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The Effect of Edible Coating on the Quality Attributes and Shelf Life of Persimmon Fruit

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ABSTRACT

In this study, the effect of edible coating materials (carboxy methyl cellulose and sodium alginate) on different quality criteria and shelf life of persimmon fruits during storage at 5°C for 15 day was evaluated. The results revealed that coating of persimmon fruits with edible degradable coating films (CMC or Alginate) improved their quality attributes and prolonged the shelf life during cold storage as compared with control sample (uncoated). Moreover, the present results indicated that the coated samples exhibited good sensory properties (especially those treated with sodium alginate) even after storage for 15 day. While, the control sample was less acceptability ($P<0.05$) and spoiled at 12 day of storage.

Key words: Edibles coatings, carboxy-methylcellulose, sodium alginate, antimicrobials, essential oil, Persimmon fruit

Introduction

Fruits and vegetables are vital parts of the diet and a rich source of bioactive compounds including dietary fiber, natural antioxidants and various phytochemicals (Butt *et al.,* 2015 and Caruso *et al.,* 2015). The individual phytochemicals that have been recognized are about 5000 in number, but large numbers of them are still unknown or unidentified (Liu, 2003). Most bioactive compounds (phytochemicals, phenolic and carotenoids) are nonnutritive but effective against different diseases (Dauchet, 2006) as they play important roles as chemopreventive or chemotherapeutic agents (Rates, 2001).

Among these fruits, persimmon is popular and widespread fruit that is enriched with many bioactive compounds, including polyphenols, terpenoids, steroids, flavonoids, carotenoids, minerals and dietary fiber (Karaman *et al*., 2014). Some components like phenolics, antioxidants, sterols, and flavonoids have a beneficial effect on human health owing to their ability to prevent or control various ailments (Dauchet, 2006). These bioactive components play an important role in reducing arterial stiffness and prevent oxidation of low-density lipoproteins (LDL) thus resulting in the prevention of atherosclerotic plaque formation (Suzuki, 2010). Many phytochemicals also possess antimutagenic effects and regulate and trigger the immune system, thus resulting in the normal functioning of metabolism (Buttand, 2009). A number of them also serve as chemopreventive (Raskin, 2002), anticancer, anti-inflammatory, and immunomodulatory agents (Miller, 2004).

Edible polymers such as polysaccharide, protein and lipid are the three main ingredients used to produce edible films. In many instances two or all of these ingredients are blended to produce composite edible films. Both polysaccharides and protein films have poor moisture barrier because of their hydrophilic properties. Lipid based edible films have good moisture barrier, but low mechanical properties due to their hydrophobic structures. The manufacture and use of composite films help to minimize the disadvantages of the individual components while making use of the strength in their properties (Hernandez-Izquierdo and Krochta, 2008).

Edible coatings, a new strategy to extend shelf life and improve food quality of whole fruits and fresh-cut fruits, have been applied to many products. They can provide a selective barrier to moisture, oxygen, and carbon dioxide gas transfer, which slows ripening, reduces moisture loss and helps to maintain fresh aroma and flavor (Olivas and Barbosa-Canovas, 2005). Edible coatings are also used as carriers of active ingredients, such as anti-browning, antimicrobial, and texture enhancing compounds, as well as flavors and nutrients, to improve the quality, safety and nutritional value of fresh-cut fruits (Rojas-Grau *et al.,* 2009).

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Incorporating antimicrobial compounds into edible films or coatings provides a novel way to improve the safety and shelf-life of ready-to-eat foods (Cagri *et al.,* 2004). The use of edible coatings with certain additives, such as those with essential oils (EOs) incorporated, has been particularly highlighted over the years, because of its effect on extending the shelf life and facilitating the processing and consumption of food (Sung *et al.,* 2013).

Therefore, this study was designed to evaluate the effect of edible coatings on the quality criteria and shelf life of persimmon fruits during storage at cooling temperature.

Materials and Methods

Materials:

Persimmon fruits (*Diospyros kaki* L.) were obtained from a local market during season of 2017. The substances used in this experiment were carboxy methyl cellulose (CMC) and sodium alginate which purchased from Morgan Company for Chemicals, Cairo, Egypt), glycerin, sodium hydroxide and sodium hypochlorite from El-Gomhouria chemical comp., Cairo, Egypt. Sunflower seed oil was purchased from the local market at Giza, Egypt. Marjoram oil was purchased from National Research Center, Cairo, Egypt.

Methods:

Experimental Treatments:

Preparation of persimmon fruits:

Persimmon fruits were sorted and selected for their uniformity, maturity stage, size, color, external appearance and absence of damage and fungal infection. The fruits were washed using chlorinated water (200 ppm) for 2 min. and then left to dry at room temperature for about 1 h before coating

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Preparation of edible coating and films with essential oil treatments:

Carboxy-methylcellulose (CMC): CMC coating was prepared by mixing 10 gm CMC and 5 mL glycerin in 10 mL alcohol 95 plus 2000 ml of distilled water. Solution pH was adjusted to pH 7 using 1 ml citric acid and 10 NaOH solution. Then the solution was heated at 75°C for 15 min using a heating magnetic stirrer according to Lin and Guong (2008). In this trail, the described film formation solution mentioned above was modified by emulsified with sunflower oil (0.050 g/100 ml coating solution) and add marjoram oil (0.5 ml/100 ml coating solution).

Sodium alginate: Alginate coating was prepared according to Rojas-Grau et al. (2007). 2 gm of sodium alginate was dissolved in 100 ml sterilized distilled water and heated at 70°C, until the solution became clear. After cooling, glycerol was added as plasticiser to a final concentration of 1.5 g/100 ml solution. The solution was emulsified with sunflower oil (0.050g/100 ml coating solution) at 24,500 rpm for five min., before pH adjustment to 5.6 by using 50 (w/v) citric acid. The solution was modified by adding marjoram oil (o.5 ml/100 ml coating solution). The persimmon samples were coated with CMC and alginate coating solution before and after addition of marjoram oil after that storage at room and cooling temperature.

Analytical Methods:

Determination of total soluble solids (TSS):

Total soluble solids was determined by the refractometric method at room temperature using an Abbe refractometr (carl-zeiss jena) in juice pressed from a sample of homogenized fruit and vegetable slices, according to Konopacka and Plocharski (2004).

pH measurement:

A digital pH meter (Fisher scientific accumet ® pH meter 25 USA) was used for pH measurement, 10 gm sample with 50 ml distilled water were blended for 2 min., according to the method described by A.O.A.C. (2000).

Determination of total titratable acidity:

Total titratable acidity was measured for fresh samples according to the method described by A.O.A.C. (2005). It was expressed as citric acid using sodium hydroxide N/10 and phynol phythaline as indictor.

Microbiological analysis:

Total plate count:

Total colony count of bacteria was estimated using plate count agar medium according to the procedures described by FAO/WHO (1995).

Psychrophilic bacterial count:

Psychrophilic bacterial count was estimated as described in typical procedure of the total bacterial count method, except incubation was carried out at 7ºC for 5 days in refrigerator according to A.P.H.A. (1976).

Molds and yeasts count:

The mold and yeast were determined using the methods for the microbiological examination of foods described by A.P.H.A. (1976).

Organoleptic evaluation:

Different products of fruits preserve were evaluated organoliptically as reported by Chen *et al.* (1999). The products were presented to trained 10 of staff from Food Science and Technology Department, Faculty of Agriculture, Cairo, Al-Azhar University for sensory evaluation .The panelists were asked for their decision concerning ,color, taste, odor, texture and overall acceptability. The following scale was applied for samples under investigation 9-10 equal excellent, 6-8 equal good 3-5 equal poor and 0-2 equal refused. So the score 5 was considered as the limit of acceptability.

Statistical Analysis :

All data of fresh fruit and vegetable samples were analyzed using SPSS (version 16.0 software Inc. Chicago, USA) of completely randomized design as described by Gomez and Gomez (1984). Treatment means were compared using least signification differences (LSD) at 0.05 levels of probability and standard error.

Results and Discussion

Total soluble solids (TSS):

The effects of coating process of fresh persimmon fruits and cold storage at 5°C for 15 day on total soluble solids (TSS) are shown in Table (1) and Fig. (1).

The total soluble solids of the control (uncoated) and coated persimmon fruits were gradually increased ($P < 0.05$) with increasing the storage period. TSS in the control sample increased from 15.5% at initial storage to 18.2% after 9 days of storage, whereas, TSS in coated samples reached to 17.8% for sample treated with CMC and 17.4% for sample treated with alginate at the 15th day of storage at 5°C. Where, the control sample was spoiled. According to (Wills *et al.,* 1980) The increase in TSS content during storage might result from hydrolysis of starch into sugars. On completion of starch hydrolysis, no further increase in sugar content occurred and subsequently the TSS content declined as the sugars were metabolized during respiration. Similar results were found by other studies that used coatings to extend the shelf life of some fruits (Duan *et al.,* 2011 and Silva *et al.,* 2011).

Table 1: Effect of cold storage periods at 5°C for 15 day on total soluble solids (%) of coated fresh persimmon

Storage period (day)	Treatments		
	Control	CMC	Alginate
0	15.5^{Da}	15.4^{Ea}	15.3^{Ea}
3	16.0^{Ca}	15.7^{DEa}	15.5^{Ea}
6	17.0^{Ba}	16.0^{CDb}	$15.8D^{Eb}$
9	18.2^{Aa}	16.4^{Cb}	16.2^{Cb}
12	-	17.1^{Ba}	16.8^{Bb}
15	-	17.8^{Aa}	$17.4A^{a}$

CMC: carboxy methyl cellulose; Alginate: sodium alginate. (-): spoiled.
Mean values in the same row (as a capital letter) or column (as a small letter) with the same letter are not significantly different (P> 0.05).

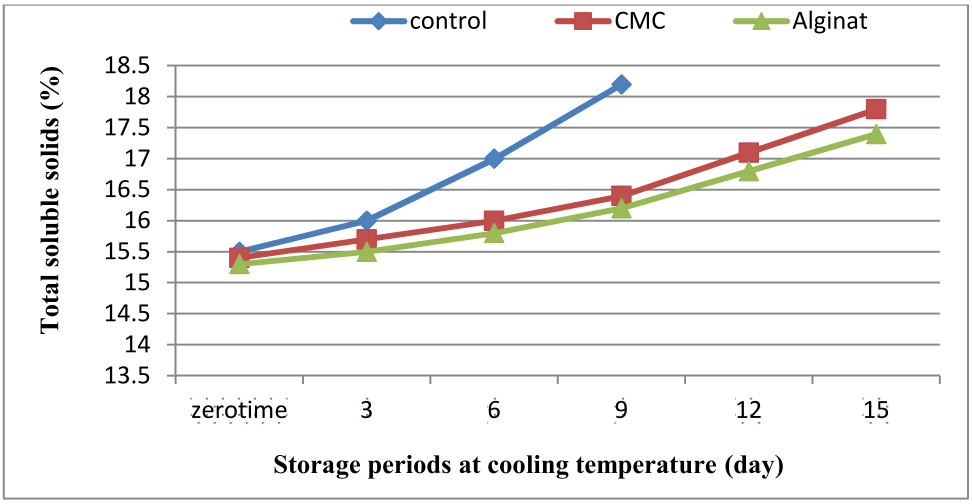

Fig. 1: Change in total soluble solids (TSS) of coated fresh persimmon during storage period for 15 day.

The effect of cold storage at 5°C for 15 day on pH values of coated fresh persimmon fruits was illustrated in Table (2) and Fig (2).

From the Table (2) and Fig (2), it could be observed that pH values recorded 5.35 and 5.33 for coated persimmon samples with CMC or alginate, respectively, against 5.36 for the control sample at zero time. On the other hand, pH values continuously increased ($P < 0.05$) in all samples during different storage periods. The pH values for coated persimmon samples were less than pH value of the control sample even after cold storage for 9 days. As the pH values for those samples after storage for 9 days recorded 5.67 and 5.54, respectively, against 6.12 for the control sample. It is worth mentioning that after 15 day of storage at 5°C, pH values of the coated persimmon samples with CMC or alginate were reached to 5.94 and 5.82, respectively. Where, the control sample was spoiled. El-Anany *et al.* (2009) reported that the organic acids (such as malic or citric acid) are primary substrates for respiration; a reduction in acidity is expected in highly respiring fruit. It is also considered that coatings reduce the rate of respiration and may therefore delay the utilization of organic acids (Yaman and Bayoindirli, 2002).

Table 2: Effect of cold storage periods at 5°C for 15 day on pH values of coated fresh persimmon

Storage period (day)	Treatments		
	Control	CMC	Alginate
0	5.36^{Da}	5.35^{Ea}	5.33^{Ea}
3	5.58^{Ca}	5.44^{Eb}	5.37^{DEb}
6	5.84^{Ba}	5.55^{Db}	5.43^{Dc}
9	6.12^{Aa}	5.67^{Cb}	5.54^{Cc}
12	-	5.78^{Ba}	5.66^{Bb}
15	-	5.94^{Aa}	5.82^{Ab}

CMC: carboxy methyl cellulose; Alginate: sodium alginate. (-): spoiled.
**Mean values in the same row (as a capital letter) or column (as a small letter) with the same letter are not significantly different (P> 0.05).*

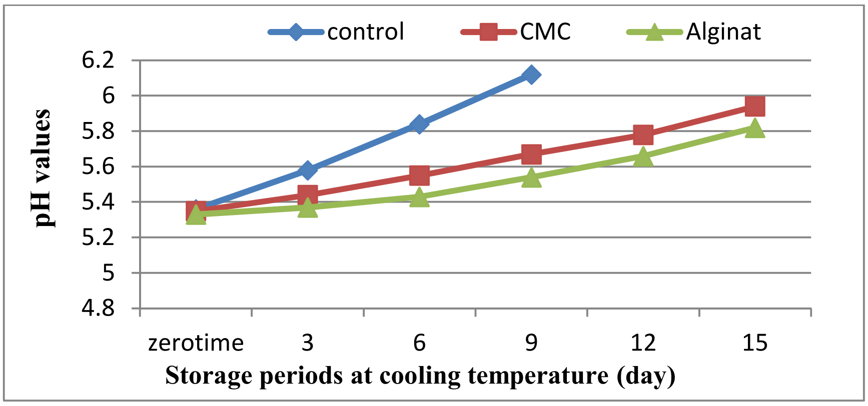

Fig. 2: Change in pH values of coated fresh persimmon during storage period for 15 day

The effects of coating process of fresh persimmon fruits and cold storage at 5°C for 15 day on titratable acidity (TA) are shown in Table (3) and Fig. (3).

The titratable acidity (TA) of the control and coated persimmon fruits (treated with CMC or alginate) were 0.40, 0.39 and 0.38%, respectively, at initial storage; and were gradually decreased ($P < 0.05$) with increasing the storage period. TA in the control sample decreased from 0.40% at zero time to 0.20% after 9 days of storage at 5°C, whereas, TA in coated samples reached to 0.23% for sample treated with CMC and 0.25% for sample treated with alginate at the 15th day of storage at 5°C. Where, the control sample was spoiled. However, others studies reported the total acidity reduction on the coated fruits during storage due to the fruit ripening what caused an organic acid consumption on the respiration (Danieli *et al.,* 2002), for example using coatings on blueberries, strawberries, apples and lychees (Duan *et al.,* 2011).

Table 3: Effect of cold storage periods at 5°C for 15 day on titratable acidity (%) of coated fresh persimmon

Storage period (day)	Treatments		
	Control	CMC	Alginate
0	0.40^{Aa}	0.39^{Aa}	0.38^{Aa}
3	0.35^{Aa}	0.37^{ABa}	0.37^{Ba}
6	0.28^{Bc}	0.34^{BCa}	0.35^{CDa}
9	0.20^{Cb}	0.31^{CDa}	0.33^{CDa}
12	-	0.27^{DEa}	0.29^{DEa}
15	-	0.23^{Fa}	0.25^{Fa}

CMC: carboxy methyl cellulose; Alginate: sodium alginate. (-): spoiled.
Mean values in the same row (as a capital letter) or column (as a small letter) with the same letter are not significantly different (P> 0.05).

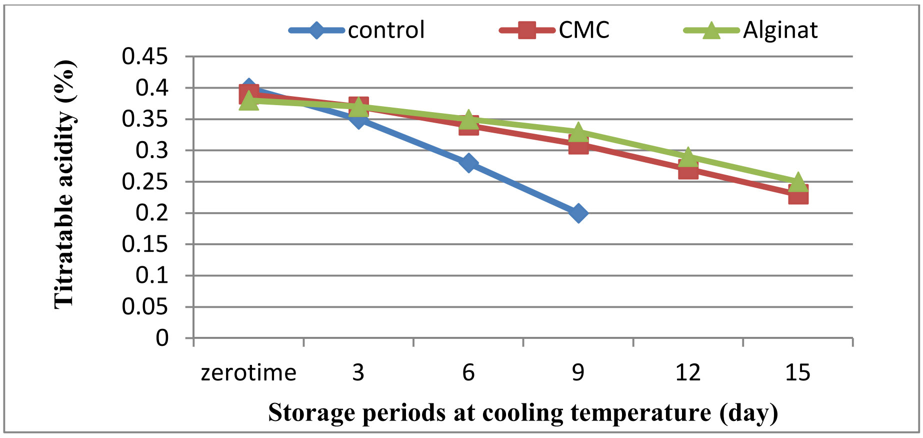

Fig. 3: Changes in titratable acidity (%) of coated fresh persimmon during storage period for 15 day

The effect of edible coating on the microbiological quality of persimmon fruit:

Total bacterial count:

Table (4) and Fig. (4) showed the change in total bacterial counts of coated and uncoated persimmon during storage period at cooling temperature.

The Table indicated that the total plate counts (TPC) recorded 1.62 and 1.40 log cfu/g for coated persimmon samples with CMC or alginate, respectively, against 2.47 log cfu/g for the control sample (uncoated) at zero time. On the other hand, these counts gradually increased in all samples during different storage periods. The TPC for coated persimmon samples were less than TPC of the control sample even after cold storage for 9 days. TPC for those samples after storage for 9 days recorded 2.22 and 2.00 log cfu/g, respectively, against 3.07 log cfu/g for the control sample. It is worth mentioning that after 15 day of storage at 5°C, TPC of the coated persimmon samples with CMC or alginate were reached to 2.73 and 2.60 log cfu/g, respectively. Where, the control sample was spoiled. This may be attribute that the coatings containing antimicrobials, such as, chitosan, essential oils or natural plant extracts (Sánchez-González *et al.,* 2011) have been effective in delaying the growth of contaminating microorganisms and maintaining the quality during storage and distribution of fresh and fresh-cut horticultural products.

In the last decade, several studies have focused on the development of coatings based on proteins or polysaccharides with natural food preservatives to control microbial growth on fruits and vegetables. Antimicrobials can be added to edible coatings to retard the growth of bacteria, yeasts and molds during storage and distribution of fresh or minimally processed products (Lucera *et al.,* 2012).

Table 4: Effect of cold storage periods at 5°C for 15 day on total bacterial count (log cfu/g) of coated fresh persimmon

Storage period (day)	Treatments		
	Control	CMC	Alginate
0	2.47	1.62	1.40
3	2.60	1.82	1.52
6	2.84	2.00	1.82
9	3.07	2.22	2.00
12	-	2.47	2.30
15	-	2.73	2.60

CMC: carboxy methyl cellulose; Alginate: sodium alginate. (-): spoiled.

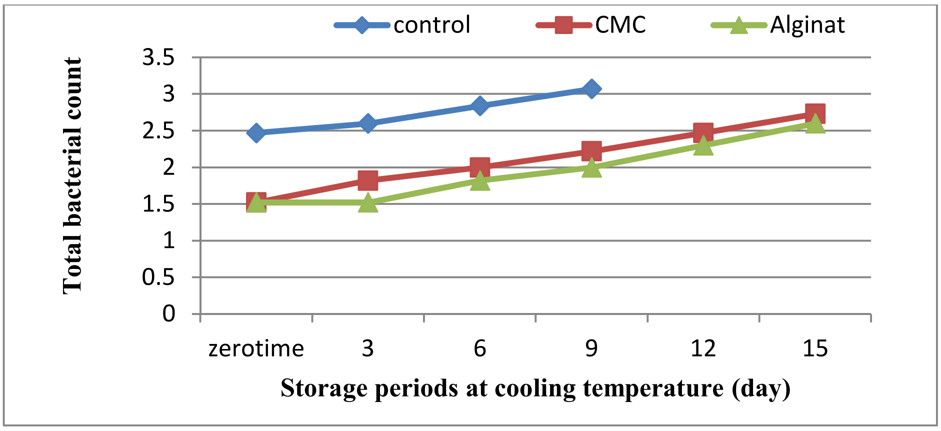

Fig. 4: Changes in total bacterial count of coated fresh persimmon during storage period for 15 day

Psychrophilic bacterial count:

The effects of coating process of fresh persimmon fruits and cold storage at 5°C for 15 day psychrophilic bacteria count are shown in Table (5) and Fig. (5).

The psychrophilic bacteria count of the control and coated persimmon fruits (treated with CMC or alginate) were 2.00, 1.82 and 1.52 log cfu/g, respectively, at initial storage; and gradually increased with increasing the storage period. Psychrophilic bacteria count in the control sample increased from 2.00 log cfu/g at zero time to 2.84 log cfu/g after 9 days of storage at 5°C, whereas, psychrophilic bacteria count in coated samples reached to 2.84 log cfu/g for sample treated with CMC and 2.77 log cfu/g for sample treated with alginate at the 15th day of storage at 5°C. Where, the control sample was spoiled.

Table 5: Effect of cold storage periods at 5°C for 15 day on psychrophilic bacterial count (log cfu/g) of coated fresh persimmon

Storage period (day)	Treatments		
	Control	CMC	Alginate
0	2.00	1.82	1.52
3	2.30	2.00	1.82
6	2.60	2.30	2.00
9	2.84	2.47	2.30
12	-	2.69	2.60
15	-	2.84	2.77

CMC: carboxy methyl cellulose; Alginate: sodium alginate. (-): spoiled.

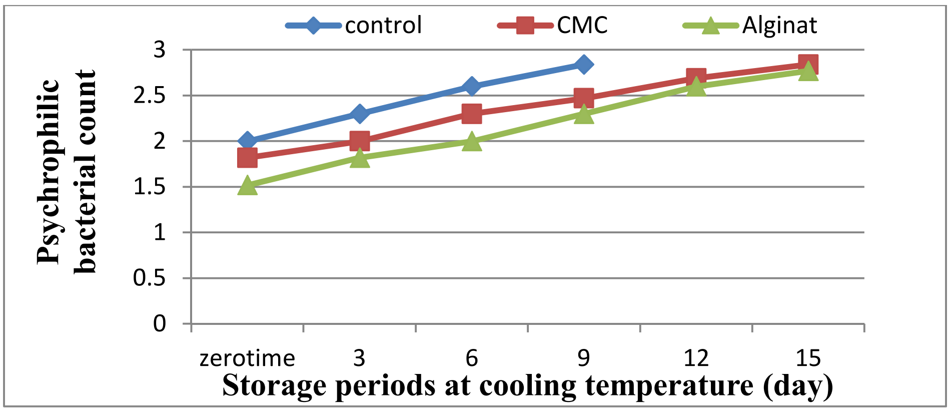

Fig. 5: Changes in psychrophilic bacterial count of coated fresh persimmon during storage period for 15 day

Mold and yeast counts :

The mold and yeast counts of coated persimmon samples were investigated during storage period at cooling temperature. The obtained results are shown in Table (6) and Fig. (6).

The Table indicated that the mold and yeast counts recorded 0.30 and 0.18 log cfu/g for coated persimmon samples with CMC or alginate, respectively, against 0.64 log cfu/g for the control sample (uncoated) at zero time. On the other hand, these counts linearly increased with progressing the storage period of all tested samples, especially the control sample was different as compared with the other persimmon samples. The mold and yeast counts for coated persimmon samples were less than those of the control sample even after cold storage for 9 days. The mold and yeast counts for those samples after storage for 9 days recorded 1.30 and 1.22 log cfu/g, respectively, against 1.63 log cfu/g for the control sample. It is worth mentioning that after 15 day of storage at 5°C, the mold and yeast counts of coated persimmon samples with CMC or alginate were reached to 1.56 and 1.48 log cfu/g, respectively. Where, the control sample was spoiled.

Table 6: Effect of cold storage periods at 5°C for 15 day on mold and yeast counts (log cfu/g) of coated fresh persimmon

Storage period (day)	Treatments		
	Control	CMC	Alginate
0	0.64	0.30	0.18
3	1.22	0.66	0.42
6	1.42	1.12	1.00
9	1.63	1.30	1.22
12	-	1.42	1.36
15	-	1.56	1.48

CMC: carboxy methyl cellulose; Alginate: sodium alginate. (-): spoiled.

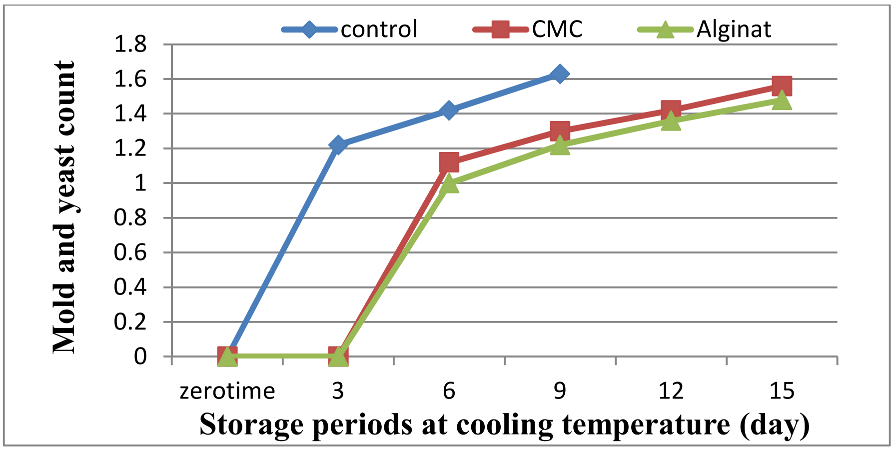

Fig. 6: Changes in mold and yeast counts of coated fresh persimmon during storage period for 15 day

Generally, the microbiological quality criteria of fresh persimmon samples were affected by coating processes either at initial time or at any storage period. Also, these results provide evidence for the presence of antimicrobial compounds in carboxy-methylcellulose (CMC) and sodium alginate. These compounds can degrade the cell wall, disrupt the cytoplasmic membrane, damage membrane proteins and interfere with membrane-integrated enzymes, which may eventually lead to cell death (Shan *et al.,* 2007).

The effect of edible coating on the sensory quality properties of persimmon fruit:

Color, aroma and taste are the major sensory attributes related to the quality perception and consumers' acceptability of foods in general. The need to control such parameters in the context of quality control is therefore beyond doubt. Despite its inherent subjectivity, sensory analysis (carried out by trained panelists or potential consumers) remains essential for the industry for such purposes such as the development of new products, the enhancement of existing products, and the assessment of preferences and so on. However, the instrumental assessment of sensory attributes offers a number of advantages that make them powerful analytical tools for the industry, one of the main ones being their objectivity (Heredia *et al.,* 2013).

Coated persimmon samples were sensory evaluated and compared with control sample (uncoated) as shown in Table (7). Data showed that there were no significant differences observed among tested coated samples and control sample in color, taste, oder and texture at zero time. With regard to the overall acceptability, the control sample was the lowest (P < 0.05) acceptable sample (8.6) as compared with coated persimmon samples with CMC (9.0) or alginate (9.0).

On the other hand, coated persimmon samples treated by CMC or alginate showed higher (P < 0.05) judging scores in all sensory characteristics than control sample during storage periods for 15 day as shown in Table (7).

Table 7: Effect of cold storage periods at 5°C for 15 day on sensory quality properties of coated fresh persimmon

Treatments		Storage period (day)					
		0	3	6	9	12	15
Control	Color	8.9^{Aa}	8.3^{Ba}	6.2^{Cb}	4.9^{Da}	-	-
	Taste	8.0^{Bc}	8.3^{Aa}	6.4^{Ca}	4.9^{Da}	-	-
	Oder	8.6^{Ab}	7.8^{Bc}	5.8^{Cc}	4.4^{Dc}	-	-
	Texture	8.9^{Aa}	8.0^{B}	5.7^{Cc}	4.7^{Db}	-	-
	Overall	8.6^{Ab}	8.1^{Bb}	6.2^{Ca}	4.9^{Da}	-	-
CMC	Color	9.0^{Aa}	8.8^{Aa}	8.3^{Ba}	7.0^{Ca}	6.2^{Da}	5.1^{Ea}
	Taste	8.0^{Bc}	8.1^{Ad}	8.0^{Aa}	6.8^{Bb}	6.2^{Ca}	5.0^{Da}
	Oder	8.7^{Ab}	8.5^{Ab}	7.8^{Bb}	6.3^{Cd}	5.7^{Db}	5.0^{Ea}
	Texture	9.0^{Aa}	8.2^{Bc}	7.5^{Cc}	6.7^{Db}	5.5^{Ec}	4.8^{Fb}
	Overall	9.0^{Aa}	8.4^{Bb}	7.8^{Cb}	6.5^{Dc}	5.7^{Eb}	5.0^{Da}
Alginate	Color	9.0^{Aa}	8.8^{Ab}	8.4^{Bb}	7.2^{Cd}	6.5^{Db}	5.2^{Eb}
	Taste	8.0^{Bc}	8.0^{Bc}	8.2^{Ad}	7.8^{Ca}	6.8^{Da}	5.1^{Ec}
	Oder	8.7^{Ab}	8.8^{Ab}	8.5^{Ba}	7.5^{Bb}	6.5^{Cb}	5.2^{Db}
	Texture	9.0^{Aa}	8.8^{Ab}	8.3^{Bc}	7.3^{Cd}	6.1^{Dd}	4.9^{Ed}
	Overall	9.0^{Aa}	9.0^{Aa}	8.4^{Bb}	7.4^{Cc}	6.3^{Dc}	5.3^{Ea}

CMC: carboxy methyl cellulose; Alginate: sodium alginate. (-): spoiled.
Mean values in the same row (as a capital letter) or column (as a small letter) with the same letter are not significantly different (P> 0.05).

Conclusion

Using the edible coating during cold storage at 5°C for 15 day can be a feasible way of improving microbial stability and quality of fresh persimmon. Thus extending their shelf life compared to the uncoated samples.

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