Development of a whey protein concentrate/apple pomace edible coating for extending shelf life of fresh-cut apple

Running title: Novel edible coating for fresh fruits

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Abstract

The present study aimed to develop a novel edible coating using whey protein concentrate (WPC) and apple pomace extract (APE) to extend shelf life of fresh-cut apple. Apple slices were coated with a mixture of WPC and APE at concentration of 0.5, 1 and 1.5% and were stored at 5°C for 12 days. The total phenolic content and DPPH radical scavenging activity of APE were determined. The weight loss, color, browning index, microbiological analysis and sensory evaluation of coated and uncoated apple slices were estimated. A total phenolic content of ethanolic APE was 6.77± 0.339 mg gallic acid equivalent/g dry apple pomace. Apple pomace extract contained the total of 15 phenolic compounds. Also, a significant antioxidant activity was observed for apple pomace extract using the DPPH method and the inhibitory concentration (IC_{50}) was 51.97 ± 1.576 µg gallic acid equivalent/mL extract compared with BHT (21.80 ± 0.424 µg/mL). Coating apple slices with WPC/APE decreased the weight loss compared to the uncoated and the apple slices coated with WPC only. The coated apple slices with WPC/1.5% APE had the highest lightness compared to other coated and uncoated apple slices after 12 days of storage. In addition, the coated apple slices with WPC/ 1 and 1.5% APE exhibited the lowest browning index compared to the uncoated apple slices. Using WPC and APE as coating agents showed antimicrobial activity and they had little effect on the sensory evaluation of apple slices.

Keywords: Whey protein, apple pomace, edible coating, fresh-cut apple.

Introduction

Fresh-cut fruits and vegetables are the most preferable foods for consumers because they are highly nutritious, convenient and healthful commodities. However, their market is still perfectly limited due to fast damage through storage and distribution. In recent years, there has been an increasing interest in achieving novel strategies to enhance storage ability, shelf life and the microbiological safety of fresh-cut products. The methods of edible coatings and films have been considered prospective strategies for meeting this demand. Edible coatings constitute a thin layer of edible agent composed as a coating over a food product and this coating can be eaten with the product (Kuorwel *et al*., 2015; Tavassoli-Kafrani *et al*., 2016). Edible coatings can preserve vegetables and fruits in fresh form by enhancing the retention of flavor, sugar, acid, and color to prolong shelf life and keep nutritional characteristics (Fakhouri *et al*., 2015; Kerch, 2015). Furthermore, edible coatings used to prevent undesirable mass transports (moisture, oxygen and flavor), improve visual properties and act as carriers to deliver active components such as antimicrobial, antioxidant and nutraceuticals agents (Reinoso *et al*., 2008).

Lipids, proteins, and polysaccharides can be utilized as biopolymers for edible coatings creation (Schmid *et al*., 2015; Jahed *et al*., 2017; Martelli *et al*., 2017; Niamlang *et al*., 2017). Generally, proteins have been given a great attention in edible coating technology for their plenty of food processing residuals. Also, the reactive amino acids enable the proteins to be modified and cross-linked through chemical and physical treatments to form new polymeric structures (Gennadios, 2002). Whey protein isolates have excellent barrier function for gas, aroma compounds, and oil as compared to the films made with polysaccharides and lipids (Krochta, 2002 and Feng *et al*., 2018). Commercially, whey proteins are available as whey protein concentrates (WPC) or whey protein isolates (WPI), with protein contents of 20-85 and >90%, respectively (Khwaldia *et al*., 2004). Since whey protein coatings are edible, they are perfect carriers for nutraceuticals to improve the nutritional value of the coated food product. The applications of whey protein films are to be utilized mainly as antimicrobial agents and as protective barrier coatings to increase the shelf-life of food products (Seydim and Sarikus, 2006).

Apple pomace is an industrial solid waste of apple manufacturing, and it represents around 30% of the original fruit. Wet pomace, generated by cider pressing, represents up to 25% of the fresh fruit weight and its moisture content is about 70-85% after being pressed. Apple pomace is a heterogeneous mixture consisting of the apple peels, leftover flesh, core with seeds and stems (Jung *et al*., 2015; Kara and Doymaz, 2015). It has been proved that apple pomace affects pharmacological targets. Nutraceutically, apple pomace appeared to have various pharmacological benefits where the preliminary studies reported promising anti-inflammatory, antiviral, antioxidative and antibacterial activities (Waldbauer *et al*., 2017). Many studies, aiming to have value-added products, have used apple pomace to produce protein-enriched feeds, ethanol, enzymes and natural antioxidants (Shrikot *et al*., 2004; Paganini *et al*., 2005; Medeiros *et al*., 2006; Albuquerque *et al*., 2006; Vendruscolo *et al*., 2008). The polyphenols content of apple pomace and its ability to scavenge DPPH radicals have been reported (Gharedaghi *et al.,* 2019, Cetkovic *et al.*, 2008 and Rana *et al*., 2014)

Based on the previously mentioned information, our study aimed to develop whey protein-based coating incorporating apple pomace extract (APE) as an anti-browning, anti-microbial and antioxidative agent for apple slices under cold storage.

Materials and methods

Materials

Whey protein concentrate (WPC, 80%), glycerol (99.5%), 1,1-diphenyl-2-picrylhydrazyl (DPPH) and Butylated hydroxytoluene (BHT) were obtained from CP Kelco, a Huber Company (Georgia, USA) and Sigma-Aldrich (St. Louis, MO, USA).Apple fruits (*Malus domestica* var. *anna*) were purchased from a local supermarket in January 2019.

Preparation of apple pomace extract (APE)

Ten kg of apple fruits were washed and cut into small pieces then squeezed in a domestic food processor (Moulinex, Compact Kitchen Machine, Egypt) and finally filtrated through muslin cloth. Apple pomace was oven-dried at 50ºC then milled and sieved at 50 mesh. About 200 g apple pomace powder was extracted by ethanol 80% at a ratio of 1:20 (w/v) using a homogenizer for 30 min. The mixture was passed through filter paper (Whatman No. 1). The filtrate was concentrated by rotary evaporator at 40ºC. The concentrate was lyophilized and stored at 5ºC before coating application.

Coating preparation

The apple fruits were cut into similar thick slices (2 cm). The pieces were divided into 5 parts. The first part was dipped in distilled water and served as a control. The second part was dipped in an aqueous solution of 10% (w/w) WPC and 3% (w/w) glycerol. The third, fourth and fifth parts were coated with the same solution incorporated with 0.5, 1 and 1.5% of APE, respectively. Dipping process was performed for 2 min. The excess of the immersion solutions on the apple slices was drained off for 5 min. Then these apple slices were placed in polypropylene packages and thermally sealed by stretch film before storage at 2-5ºC and 80% RH for 12 days for analyses. At least three batches for each treatment were performed.

Total phenolic content and antioxidant activity of apple pomace extract (APE)

Total phenolic compounds of ethanolic APE were determined using the Folin-Ciocalteau reagent, and gallic acid was used as a standard. The results were expressed as mg gallic acid equivalent/g dry matter according to Khalifa *et al*. (2017). The ability of APE to scavenge DPPH radicals was measured according to Marquez *et al*. (2017).

Determination of phenolic compounds of apple pomace extract (APE)

Determination of phenolic compounds was performed by high-performance liquid chromatography (HPLC). Samples were analyzed using an Agilent 1260 series HPLC system. The separation was carried out using Agilent Zorbax C_{18} column (4.6 mm i.d. x 250 mm., 5 µm, Agilent Technologies Co. Ltd., CA, USA). The mobile phase consisted of water (A) and acetonitrile (B) at a flow rate of 1 mL/min. The mobile phase was programmed consecutively in a linear gradient as follows: 0–5 min (80% A); 5-8 min (40% A); 8-12 min (50% A); and 12-16 min (80%

A). The multi-wavelength detector was monitored at 280 nm. Each sample was injected at 10 µL. The column temperature was maintained at 35ºC.

Determination of weight loss

Weight loss of different apple slices was estimated in triplicate after 1, 4, 8 and 12 days of storage as follows:

$$\text{Weight loss }(\%) = \frac{(\text{initial weight } - \text{ final weight})}{(\text{initial weight})} \times 100$$

Measurement of color

Color of apple pieces was measured with a chromameter Minolta CR-400 (Minolta. Inc., Tokyo, Japan) using the CIE color parameters L^*, a^*, b^*. The samples were measured after 1, 4, 8 and 12 days of storage. The browning index (BI) was calculated according to Olivas *et al.* (2007) as follows:

$$BI = \frac{100\,(x - 0.31)}{0.172}$$

$$x = \frac{(a^* + 1.75L^*)}{(5.645L^* + a^* - 3.01b^*)}$$

Antimicrobial activity of apple pomace extract

The antimicrobial activity of apple pomace extract was determined using agar well diffusion method against gram positive bacteria (*Staphylococcus aureus* and *Bacillus subtilis* NRRL B-543), gram negative bacteria (*Escherichia coli* ATCC 25955 and *Proteus vulgaris* ATCC13315) and fungi (*Aspergillus fumigates* and *Candida albicans* ATCC 10231) as described by Boyanova *et al*. (2005).

Microbiological examination

Each sample of apple slice (10 g) was homogenized aseptically with 90 mL of Ringer's solution as described by ICMSF, 1978. Serial dilutions were made using Ringer's solution and they were poured onto sterile standard plate count agar plates. The plates were incubated at 32ºC for 48 h for the enumeration of total bacterial count or at 7°C for 5 days for the enumeration of psychrotrophic bacteria. Colonies were counted and results are expressed as log CFU/g of the sample.

Sensory evaluation

Ten panelists from the staff members of the Food Science Department, Faculty of Agriculture, Cairo University, Egypt, used a quality rating scorecard for the evaluation of treated apple slices for taste, odor, texture, and overall acceptability. Based on their preference and liking, panelists were demanded to classify the samples on a ten-point hedonic scale; 1 is unacceptable and 10 is very much like.

Statistical analysis

The results were expressed as the mean ± standard deviation. All data were analyzed in three replications for each parameter. Statistical analysis was performed using XLSTAT 2014 (5.03) software (USA). Significant differences (p<0.05) between means were determined by Tukey's test.

Results and discussion

Total phenolic content and phenolic composition

The phenolic compounds are responsible for most of the antioxidant activity as well as the health benefits of apple consumption (Feng *et al*., 2018). Total phenolic content of ethanolic APE was 6.77 ±0.339 mg gallic acid equivalent/g dry apple pomace, while it was 14.969 ± 0.359 mg gallic acid equivalent/g dry lyophilized extract. Suárez *et al*. (2010) found that the total phenolic content of apple pomace methanolic and acetonic extracts was 3.63 and 6.48 mg gallic acid equivalent/g of dry wt. pomace, respectively.

Apple pomace extract was subjected to HPLC analysis and the total identified phenolic compounds were 15 (Figure 1). The major polyphenols of APE were ellagic acid (2494.93 mg/L), salicylic acid (174.83 mg/L), quinol (138.65 mg/L), gallic acid (73.39 mg/L), benzoic acid (70.95 mg/L), rosmarinic acid (50.51 mg/L), syringic acid (16.05 mg/L), chlorogenic acid (12.13 mg/L), o-coumaric acid (9.39 mg/L), and vanillin (9.18 mg/L) while the main identified flavonoids were myricetin (3184.31 mg/L), naringin (94.93 mg/L), kampherol (57.62 mg/L), quercetin (12.79 mg/L) and rutin (7.90 mg/L). Suárez *et al*., (2010) indicated the presence of chlorogenic acid, (−)-epicatechin, quercetrin, protocatechuic acid, and caffeic acid in apple pomace methanol extract.

Free radical scavenging capacity of apple pomace extract (APE)

The obtained results showed that the antioxidant activity of APE increased as polyphenols concentration increased. The IC_{50} (concentration of APE that is required to inhibit 50% of DPPH free radicals) value of APE was 51.97± 1.576 µg gallic acid equivalent/ mL whereas the IC_{50} value of BHT was 21.80 ± 0.424 µg/mL. The radical scavenging capacity of APE could be attributed to the presence of ellagic acid which is the main phenolic compound in apple pomace (Hayes *et al.*, 2011). Cetkovic *et al.*, (2008) found that IC_{50}^{DPPH} radical scavenging activity of apple pomace methanol extract ranged from 6.33 to 15.72 mg/mL. They used 5 apple varieties. Rana *et al*., (2014) found that the IC_{50}^{DPPH} of ethyl acetate fraction of APE was 7.37 mg/mL.

Weight loss of apple slices

The effect of WPC/ APE coating on the weight loss of apple slices during cold storage is shown in Figure 2. The weight loss of WPC/ APE coated samples was < 0.25 % after 4 days of storage instead of >2% in the case of uncoated and WPC coated apple slices. After 12 days of cold storage, uncoated apple slices showed the highest weight loss (3.07± 0.042 %). However, the weight loss of coated apple slices with WPC incorporated with apple pomace extract at concentrations of 0.5, 1 and 1.5% decreased significantly (p<0.05) to 1.06±0.021, 0.98±0.014 and 0.58±0.028%, respectively compared to the uncoated and coated apple slices with WPC only. Increasing apple pomace concentration in the coating mixture to 1.5% was significantly (p<0.05) effective in reducing the weight loss of apples. This could be due to the high sugar content of the dried apple pomace as reported by O'Shea *et al*. (2015).

Weight loss of uncoated apple slices varied from 0.53% to 1.29% after 12 days of cold storage at 2°C according to the investigated cultivars (Kim *et al*., 1993). Khalifa *et al*. (2017) found that the weight loss of uncoated apple samples reached 3.03% and 8.50% after 21 and 35 days of storage. Marquez *et al.* (2017) reported that coating apple pieces with whey protein concentrate decreased the weight loss from 10% to 8% after 10 days of storage at 4-6°C. McHugh and Krochta (2014) concluded that protein-based films have high sensitivity to moisture and poor water vapor barrier properties due to their hydrophilic nature. Umaraw and

Verma (2017) reported that whey protein isolates (WPI) have high water vapor permeability owing to the high degree of hydrophilic amino acids in their structure. In addition, Alves *et al*. (2017) found that coating formula containing sodium ascorbate (10 g/L) was more effective in controlling weight loss of apple slices than that without antioxidants. This result may be due to the additional protective effect provided by the interactions of the antioxidants with compounds at the surface of the apples.

Color changes and browning assessment of apple slices

Extending storage period of apple slices was accompanied by an increase in the enzymatic browning as indicated by an increase in a* and b* values and decrease in lightness (L*) and hue values (Perez-Gago *et al*., 2006). In Figure 3a, results indicated that the uncoated apple slices and those coated with WPC significantly ($p<0.05$) recorded the lowest lightness after 12 days of storage. L* values of apple slices coated with WPC/APE were not significantly ($p>0.05$) different at the end of storage, regardless level of apple pomace used in the coating formula. Coating apple slices with WPC/ APE kept its L* values for 12 days not significantly ($p>0.05$) different from those of WPC coated apple slices that stored for 4 days.

A significant ($p<0.05$) increase in (a*) value of all treatments was observed during the cold storage period (Figure 3b). The lowest increase of a* value after 12 days of storage was recorded for apple slices coated with WPC/ APE (1.5%). The highest (+b*) value (33.81±0.168) was recorded for the uncoated apple slices at the end of storage (Figure 3c). There was no significant ($p>0.05$) change between (+b*) value of apple slices coated with WPC/ APE at 1% or 1.5% after 12 days of storage and that of the freshly cut apple slices (uncoated).

Extending storage time of all treatments to 12 days was accompanied by a significant (*p*<0.05) increase in the chroma (C*) values (Figure 3d). The chroma (C*) values of WPC / APE (1% or 1.5%) coated apple samples, at the end of storage period, was not significantly (*p*>0.05) different from those of the 4 days stored uncoated or WPC coated apple slices.

Hue values decreased slightly during storage of the uncoated and coated apple slices (Figure 3e). After 12 days of storage, the hue value of the WPC / APE (1.5%) coated apple samples was not significantly (*p*>0.05) different from that of the uncoated slices at zero-time storage.

The browning index is an indicator for tissue decay. The results in Figure 3f showed that browning index increased during the cold storage of all treatments. The uncoated apple slices significantly (*p*<0.05) recorded the highest browning index (60.57±0.338) at the end of the cold storage period. Meanwhile, browning index of apple slices coated with WPC only was 58.54±0.453. On the other hand, enriching coating formula with APE at levels of 0.5, 1 and 1.5% significantly (*p*<0.05) reduced the increase of browning index to 37.66±0.174, 37.10±0.425 and 35.01±0.200, respectively. Coatings which incorporated with antioxidants reduced oxygen permeability and affect polyphenol oxidase activity (Alves *et al*., 2017). In this regard, Perez-Gago *et al*. (2006) found that apple pieces coated with whey protein-based coatings had higher L* and lower b* and a* values. They reported that browning index values of the coated apple pieces were lower than those of the uncoated ones.

Microbiological examination of apple slices

The antimicrobial activity of apple pomace extract (200 mg/ mL) was determined against six species of spoilage and pathogenic microorganisms and the results showed that the apple pomace extract showed large zone of inhibition (8.00 mm) for *Staphylococcus aureus* NRRL B-543 and *Escherichia coli* ATCC 25955. However, no inhibition zones were detected for other investigated microorganisms. These results are in consistent with those of Younis and Ahmad (2015). The growth inhibition property of apple pomace is attributed to the presence of polyphenols (Agourram *et al*., 2013).

As shown in Table 1, coating apple slices with WPC or WPC/APE at 0.5% or 1.0% decreased significantly ($p<0.05$) the TBC during storage period. Increasing APE concentration in the coating mixture from 0.5% to 1% decreased significantly ($p<0.05$) the TBC during storage of apple slices. The phenolic compounds of apple pomace have antimicrobial activity (Zhang *et al*. 2016 and Riaz *et al*., 2018).

The lowest bacterial count was recorded for the WPC/APE (1%) coated samples that was significantly ($p<0.05$) different from all other investigated treatments. Extending storage time to 12 days did not significantly ($p<0.05$) affect the bacterial count of WPC/APE (1%) coated samples. On the other hand, coating apple slices with WPC/APE at 1.5% did not significantly ($p<0.05$) decrease TBC during the first 4 days of storage, after which the TBC decreased significantly

($p<0.05$). These results indicated that whey protein concentrate and apple pomace may have antimicrobial activity. In this respect, Marquez *et al*. (2017) found that the whey protein/pectin/transglutaminase edible coating is efficacious to obviate fresh-cut apple spoilage during the ten days of storage, as demonstrated by microbial growth prevention.

Sensory evaluation of apple slices

The utilization of functional ingredients as coating agents to the fruits may alter the sensory attributes of the fruits that might cause a decrease in consumer acceptability. Consequently, it is essential to study the changes in sensory attributes of apple slices as a result of using whey proteins and apple pomace as coating agents. The sensory attributes of taste, odor and texture of coated and uncoated apple slices are listed in Table 2. On day 1 of cold storage, no significant ($p<0.05$) differences were noted in all treatments for the taste and odor sensory attributes. The highest scores for texture and overall acceptability were recorded for WPC/APE (1% and 1.5 %) coated samples at the first day of storage. During the cold storage period, it was observed that there was a gradual decrease in the sensory properties of all samples, except WPC/APE1.5% coated samples, till the end of the storage period. Coating with WPC/APE1.5% kept sensory attributes of apple slices during the first 4 days of storage without significant ($p<0.05$) difference from those of the freshly cut slices. Extending storage time to 12 days did not significantly affect the overall acceptability of the WPC/APE1.5% coated samples. Our findings pointed out that using whey protein concentrate and apple pomace as coating agents attained the sensory properties of apple slices during storage.

In this regard, Javanmard (2011) found that WPC-gellan coating maintained the color, firmness, glossiness and overall acceptability of apple during storage. Hassani *et al*. (2012) reported that using a composite of WPC and rice bran oil as a coating agent was effective in the preservation of color, firmness, taste and overall acceptability of the kiwifruit during storage. Marquez *et al*. (2017) observed no significant differences in acceptability scores for the texture and flavor of the coated samples with whey protein/pectin/transglutaminase edible coating after storage compared to all samples tested before storage.

Conclusion

The present study revealed that the use of a mixture of whey protein concentrate and apple pomace extract as an edible coating was effective to obviate fresh apple slices damage or spoilage during the 12 days of cold storage. This edible coating led to the reduction of weight loss, color changes, browning index and microbial growth of fresh apple slices. Also, coating apple slices with WPC and apple pomace did not have a negative effect on the sensory attributes of apple slices. Finally, a blend of WPC and apple pomace can be used as coating agents for fresh-cut fruit without affecting their properties during the cold storage period.

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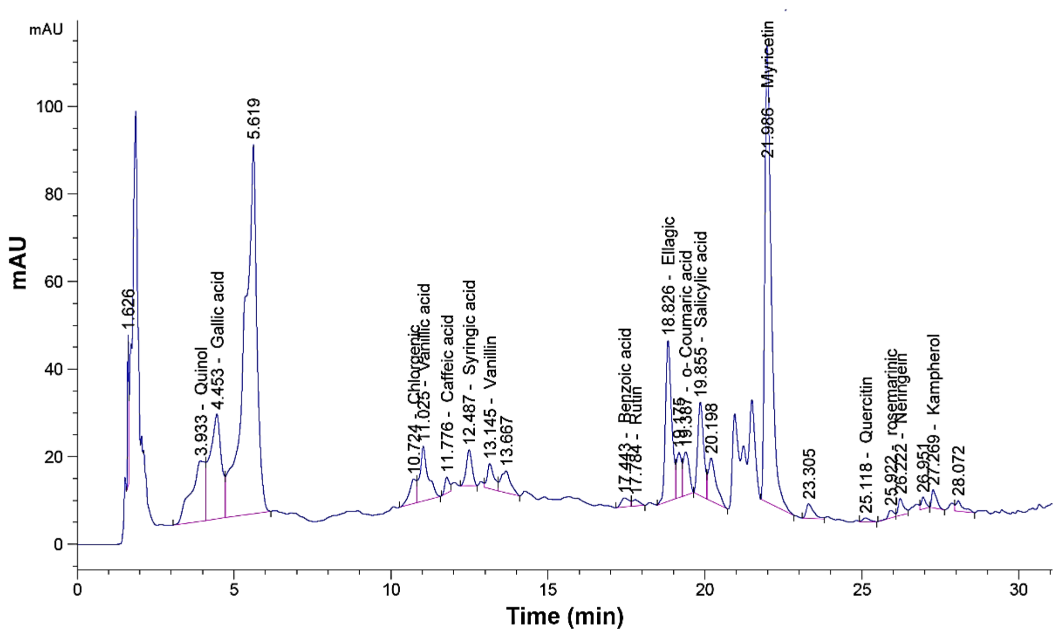

Figure 1. HPLC profile of phenolic compounds in apple pomace extract

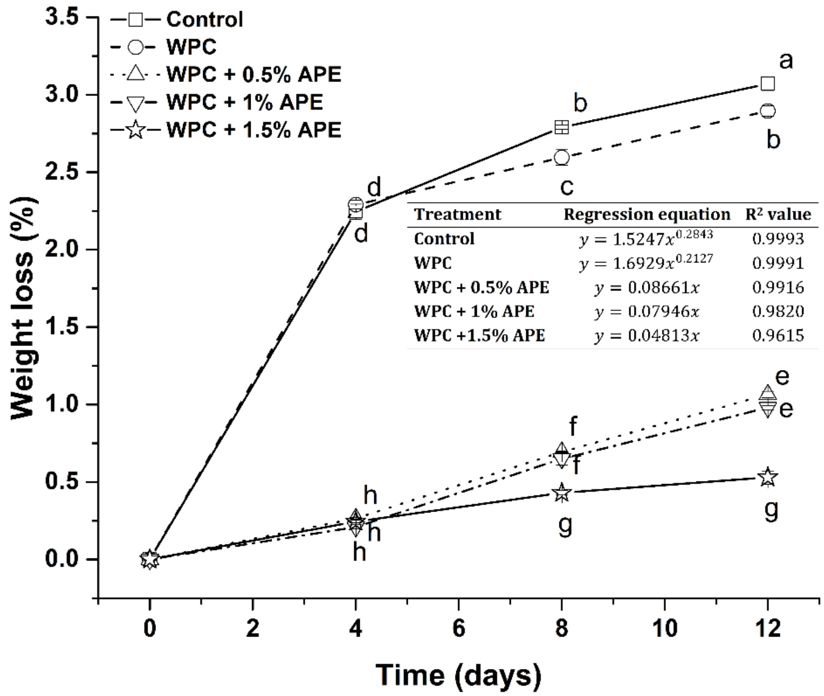

Figure 2. Weight loss of apple treated with different coating formulations during cold storage

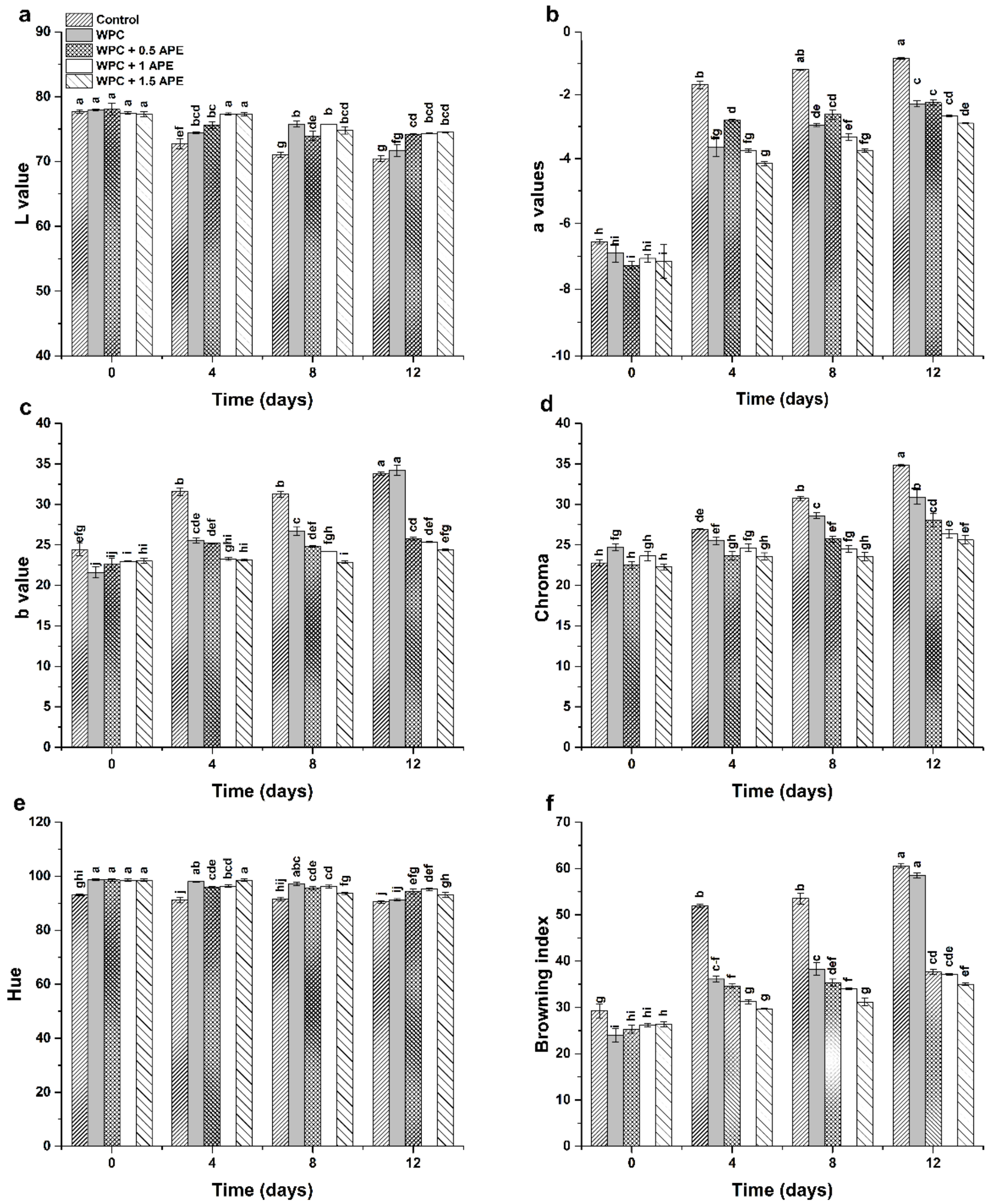

Figure 3. Color changes and browning index of apple treated with different coating formulations during cold storage

Table 1. Total bacterial count (log CFU/g) of apple treated with different coating formulations during cold storage

Treatments	Storage days			
	1	4	8	12
Control	2.17±0.01[c]	2.16±0.01[c]	2.26±0.02[b]	2.38±0.01[a]
WPC	1.55±0.05[fg]	1.97±0.01[d]	1.82±0.05[e]	1.52±0.02[g]
WPC+0.5%APE	1.28±0.02[h]	2.10±0.04[c]	1.89±0.01[e]	1.49±0.04[g]
WPC+1 % APE	1.16±0.02[i]	1.21±0.04[hi]	1.18±0.01[i]	1.14±0.04[i]
WPC+1.5% APE	2.17±0.02[c]	2.16±0.03[c]	2.13±0.02[c]	1.62±0.03[f]

Values are means ± standard deviation. Means with the same letter indicated no significant difference at 5% level of probability by Tukey's test.

Control: uncoated apple; WPC: whey protein concentrate; APE: apple pomace extract. Pyschrotrophic bacteria were not detected in all treatments at day 1 and during storage.

Table 2. Sensory evaluation of apple treated with different coating formulations during cold storage

Treatments	Storage days	Taste	Odor	Texture	Over all acceptability
Control	1	9.62±0.45^{a}	9.87±0.33^{a}	8.50±0.50^{cd}	9.62±0.48^{abc}
	4	8.03±0.27^{c}	6.93±0.24^{g}	7.81±0.52^{g}	8.18±0.52^{cd}
	8	5.62±0.24^{d}	4.25±0.82^{j}	5.62±0.55^{i}	5.75±0.24^{g}
	12	3.81±0.94^{f}	3.37±0.72^{i}	2.31±0.59^{l}	3.87±0.48^{k}
WPC	1	9.62±0.45^{a}	9.80±0.40^{a}	9.00±0.36^{b}	9.86±0.44^{ab}
	4	8.20±0.24^{c}	8.46±0.80^{c}	8.00±0.36^{e}	8.66±0.59^{e}
	8	6.20±0.67^{h}	6.33±0.69^{e}	6.80±0.54^{h}	7.86±0.24^{c}
	12	4.86±0.88^{e}	3.46±0.74^{k}	5.00±0.44^{j}	5.33±0.59^{h}
WPC+0.5%APE	1	9.70±0.40^{a}	9.73±0.44^{a}	9.40±0.48^{cd}	9.93±0.24^{a}
	4	8.30±0.52^{bc}	8.66±0.47^{bc}	9.06±0.85^{de}	9.13±0.33^{b}
	8	8.00±0.24^{c}	7.33±0.73^{e}	7.93±0.59^{e}	8.33±0.57^{f}
	12	5.33±0.59^{e}	6.20±0.40^{f}	5.73±0.44^{i}	7.00±0.36^{h}
WPC+1 % APE	1	9.64±0.23^{a}	10.00±0.54^{a}	10.00±0.33^{a}	10.00±0.33^{a}
	4	8.16±0.23^{c}	8.93±0.24^{b}	9.26±0.57^{cd}	9.60±0.48^{a}
	8	8.80±0.24^{b}	8.80±0.40^{bc}	8.66±0.33^{ef}	9.60±0.40^{a}
	12	5.53±0.49^{e}	7.00±0.24^{f}	7.13±0.71^{h}	7.40±0.71^{f}
WPC+1.5%APE	1	9.87±0.21^{a}	9.75±0.43^{a}	10.00±0.33^{a}	10.00±0.33^{a}
	4	9.62±0.34^{a}	9.75±0.42^{a}	9.62±0.48^{a}	10.00±049^{a}
	8	8.34±0.24^{bc}	8.93±0.74^{b}	9.43±0.49^{bcd}	9.62±0.39^{a}
	12	7.93±0.82^{c}	8.81±0.48^{b}	8.18±0.88^{de}	10.00±0.33^{a}

Values are means ± standard deviation. Means for each parameter with different superscript letters differ significantly ($p < 0.05$).

Control: uncoated apple; WPC: whey protein concentrate; APE: apple pomace extract.