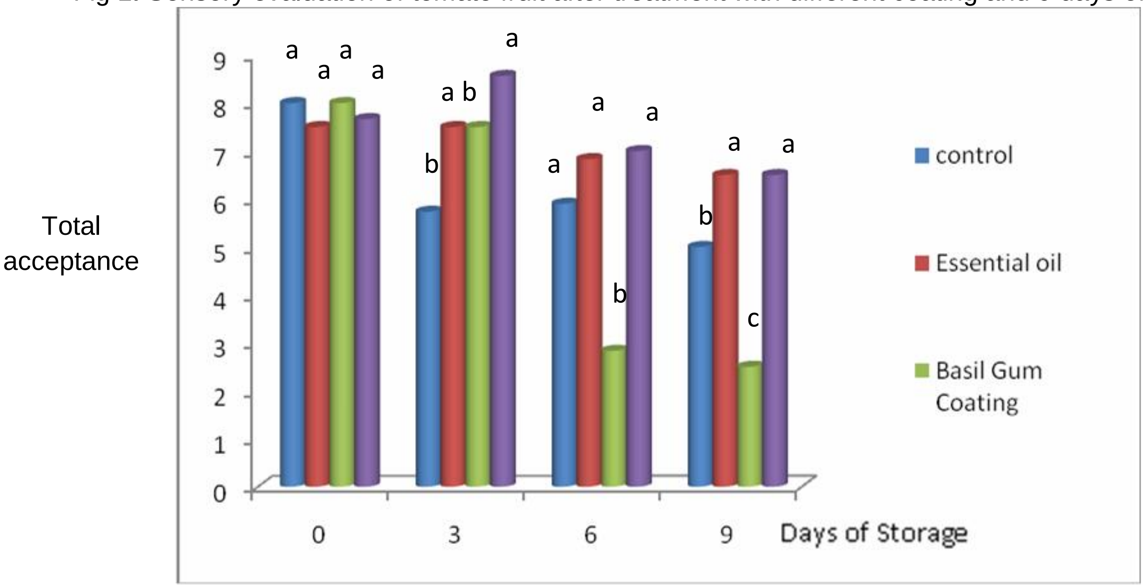
Means in the same column that do not share a common letter differ significantly (p<0.05).

Table 8. Effect of different treatments on tomato fruit a* / b* ratio during storage

Treatment	a*/b* ratio			
	0	3	6	9
Control	1.12±0.01[d]	1.6±0.03[c]	1.2±0.15[a]	1.34±0.0[b]
Essential oil	1.24±0.02[c]	1.18±0.01[b]	1.12±0.01[a]	1.25±0.1[a]
Basil Gum Coating	1.29±0.01[a]	1.25±0.03[d]	1.23±0.01[b]	1.28±0.0[a]
Gum+Essential oil	1.25±0.01[b]	1.23±0.01[a]	1.26±0.01[a]	1.2±0.01[a]

Means in the same column that do not share a common letter differ significantly (p<0.05).

Fig 1. Sensory evaluation of tomato fruit after treatment with different coating and 9 days of storage



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