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Effect of Some Colloidal Coating Treatments on the Shelf Life and Quality Characteristics of Strawberry Fruits

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Abstract

Short shelf life after harvest is one of the biggest problems for fresh strawberries. In this study, the effects of next generation edible colloidal coating agents formed from combinations of chitosan, selenium and thyme essential oil obtained by ionic gelation method on the post-harvest quality criteria of strawberries were investigated. The quality parameters (weight loss, decay rate, respiration rate, fruit color, firmness, total soluble solids: TSS, titratable acid: TA, ascorbic acid content, total phenolic content, antioxidant capacity and total anthocyanin content) of fruits of Albion strawberry variety kept at 21°C (room temperature conditions, relative humidity) were measured on days on 0th, 3rd, 5th, 7th and 10th. All coating treatments showed positive effects on quality parameters during shelf life. Edible colloidal coating treatments showed positive effects on the reduction of weight loss, reduction of decay, respiration rate, color values, fruit firmness, titratable acid content, ascorbic acid content, total phenolic content, total anthocyanin content and total antioxidant capacity values during shelf life compared to the control group. Among all the treatments, the most effective treatments in preserving quality properties were Chitosan + Selenium and Chitosan + Selenium + Thyme essential oil treatments. The research of results will provide information on the development of edible colloidal coating materials in related future studies planned on similar topics.

1. Introduction

Strawberry is one of the most consumed fruit species in the world. Strawberry is an important fruit species in human nutrition due to its high vitamin, mineral and nutrient content. Strawberries are consumed intensively both fresh and processed due to their superior sensory properties such as colour, aroma and flavor (Yang and Kim, 2023).

Strawberries spoil quickly due to their high metabolic activity and this situation creates serious problems in the marketing of strawberries (Barikloo and Ahmadi, 2018). Post-harvest physical damage and spoilage caused by microorganisms cause losses in fruit firmness, quality and color of strawberries. Therefore, it is important to determine appropriate methods to preserve the post-harvest quality and nutritional value of strawberries (Fernandez-Leon et al., 2013).

Packaging of foods has an important place in the global economy. However, synthetic plastics, which have superior mechanical and protective properties used in packaging, are the biggest environmental threat nowadays because they are not biodegradable (John et al., 2023). Nowadays, environmentally friendly technologies are important to reduce post-harvest losses and extend shelf life of agricultural products.

The edible material coating method has gained popularity in recent years in order to extend the storage life and preserve the quality of fruits. Edible coatings provide an ecological advantage compared to plastic-based food packaging because they are biodegradable and environmentally friendly (Şen and Güner, 2023). Edible coatings are packaging materials that preserve food quality, extend shelf life of foods, have antimicrobial activity and are consumed with foods (Jeevahan and Chandrasekaran, 2019). Edible coatings consisting of proteins and polysaccharides are biodegradable substances composed individually or in combination of essential oils, extracts, polyphenols and antioxidant agents (Pham et al., 2023).

Researchers have developed edible colloidal coatings using various components from nanoparticles to microparticles to extend shelf life of foods, maintain freshness, and prevent decay by improving antimicrobial activity (Feyzioglu and Tornuk, 2016; Vera et al., 2018). Colloids (colloidal solutions or colloidal systems) are a mixture dissolved in another substance of microscopic in size insoluble particles of one substance. Colloids, with sizes ranging from 1 to 1000 nm, can be in solid, liquid and gas form. Most colloidal systems are nano-sized or composed of nano-sized particles through colloidal interactions. Therefore, nanoparticles are important (John et al., 2023). The particle size limit value of nanoparticles is known as less than 100 nm. However, large sized particles have been accepted as nano in various studies. The dimensions of chitosan-based nanoparticles were reported as 135–237 nm by Feyzioglu and Tornuk (2016) and 532–716 nm by Keawchaoon and Yoksan (2011). The concentration of the materials and the solvent used in nanoparticles and the pH value of compound are the factors which determine size of particles (Feyzioglu and Tornuk, 2016).

Colloids are effective in providing a large interaction surface area and as preservative, maintain freshness of products from production to consumption and extending shelf life (Kontogeorgis and Kill, 2016). Colloidal systems are an ideal system for the controlled delivery of active ingredients (Moreno and Peinado, 2012). In addition, colloidal systems are low in cost due to need a small amount of active substance (John et al., 2023).

Biopolymers such as enzymes, polysaccharides and proteins are compounds that generally create macromolecular colloids and are used as coatings on packaging surfaces (John et al., 2023). Different biopolymers are used for colloidal coatings. Chitosan is a polysaccharide-based biopolymer commonly used in colloidal coatings (Moustafa et al., 2019). Chitosan is the most abundant polysaccharide in nature after cellulose. It is important among biopolymers due to its antibacterial and antifungal properties (Aider, 2010). The mixture of biologically active compounds such as chitosan and plant essential oils has significant potential in controlling post-harvest decay of fresh fruits (Perdones et al., 2016). Adding plant essential oils and extracts to edible colloidal coatings by increasing the antimicrobial effect, ensuring food safety and food quality against microbes (Li et al., 2024). By adding plant essential oils to colloidal coatings controls diseases that may occur in the fruit by providing active molecules on the fruit surfaces (Aloui et al., 2014). Edible colloidal coatings created by combining chitosan and plant essential oils have strong antimicrobial and antifungal activity that is highly degradable and controls decay in fruits (Kong et al., 2010; Zhang et al., 2011). Especially essential oils, which have antimicrobial effects, are used extensively to prevent microbial spoilage. Plant-derived essential oils and components such as thyme oil, citral, lemon grass oil, cinnamon aldehyde, cinnamon oil can be used in antimicrobial edible coatings (Rojas-Graü et al., 2007).

The main source of Selenium is foods of plant and animal origin (Roman et al., 2014). In recent studies, Selenium nanoparticles, which have anticancer, antimicrobial and antioxidant properties, are used in packaging (Skalickova et al., 2017). Oxidation of foods is prevented by adding selenium to active packaging as an antioxidant source (Vera et al., 2018). One of the best solutions to obtain active food packaging is addition of selenium nanoparticles into the polymeric layer (Palomo-Siguero and Madrid, 2017).

The aim of the study is develop an edible colloidal coating with antimicrobial properties to prevent post-harvest spoilage of short shelf-life strawberries and determine its practical applicability. Various combinations have been obtained by combining chitosan, selenium synthesized from black tea leaf extracts, and thyme oil. The effects of the edible colloidal coatings obtained in the study on the post-harvest quality parameters of Albion strawberry variety fruits kept at room temperature conditions (21°C) were revealed.

2. Material and Methods

In the study, the preparation of chitosan microparticles was carried out according to the ionic gelation method modified by Ilk et al. (2017). Selenium microparticles were obtained by green synthesis method using black tea leaf extract (Mareedu et al., 2021). In the study, four coating solutions were prepared (Chitosan colloidal solution: CsCS, Chitosan colloidal solution + thyme essential oil: CsCS+Oil, Chitosan colloidal solution + Selenium colloidal solution: CsCS+SeCS, and Chitosan colloidal solution + Selenium colloidal solution + thyme essential oil: CsCS+SeCS+Oil) and applied to the fruits of Albion strawberry species. Strawberry fruits were collected early in the morning and brought to the laboratory quickly. Composites were prepared at 1% active substance rate and essential oil rate was adjusted as 1000 ppm. Fruit samples were kept at room conditions (21°C). The study was planned with three replications and 150 g sample in each replication. Various quality parameters were analyzed on 0th, 3rd, 5th, 7th and 10th days to during shelf life of the samples.

Within the scope of the study, weight loss (%), decay rate (%), respiration rate (mg CO_2 kg^{-1} h^{-1}), fruit color, fruit firmness (N), total soluble solids (TSS) content (%), titratable acid (TA) content (%), vitamin C content (mg 100 g^{-1} AsAE), total phenol content (mg 100 g^{-1} gallic acid), total antioxidant capacity (% inhibition) and total anthocyanin content (µg cy-3-glu g^{-1}) were determined during shelf life of fruits. Respiration rate was determined by measuring the amount of CO_2 spreaded by the fruits to the external environment with a digital carbon dioxide analyzer (Öztürk, 2020) and fruit color was determined with a colorimeter (Minolta, model CR-400, Tokyo, Japan) in terms of CIE L*, chroma and hue (McGuire, 1992). Among the biochemical properties, vitamin C content was determined using the method used by Özdemir and Dündar (2006); total phenol amount was determined using the Folin-Ciocalteu's chemical defined by Singleton and Rossi (1965); total antioxidant capacity was determined using the DPPH method specified by Brand-Williams et al. (1995); and total anthocyanin amount was determined using the pH differential method (Giusti et al., 1999).

The research was carried out according to the random plots experimental design with 3 replicates. Analysis of variance of data was performed by using JMP Pro 17.0 statistical package program and statistically significant parameter values according to the results of analysis of variance were compared with LSD test.

3. Results and Discussion

In the experiment, the effects of the treatment×shelf life time interaction on the weight loss, decay rate and color values (L*, chroma and hue) of strawberries were found statistically significant, while the treatment and shelf life time had statistically significant effects on the respiration rate separately (Table 1).

Weight loss of strawberries increased in parallel with the shelf life in all treatments. The lowest weight loss rate occurred in CsCS+Oil treatment on the 3rd day, CsCS+SeCS+Oil treatment on the 5th day, and CsCS+SeCS treatment on the 7th and 10th days. Our study findings confirm that edible colloidal coatings can significantly reduce weight loss by creating a semi-permeable barrier that reduces transpiration and moisture loss (Jafarzadeh et al., 2018). CsCS+SeCS treatment was the most effective method to reduce weight loss of strawberries. Due to the high synergistic effects of CsCs and SeCS compounds (Dorazilova et al., 2020) the retention of moisture in plant tissues is increased by using these compounds in coatings.

According to the mean of the treatments, the lowest respiration rate occurred in CsCS+SeCS and CsCS+SeCS+Oil treatments. Respiration rate, which is an indicator of the metabolic activities of fresh fruits, is an important factor affecting shelf life. In general, as the respiration rate of fruits and vegetables increases, their storability and shelf life decrease at the same rate (Jafarzadeh et al., 2021). Coatings are known to change gas exchange characteristics of fresh produce, effectively reducing respiration rates and delaying ripening (Iderawumi and Yusuff, 2021).

In strawberry fruits, CsCS+SeCS and CsCS+SeCS+Oil treatments showed lower decay rate than the other treatments starting from the 5th day of shelf life. The 5th day, when the decay rate in fruits is at least 25%, is recommended as the shelf life. These treatments stand out as the most effective methods in delaying decay by preserving the freshness during shelf life of strawberries. The coatings have antimicrobial properties that inhibit microbial contamination and delay decay in fruit and vegetables (Wang et al., 2020). Our study findings may be attributed to the physical barrier formation of coating agents as well as the antimicrobial effect of thyme essential oil (Mith et al., 2014). Chitosan used in coatings acts as a barrier preventing microbial development in fruits (Butler et al., 1996). Many studies have reported that chitosan coatings applied to strawberry fruits reduce decay (Gol et al., 2013; Sangsuwan et al., 2016).

The L* value, which expresses the brightness of fruit color, showed tendency to decrease as the shelf life period increased. Starting from the 5th day of shelf life, CsCS+SeCS+Oil treatment showed higher L* value than other treatments. CsCS+SeCS+Oil treatment was the most effective method to preserving the color of strawberries during shelf life. Chroma and hue values, which are color indicators, showed tendency to decrease as the shelf life period increased. Although there were differences between treatments on these color parameters, in general, treatments preserved chroma and hue values of fruit better compared to control and helped to keep color tone constant during the shelf life. Colloidal coatings, which act as a semi-permeable barrier, control microbial damage and preserve color and texture (Bourtoom, 2008). Coatings slow down the decrease in L*, chroma and hue values of strawberries during shelf life (Sangsuwan et al., 2016; Vargas et al., 2006).

While treatment and shelf life period had a statistically significant effect on fruit firmness separately, this value showed a tendency to decrease during the shelf life. According to the mean of treatments, the highest fruit firmness was

Table 1. Weight loss, respiratory rate, decay rate, L* value, chroma value and hue value of control and coated strawberry during 10 days of 21°C storage.

Coating	Control	CsCS	CsCS+Oil	CsCS+SeCS	CsCS+ SeCS +Oil	Mean
Weight loss (%)						
0	0.00 l	0.00 l	0.00 l	0.00 l	0.00 l	0.00
3	7.35 hı	4.84 j	3.16 k	3.27 k	3.68 k	4.46
5	10.13 c	6.99 ı	6.77 ı	5.73 j	5.19 j	6.96
7	12.19 b	8.10 gh	8.64 eg	8.32 fh	8.39 fg	9.13
10	13.32 a	9.45 ce	9.86 cd	9.00 dg	9.12 cf	10.15
Mean	8.60	5.88	5.69	5.26	5.28	
Respiratory rate (mg CO_2 kg^{-1} h^{-1})						
0	148.90	139.10	133.30	118.40	117.70	131.47 d
3	151.90	141.80	136.00	120.70	120.10	134.10 c
5	154.10	143.80	139.20	123.90	122.80	136.75 b
7	156.40	146.10	140.10	124.30	123.70	138.12 ab
10	158.00	147.60	141.50	125.60	124.90	139.50 a
Mean	153.86 a	143.67 b	138.01 c	122.58 d	121.81 d	
Decay rate (%)						
0	0.00 n	0.00 n	0.00 n	0.00 n	0.00 n	0.00
3	25.00 j	18.75 k	18.75 k	6.25 m	12.50 k	16.25
5	50.00 g	31.25 ı	37.50 h	25.00 j	25.00 j	33.75
7	85.40 b	75.00 d	75.00 d	65.30 e	62.50 f	72.64
10	93.75 a	81.25 c	81.25 c	75.00 d	75.00 d	81.25
Mean	50.83	41.25	42.50	34.31	35.00	
L* value						
0	33.79 ab	33.42 ab	31.21 de	34.07 a	34.15 a	33.33
3	30.66 df	30.14 eg	30.80 df	32.73 bc	33.14 ab	31.49
5	30.76 df	29.27 gı	28.71 hj	30.88 df	31.76 cd	30.28
7	27.93 j	27.98 ıj	28.11 ıj	29.60 fh	29.90 eh	28.70
10	25.34 l	26.55 kl	26.12 l	27.60 jk	27.80 jk	26.68
Mean	29.70	29.47	28.99	30.98	31.35	
Chroma value						
0	33.28 ab	34.01 a	33.41 a	33.71 a	34.07 a	33.70
3	31.28 de	32.29 bc	31.90 cd	31.23 de	32.32 bc	31.80
5	28.37 hj	29.19 gh	30.50 ef	30.61 ef	30.61 ef	29.85
7	27.32 k	28.56 hı	29.66 fg	29.62 fg	28.02 ık	28.64
10	26.17 l	27.87 ık	27.39 jk	28.09 ık	27.99 ık	27.50
Mean	29.28	30.38	30.57	30.65	30.60	
Hue value						
0	35.85 bc	36.68 ab	36.18 ab	36.28 ab	36.84 a	36.37
3	33.85 ef	34.96 cd	34.67 de	33.80 ef	35.09 cd	34.47
5	30.94 km	31.86 ık	33.27 fg	33.18 fh	33.38 fg	32.52
7	29.89 n	31.23 jl	32.43 gı	32.19 hj	30.79 ln	31.31
10	28.74 o	30.54 ln	30.16 mn	30.66 ln	30.76 ln	30.17
Mean	31.85	33.05	33.34	33.22	33.37	

Chitosan colloidal solution: CsCS, Chitosan colloidal solution + thyme essential oil: CsCS+Oil, Chitosan colloidal solution + Selenium colloidal solution: CsCS+SeCS, and Chitosan colloidal solution + Selenium colloidal solution + thyme essential oil: CsCS+SeCS+Oil.
* Mean differences indicated by different letters in the same column are significant ($p < 0.05$). If the interactions were not statistically significant, the differences between the means were compared statistically.

determined in CsCS+SeCS and CsCS+SeCS+Oil treatments, while according to during the shelf life, the highest fruit firmness was determined on day 0^{th} (Table 2). Fruit firmness is a main quality parameter to preserve the freshness and commercial value of strawberries. Edible coatings reduce metabolic activity by reducing oxygen uptake of strawberry fruits, and in this case, slow down the ripening process, that is, softening. Our results are consistent with previous studies on strawberries (Barikloo and Ahmadi, 2018; Sogvar et al., 2016).

The effect of the treatment*shelf life period interaction on the amount of TSS was found statistically significant, and in general the amount of TSS increased during the shelf life. The lowest TSS amount was detected in CsCS+SeCS treatment on the 10^{th} day of shelf life (Table 2). The amount of TSS expressed as a percentage of Brix represents the percentage of dissolved solids and is an indicator of the sweetness and flavor profile in products. While decreases in the amount of TSS may occur as a result of the use of sugars in respiration during the shelf life of fruits, it is more likely that this parameter will increase due to the concentration effect of water losses (Velickova et al., 2013). In addition, coating agents delay synthesis and use of metabolites by reducing the respiration rate in fruits, due to reducing the amount of TSS (Xing et al., 2020).

The effect of shelf life period on TA content was found statistically significant. In the study, it was observed that TA content in strawberry fruits decreased during shelf life. In general, CsCS and CsCS+SeCS treatments were successful in

Table 2. Fruit firmness, total soluble solids, titratable acid, ascorbic acid, total phenols, total antioxidant and total anthocyanin of control and coated strawberry during 10 days of 21°C storage.

Coating	Control	CsCS	CsCS+Oil	CsCS+SeCS	CsCS+ SeCS +Oil	Mean
Fruit firmness (N)						
0	6.77	6.81	6.79	7.50	7.45	7.06 a
3	4.64	4.77	4.77	5.28	5.23	4.94 b
5	3.84	4.00	4.01	4.44	4.39	4.13 c
7	3.04	3.23	3.25	3.61	3.56	3.34 d
10	1.65	1.85	1.83	2.46	2.43	2.05 e
Mean	3.99 c	4.13 bc	4.13 bc	4.66 a	4.61 ab	
Total soluble solids (%)						
0	9.77 ı	9.83 gı	9.77 ı	9.80 hı	9.83 g-ı	9.80
3	9.93 fg	9.93 fg	9.90 fh	9.83 gı	9.93 fg	9.91
5	10.00 ef	9.93 fg	9.93 fg	9.93 fg	9.93 fg	9.95
7	10.23 bc	10.10 de	10.13 cd	10.07 de	10.10 de	10.13
10	10.63 a	10.23 bc	10.27 b	10.13 cd	10.33 b	10.32
Mean	10.11	10.01	10.00	9.95	10.03	
Titratable acid (%)						
0	0.78	0.80	0.78	0.80	0.79	0.79 a
3	0.76	0.78	0.75	0.80	0.77	0.77 ab
5	0.70	0.77	0.71	0.78	0.76	0.75 ac
7	0.68	0.72	0.70	0.75	0.72	0.72 bc
10	0.65	0.71	0.67	0.69	0.69	0.68 c
Mean	0.72	0.76	0.72	0.76	0.75	
Vitamin C (mg 100 g^{-1} AsAE)						
0	51.02 bd	52.01 ab	51.51 bc	53.19 a	52.47 ab	52.04
3	50.08 ce	49.36	49.36 dg	48.46 eh	50.20 cd	49.49
5	47.80 -h	49.60 de	47.09 h	47.75 gh	49.45 df	48.34
7	41.79 lm	44.12 ı	43.86 ıj	43.75 ık	43.54 ık	43.41
10	37.83 n	41.11 lm	40.66 m	42.44 jl	42.14 km	40.84
Mean	45.70	47.24	46.50	47.12	47.56	
Total phenol content (mg 100 g^{-1} gallic acid)						
0	335.95	338.91	335.21	338.54	337.06	337.13 e
3	342.60	342.73	341.99	340.51	340.32	341.63 d
5	360.88	358.66	358.49	352.83	354.95	357.16 c
7	384.16	381.25	376.62	373.64	374.40	378.02 b
10	401.80	399.21	393.84	391.86	393.66	396.08 a
Mean	365.08 a	364.15 a	361.23 b	359.48 b	360.08 b	
Total antioxidant capacity (% inhibition)						
0	68.79	69.19	70.21	71.11	70.40	69.94 a
3	63.72	64.79	66.71	66.87	67.17	65.85 b
5	61.11	62.13	63.77	64.13	64.85	63.20 c
7	58.11	59.09	60.38	60.98	62.18	60.15 d
10	56.31	57.26	58.35	59.09	60.16	58.23 e
Mean	61.61 d	62.49 c	63.88 b	64.44 ab	64.95 a	
Total anthocyanin content (µg cy-3-glu g^{-1})						
0	248.53	249.93	248.17	249.76	249.04	249.09 d
3	251.70	251.77	251.43	250.71	250.62	251.25 d
5	260.52	259.44	259.35	256.65	257.67	258.73 c
7	271.74	270.31	268.08	266.66	267.04	268.77 b
10	280.22	278.97	276.40	275.42	276.30	277.46 a
Mean	262.54	262.09	260.69	259.84	260.13	

Chitosan colloidal solution: CsCS, Chitosan colloidal solution + thyme essential oil: CsCS+Oil, Chitosan colloidal solution + Selenium colloidal solution: CsCS+SeCS, and Chitosan colloidal solution + Selenium colloidal solution + thyme essential oil: CsCS+SeCS+Oil.
* Mean differences indicated by different letters in the same column are significant ($p < 0.05$). If the interactions were not statistically significant, the differences between the means were compared statistically.

preserving TA content, while the lowest values were determined in the control group (Table 2). The reason is that the coatings may be slow down the rate of degradation of organic acids in the product by inhibiting enzyme activity associated with organic acid metabolism. It is stated that the changes in TA content during storage period in fresh fruits are related to respiration, organic acids are consumed by respiration and as a result, acid content decreases (Rivera-Pastrana et al., 2007). It is also known that post-harvest coating agent treatment slows down the metabolic activity in products, and as a result, delays the synthesis and degradation mechanisms (No et al., 2007). Similar findings have been reported in previous studies (Candir et al., 2018; Çınar and Sabır, 2021; Song et al., 2016).

The treatment*shelf life period interaction had a statistically significant effect on vitamin C content. The vitamin C content of strawberries decreased during shelf life. A significant decrease in vitamin C content was observed on the 7th and 10th days during shelf life. However, CsCS+SeCS treatment has been successful in minimizing vitamin C loss (Table 2). Vitamin C is easily degraded by heat, light and enzymes during storage (Frias and Oliveira, 2001), and the resulting water losses increase oxidation, which can lead to loss of vitamin C content (Nunes et al., 1998). The addition of chitosan to edible coatings can delay vitamin C oxidation of fruits by reducing O_2 diffusion and slowing the respiration rate (Amal et al., 2010). In addition, preservation of vitamin C content by increasing antioxidant activity of selenium colloidal particles can be attributed to their ability to form a light barrier. It is known that edible coating treatments slow down the decrease in vitamin C content of fruits (Emamifar and Mohammadizadeh, 2015; Gol et al., 2013).

Treatment and shelf life period had a statistically significant effects on total phenolic content. According to the study findings, it was observed that total phenolic content increased during shelf life. Total phenolic content was determined the highest in the control group according to mean values. According to the mean of the treatments, the lowest total phenolic content was determined in CsCS+SeCS, CsCS+SeCS+Oil and CsCS+Oil treatments, respectively (Table 2). Phenolic compounds are secondary metabolites which have an important effect on color and taste formation in fruits. Post-harvest changes occur in the phenolic content of fresh fruits and vegetables, and these changes are affected by many factors such as species, variety, harvest time, cultural practices and storage time. Especially in storage studies, phenolic compound contents increase by 40-60% with the extension of storage time (Valero et al., 2011). During shelf life, lower total phenolic content was determined in colloidal coating applications compared to the control. Consistent with our findings, the total phenolic content in many products stored with coating applied was lower than the control (Sogvar et al., 2016; Valizadeh et al., 2021). The suppression of the increase in phenolic content by colloidal coating applications can be attributed to the delay in respiration.

Treatment and shelf life period had statistically significant effects on total antioxidant capacity. A decrease in antioxidant capacity was observed as shelf life increased. In the study, CsCS+SeCS+Oil treatment provided the highest antioxidant capacity and was the method that best preserved the antioxidant capacity. Although a decrease in antioxidant capacity was observed as shelf life increased in all treatments, the treatments were effective in slowing down this decrease. CsCS+SeCS+Oil treatment is application that best preserves antioxidant capacity (Table 2). The total antioxidant capacity value of many fresh fruits and vegetables to which coating was applied was higher than that of control products (Arabpoor et al., 2021; Cid-Lopez et al., 2021; Nguyen et al., 2020). In general, it has been concluded that the applications delay aging by slowing down metabolic activity in products and thus prevent nutritional losses.

Shelf life period had a statistically significant effect on total anthocyanin content. In the study, total anthocyanin content showed a tendency to increase all treatments during shelf life. The least increase in total anthocyanin amount was detected in CsCS+SeCS treatment (Table 2). Anthocyanins are a group of phenolic compounds which are responsible for the red-blue color of fruits and vegetables (Mullen et al., 2002) and have beneficial effects on human health (Garcia-Alonso et al., 2004). Additionally, anthocyanins have strong antioxidant properties. In the study, the increase in total anthocyanin content can be attributed to the decrease in TA content (Sogvar et al., 2016).

4. Conclusion

In this study, the effect of edible coatings consisting of combinations of chitosan, selenium and essential thyme oil, whose particle size was reduced to colloidal limits, on the quality criteria of strawberry fruits during shelf life was investigated. As a result of the study, it was determined that CsCS+SeCS and CsCS+SeCS+Oil treatments from edible colloidal coatings reduced weight loss, respiration rate and decay rate, and were the most effective applications in preserving color values (L*, chroma and hue), fruit firmness, TSS, TA, vitamin C content, total phenol, total anthocyanin and antioxidative capacity. These results indicate that CsCS+SeCS and CsCS+SeCS+Oil treatments can be used as edible coatings to protect fruit quality and extend post-harvest shelf life of strawberries. The results of the study will contribute to the process of obtaining edible colloidal coating agents produced with new technology in extending the shelf life of post-harvest perishable products. In addition, it can be said that the results can be used to shed light on possible future studies on similar topics.

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