

EFFECT OF EDIBLE FILMS BASED ON RED ONION PEELS ON THE QUALITY AND SHELF LIFE OF BLUEBERRY FRUIT

Short communication

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ABSTRACT

Blueberries (*Vaccinium* spp.), valued by consumers for their sensory and nutritional qualities, have a limited shelf life. Preliminary results showed that 14-day storage of blueberry fruits at 3.5°C enveloped in edible films made of biopolymers containing red onion extract delayed quality decline. Analysis of the films revealed higher antioxidant content in the 5% and 10% extracts compared to the films without extract. The decline in berry firmness was significantly delayed in the fruits enveloped with films containing 5% or 10% extract. When wrapped with a film with red onion extract, the berries darkened and reddened, but this had no effect on the total soluble solids and antioxidant content. This is the first report on the use of red onion-based films in blueberry fruit during short-term storage. Further research is needed to enhance the appearance of the film, specifically the color changes from onion extracts. The effect of agronomic management and genotype on blueberry quality requires further investigation.

Key words: *Vaccinium*, antioxidants, firmness, cold storage, short-term storage

INTRODUCTION

Blueberry (*Vaccinium* spp.) is the second most produced berry crop worldwide (FAO 2023). Consumer preference for this berry is driven by its taste and high content of health-promoting phytochemicals, establishing its status as a superfood (Krishna et al. 2023). Blueberries are highly perishable. After harvest, their appearance, taste, and texture decline, leading to consumer dissatisfaction and increased food loss and waste (Casorzo et al. 2024). Postharvest strategies to reduce deterioration are essential for maintaining blueberry quality and extending shelf life. Edible biopolymer-based films are safe for consumption and have become a sustainable alternative to plastic packaging (Summo & De Angelis 2022).

Edible films are thin, preformed solid layers made of materials suitable for consumption that can be used as wraps, either on or between food products (McHugh 2000; Falguera et al. 2011). They can be based on proteins (gelatin, casein), polysaccharides (starch, alginate, agar), and lipids (glycerides, paraffin) and allow the incorporation of additives (Díaz-Montes & Castro-Muñoz 2021). In fresh produce, edible films act as protective layers against mechanical damage and water loss. They also function as modified atmosphere packaging, altering the rate of gas exchange to slow deterioration and spoilage (Gammage & Marangoni 2025). Additives such as bioactive compounds, essential oils, and other natural extracts have become a viable alternative for enhancing the functionality of edible coatings (Balakrishnan et al. 2025; Sholokhova et al. 2025).

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The food industry generates copious amounts of waste from onion (*Allium cepa*) processing, including roots and peels, which exhibit antioxidant, antimicrobial, and anticarcinogenic biological activity (Chadorshabi et al. 2022; Jaganmohanrao 2025). Valorization of onion waste and byproducts to films for the fresh produce industry offers a sustainable approach to reducing food losses (Kumar et al. 2022a, b). Adding onion peel or shallot extracts to films resulted in higher phenolic and anthocyanin content, antioxidant activity, and lower film water solubility (Santos et al. 2021; Gulati et al. 2023). It also effectively controlled browning of fresh-cut produce during storage (Thivya et al. 2021).

This study aimed to assess the effect of edible films based on red onion peel extract on the quality of blueberry during postharvest storage. It was hypothesized that the bioactive compounds in the films would extend blueberry shelf life. Characterization of the edible films and blueberry fruit was carried out before and after 14 days of storage at 3°C. This is the first report of the effect of red onion peel extract-based edible films on the performance of blueberry fruit during storage.

MATERIALS AND METHODS

Onion extract preparation

Red onions (*Allium cepa*) of unknown cultivar at horticultural maturity were purchased from a local market in Concepción, Biobío Region, Chile, in December 2022. They were stored overnight at 3°C and used the next day. The dry outer layer was removed, placed in an infrared food dehydrator (IR D5, Counter Intelligence, South Korea) at 50°C for three days, and ground to a fine powder. Ten grams of the powder was mixed with 100 mL water and ethanol (1 : 1), sonicated in an ultrasonic cleaner (Branson 5800, Emerson, USA) for 30 min, and filtered. The solvent was evaporated using a rotary evaporator (RE100-PRO DLab, China) at 38 rpm and 72°C. A fine powder of red onion extract (ROE) was obtained and then stored at 4°C.

Alginate film preparation

Alginate films were prepared according to Rhim (2004) with some modifications. Alginate solutions at 2% (w/v) were prepared by mixing 2 g of sodium alginate with 100 mL of distilled water at 60°C. ROE was then added to final concentrations of 5% (EX5) and 10% (EX10) (w/v), based on the weight of alginate. These procedures were based on previous results and their effect on the physicochemical and mechanical properties of the films (data not shown). After cooling to room temperature, 3 g of glycerin was added to the solutions, shaken for 30 min, and then 20 g was transferred evenly to a 150 × 15 mm Petri dish. Calcium chloride at 1% (w/v) was sprayed onto a Petri dish, which was placed in a vacuum dryer oven (BIOBASE 30, BIOBASE, China) at 40°C for 24–48 h and then in a desiccator for 24–48 h. The film was carefully removed from the Petri dish and placed on wax paper until use. The EX0 film was obtained by the same process, but without the addition of ROE.

Edible films characterization

CIELab color determination

Film color was determined using a colorimeter (CS-10, CHN Spec, China) with a D65/10° illuminant/observer system and an L*a*b* scale. Five readings were averaged for each film.

Antioxidant extract preparation

The films were cut into small pieces, 100 mg of which was homogenized with 2 mL of a 1 : 1 ethanol–water mixture at room temperature with constant agitation for 30 min. The extract was used in the next steps.

Total phenolic content (TPC)

TPC was determined by the Folin–Ciocalteu method (Peñarrieta et al. 2009; Gasti et al. 2021) with some modifications. In a test tube, 100 µL of extract was mixed with 1,450 µL of deionized water and 100 µL of tenfold diluted Folin–Ciocalteu reagent, homogenized, and incubated for 8 min. Then, 300 µL of 20% (w/v) aqueous sodium carbonate solution was added, the mixture was vortexed, and incubated in an oven at 25 °C for 120 min. The absorbance of the solution was measured at 750 nm using a UV–visible spectrophotometer (Jasco V-530, Shimadzu, Japan). Gallic acid was used as a standard for the calibration curve (0–200 µg·mL⁻¹). Three technical replicates were used. TPC was expressed as mg of gallic acid equivalent (GAE) per g of film.

2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity

DPPH scavenging activity was determined as described by Fan et al. (2022), with some modifications. A 300 µL aliquot of the extract was mixed with 300 µL 100% (v/v) ethanol and 900 µL of DPPH, incubated at room temperature for 30 min, and the absorbance was recorded at 517 nm (Jasco V-530, Shimadzu, Japan). A calibration curve prepared with Trolox was used as the standard. Three technical replicates were used. Results were expressed as mg of Trolox equivalent antioxidant capacity (TEAC) per g of film.

2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS) antioxidant capacity

The antioxidant capacity of ABTS was assessed as described by Peñarrieta et al. (2009), with some modifications. The ABTS^{•+} radical was generated by adding potassium persulfate (K₂S₂O₈), and on the day of analysis, the ABTS^{•+} solution was diluted with ethanol to an absorbance of 0.70 (±0.02) at 734 nm. After adding 3.0 mL of ABTS^{•+} solution to 30 µL of the extract, the mixture was agitated, and absorbance was recorded at 734 nm and 25°C after 6 min of incubation in the dark (Jasco V-530, Shimadzu, Japan). A calibration curve prepared using Trolox was used as the standard. Three technical replicates were used. Results were expressed as mg of TEAC per g of film.

Fruit material and postharvest storage

Blueberry (*Vaccinium* spp.) fruits of an unknown cultivar at horticultural maturity (fully ripe, dark purple surface color) were purchased in December 2022 from a single grower at a local supermarket in Concepción, Biobío Region, Chile. Fruit without damage or defects were selected for the experiment. Eight berries were placed in the center of a piece of alginate film for each treatment (EX0, EX5, and EX10) and tightly wrapped. This was the maximum number that could be accommodated in each piece of film without compression or damage. The sides of the film were pressed to reduce water loss during storage. The fruits in the film were stored at 3.5 ± 1°C for 14 days to simulate typical home storage conditions. The unwrapped control consisted of eight berries placed on an aluminum foil tray and stored under the same conditions as the edible film treatments. Fruit characterization during postharvest storage was carried out in a total of four replicates for each treatment.

Fruit characterization

CIELab color determination of the berry surface

Color was determined using a colorimeter. Three readings were taken from the equator of each berry and averaged. The Hue angle was calculated as $\tan^{-1}(b^*/a^*)$, and Chroma as $(a^{*2}+b^{*2})^{1/2}$.

Fresh weight (FW) loss

The weight of eight berries was measured individually for each treatment on days 0 and 14 of cold storage. Weight loss was expressed as the percentage of the difference between initial and final weight (Chiabrando & Giacalone 2011).

Firmness

Blueberry firmness (kg per cm²) was determined using a portable penetrometer (GY-2, NEWTRY, China) with a 3.5 mm probe and a 10 mm penetration depth in the proximal part of the fruit.

Decay

Decayed fruits were defined as those exhibiting mycelial growth on the surface. The percentage of decayed fruits relative to the total number of fruits was calculated after 14 days of storage.

Total soluble solids (TSS)

TSS (°Brix) were measured by squeezing the berry with a piece of cheesecloth and placing a drop of juice on the prism of a portable digital refractometer (HI 96801, Hanna Instruments, USA).

Antioxidant extract preparation

Frozen samples were homogenized in a solution of methanol, water, and formic acid (25 : 24 : 1), sonicated for 1 h (Branson 5800, Emerson Electric, USA), stored at 4°C for 24 h, then sonicated for 1 h and centrifuged at 3,500 rpm for 5 min (Romero Román et al. 2019). The following assays were performed in a microplate reader (Synergy H1, BioTek, USA) with three technical replicates.

Total phenolic content (TPC)

Twenty-five microliters of extract, 200 µL of water, and 25 µL of 0.5 N Folin–Ciocalteu reagent were mixed, shaken, and incubated in the dark at room temperature for 5 min. Then, 25 µL of 10% (w/v) sodium carbonate was added, shaken, and incubated in the dark for 1 h. A calibration curve was prepared using gallic acid as the standard. Absorbance was measured at 760 nm. A reagent blank was prepared by replacing the sample with water. TPC was expressed as mg of GAE per 100 g FW (Cabrera-Barjas et al. 2024).

2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity

Twenty-five microliters of the extract was mixed with 200 μ L of DPPH solution, shaken for 30 s, incubated at 25°C for 30 min, and shaken for 30 s. Absorbance was recorded at 517 nm. A calibration curve covering the range of 25–250 μ M Trolox was used as a standard. DPPH reagent was added instead of the extract for the blank. Antioxidant activity was expressed as μ mol of Trolox per 100 g FW (Romero Román et al. 2019).

Antioxidant capacity assay – ferric reducing antioxidant power (FRAP)

Twenty-five microliters of extract and 200 μ L of FRAP reagent were mixed, shaken for 30 s, incubated at 37°C for 30 min, and absorbance was recorded at 595 nm. A calibration curve from 25 to 250 μ M Trolox was used as the standard. A reagent blank was prepared by adding water instead of extract. Antioxidant capacity was expressed as μ mol of Trolox per 100 g FW (Romero Román et al. 2019).

Statistical analysis

Alginate film analysis was performed in triplicate, and results were presented as means $\pm$ standard deviations. Analysis of variance (one-way ANOVA) followed by Tukey's test (color descriptors) or Kruskal-Wallis test followed by Dunn's test (antioxidant parameters) was used to identify significant differences between film properties at a 95% confidence level. For fruit experiments, a completely randomized factorial design was used, with film treatment and number of days of storage as factors. Data were analyzed using two-way ANOVA and Tukey's test at a 95% confidence level to compare means. A power transformation ($\wedge 3.2$) was applied to the firmness data to address heteroscedasticity. Decay and FW loss were analyzed using the Kruskal-Wallis test followed by Dunn's test. Data analysis was performed using SAS OnDemand for Academics 3.81.

RESULTS AND DISCUSSION

Edible film characterization

Color is an important characteristic of the overall appearance of films and influences consumer acceptance (Singh et al. 2020). EX5 and EX10 differed significantly from EX0 in all color parameters (Table 1). Reducing the L^* values resulted in a decrease in film brightness after the addition of ROE, which is attributed to the presence of anthocyanins, which also increased the a^* parameter. This suggests that the extract resulted in a decreased brightness and a darker appearance of the films compared to EX0 (Fig. 1A, B).

The TPC and antioxidant activity of the films, determined by the DPPH and ABTS assays, increased proportionally to the concentration of ROE. All three parameters for EX10 were higher than for EX5 (Table 1). Due to the higher TPC, the EX10 film had the highest antioxidant activity. Similar results were obtained by Santos et al. (2021), who prepared alginate films with purple onion peel extract at 10–30% (v/v). In the study by Santos and Martins (2024), the alginate film prepared with a purple onion peel extract concentration of 30% (v/v) showed an intense red color compared with the transparent control film. This incorporation led to an increase in a^* and a decrease in L^* , indicating that the extract reduced brightness compared to the control film. As summarized by Muhie (2022), the composition of onions can be influenced by preharvest factors. Therefore, the chemical properties of ROE-based films may vary depending on the onion source.

Fruit quality parameters

Objective color measurement

Objective color descriptors L^* , a^* , b^* , Chroma, and Hue provide information on different color dimensions in blueberries during storage (Hu et al. 2021). In this study, changes in the external berry color after storage, not caused by the presence of edible films, were observed (Table 2). For all descriptors, no interaction between storage time and film treatment was found. L^* and Chroma values decreased after 14 days of cold storage in wrapped berries (EX5 and EX10), indicating darkening and loss of color intensity.

However, they remained unaltered in EX0 and the unwrapped control. The surface darkening of the samples in the present study was consistent with the study by Chiabrando and Giacalone (2015), in which the L^* values of berries coated with 2% (w/v) chitosan and 1% (w/v) sodium alginate + 1.5% (w/v) chitosan decreased more than in samples with 1.5% (w/v) sodium alginate

after 15 days of storage at 0°C. It was hypothesized that the chitosan became opaque and altered the reflective properties of the coating surface (Hoagland & Parris 1996; Chiabrando & Giacalone 2015). However, it is important to note that in those studies the coatings were applied by immersion, whereas in the present study the berries were wrapped.

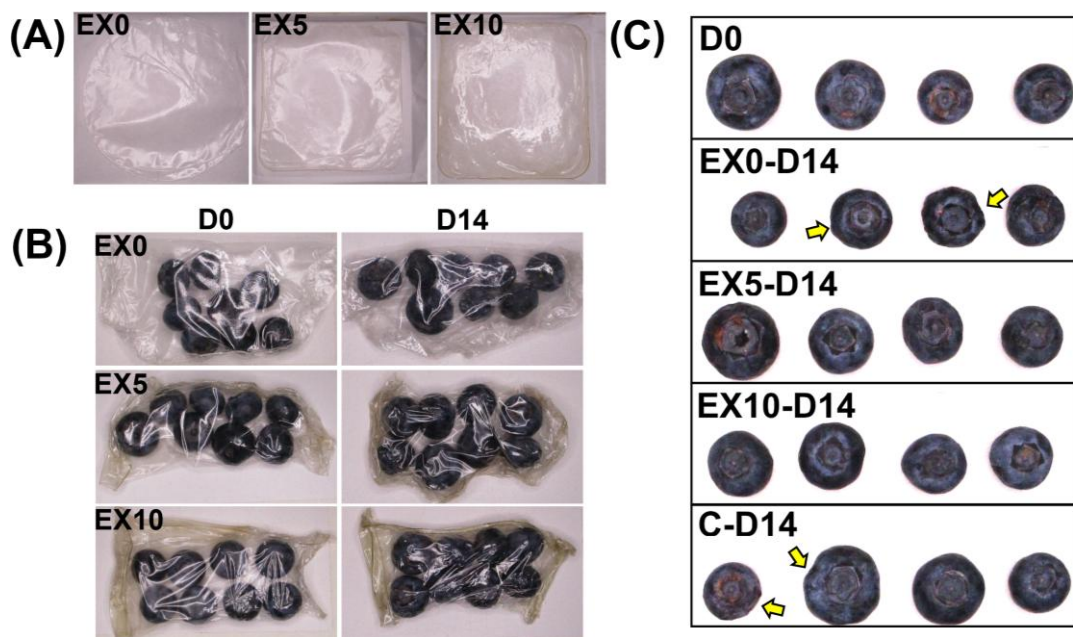


Figure 1. Appearance of edible films before storage (A) and blueberries wrapped in these films before storage (D0) and after 14 days of storage (D14) at 3.5°C (B), external appearance of blueberries (C), yellow arrows indicate areas of deformation EX0 – film without additives, EX5 – film with 5% red onion extract, EX10 – film with 10% red onion extract, D0 – day 0, D14 – day 14 of storage

Table 1. Summary of alginate films characteristics

Parameters	EX0	EX5	EX10
L^*	$91.40 \pm 0.24a$	$89.90 \pm 0.38b$	$90.30 \pm 0.19bc$
a^*	$-0.76 \pm 0.01a$	$-0.59 \pm 0.06b$	$-0.62 \pm 0.02bc$
b^*	$0.72 \pm 0.13c$	$2.04 \pm 0.32b$	$2.34 \pm 0.21ab$
TPC (mg GAE per g of film)	0	0.50 ± 0.00	$0.53 \pm 0.06^\dagger$
DPPH (mg TEAC per g of film)	0	50.50 ± 0.60	$112.00 \pm 3.20^\dagger$
ABTS (mg TEAC per g of film)	0	0.55 ± 0.09	$0.58 \pm 0.05^\dagger$

Mean $\pm$ standard deviation; Different letters in the same row indicate significant differences ($p < 0.05$) according to Tukey's test for color descriptors; Dagger (†) indicates significant difference ($p < 0.05$) between EX5 and EX10 according to Kruskal–Wallis test followed by Dunn's test; EX0 – film without added red onion extract, EX5 – film with added 5% red onion extract, EX10 – film with added 10% red onion extract; TPC – total phenolic content; DPPH – 2,2-diphenyl-1-picrylhydrazyl; ABTS – 2,2-azino-bis-3-ethylbenzothiazoline-6-sulfonic; GAE – gallic acid equivalents; TEAC – Trolox equivalent antioxidant capacity

Table 2. Changes in the quality and composition of blueberry fruit stored at 3.5°C for 14 days

Variable	Day	Control	EX0	EX5	EX10
L*	0	31.99 ± 0.4aA	32.13 ± 0.91aA	32.99 ± 0.16aA	32.95 ± 0.35aA
	14	31.35 ± 0.18aA	30.48 ± 0.25aA	30.6 ± 0.37aB	31.15 ± 0.29aB
a*	0	-6.75 ± 0.06aA	-6.85 ± 0.19aA	-6.94 ± 0.06aB	-7.07 ± 0.09aB
	14	-6.65 ± 0.07aA	-6.75 ± 0.08aA	-6.55 ± 0.04aA	-6.65 ± 0.06aA
b*	0	-1.33 ± 0.11aA	-1.36 ± 0.26aA	-1.62 ± 0.09aA	-1.68 ± 0.11aA
	14	-1.37 ± 0.06aA	-1.22 ± 0.09aA	-1.35 ± 0.17aA	-1.48 ± 0.12aA
Hue	0	190.8 ± 0.87aA	190.59 ± 1.85aA	192.72 ± 0.51aA	192.91 ± 0.71aA
	14	191.23 ± 0.71aA	189.78 ± 0.77aA	191.14 ± 1.31aA	192.14 ± 1.16aA
Chroma	0	6.91 ± 0.07aA	7.03 ± 0.24aA	7.16 ± 0.08aA	7.29 ± 0.11aA
	14	6.82 ± 0.06aA	6.9 ± 0.09aA	6.72 ± 0.06aB	6.86 ± 0.05aB
TSS	0	13.08 ± 0.48aA	13.12 ± 0.19aB	12.78 ± 0.46aB	12.31 ± 0.43aB
	14	14.01 ± 0.26aA	15.58 ± 0.7aA	14.44 ± 0.27aA	14.54 ± 0.53aA
TPC	0	268.1 ± 20.95aA	297.61 ± 16.32aB	278.68 ± 10.41aA	268.42 ± 20.98aA
	14	294.66 ± 19.14aA	349.94 ± 10.79aA	310.1 ± 24.4aA	296.61 ± 5.58aA
FRAP	0	nd	114.21 ± 37.77aA	109.33 ± 34.31aA	98.85 ± 23.04aA
	14	nd	32.45 ± 3.5aA	36.37 ± 7.74aA	28.28 ± 2.64aB
DPPH	0	1469.18 ± 64.72aA	1456.17 ± 36.34aB	1476.26 ± 21.91aA	1345.51 ± 41.13aA
	14	1646.17 ± 102.54aA	1698.62 ± 75.62aA	1593.54 ± 86.3aA	1457.55 ± 38.06aA
Firmness (†)	0	1.74 ± 0.03a	1.66 ± 0.02a	1.61 ± 0.05a	1.65 ± 0.04a
	14	0.5 ± 0.1c	0.59 ± 0.12c	1.06 ± 0.06b	1 ± 0.07b

Mean ± standard error; Different lowercase letters indicate significant differences between treatments on the same day of storage, while different capital letters indicate significant differences between days 0 and 14 of storage of the same treatment by Tukey's test; FRAP was not determined (nd) in the control; To account for the significant interaction between storage time and film treatment on firmness, data were combined into eight categories (†); EX0 – film without added red onion extract, EX5 – film with added 5% red onion extract, EX10 – film with added 10% red onion extract; Total soluble solids; TPC – total phenolic content; FRAP – ferric reducing antioxidant power; DPPH – 2,2-diphenyl-1-picrylhydrazyl

Fresh weight (FW) loss and decay incidence

After 14 days of storage, blueberries showed slight but nonsignificant differences in fresh weight loss between treatments, with 11.44% for EX0, 10.68% for EX5, 9.95% for EX10, and 10.91% for the control, exceeding the maximum marketability range of 5–8% (Nunes et al. 2004). The incidence of decay remained low and did not differ between treatments, averaging 2.34% for EX0 and 0.78% for EX5, EX10, and the control. Similarly, Giuggioli et al. (2017) observed no differences in these parameters in berries packaged in a commercial microperforated polypropylene film and three biodegradable, compostable, nonperforated, starch-based films during storage at 1°C for up to 15 days. Blueberries benefit from low-temperature storage (Paniagua et al. 2014), and the 0–5°C range has been correlated with limited decay (Nunes et al. 2004; Perkins-Veazie et al. 2008).

Compositional quality

Changes in blueberry composition, particularly TSS, TPC, and antioxidant activity and capacity, were monitored before and after 14 days of storage at 3.5°C (Table 2). For all parameters, only differences due to storage time were observed, while the effect of film treatment was marginal.

Blueberries are a rich source of antioxidants, which is attributed to their high phenolic content (Rossi et al. 2022). In the present study, TPC did not differ before and after storage or between treatments, with the exception of EX0, which showed an increase towards the end of storage. TPC in blackberries packaged in commercial polypropylene or cornstarch-based films increased after 5 or 10 days at 1°C and then decreased after 15 days (Giuggioli et al. 2017). Chiabrando and Giacalone (2015) showed that berries immersed in alginate-based coatings increased their TPC during the first 15 days of storage

at 0°C, reaching a peak after 30 days and then decreasing. The antioxidant potential of blueberry fruit was assessed in the present study based on FRAP and DPPH. Berries remained mostly unchanged during storage, but EX10 showed a decrease in FRAP after 14 days. EX0 displayed an increase in DPPH activity, corresponding to TPC. Variations in antioxidant potential were also reported for berries wrapped in cornstarch film and stored at 1°C for up to 15 days (Giuggioli et al. 2017). Edible coatings applied to ‘O’Neal’ and ‘Berkeley’ blueberry fruit induced a heterogeneous response throughout storage, with some treatments promoting increased antioxidant capacity (Chiabrande & Giacalone 2015). Due to the strong influence of genotype on antioxidant activity and TPC of blueberries (Connor et al. 2002), direct comparisons across studies may yield inconclusive results. Nevertheless, the presence of films in the present study likely acted as a barrier, partially protecting berries from the degradation of antioxidant compounds during cold storage (Yang et al. 2019).

Firmness

Firmness is one of the most important quality traits of blueberries. Firmer fruits tolerate handling and transport better than softer ones (Ehlenfeldt & Martin 2002). Firmness is strongly related to sensory perception and influences postharvest quality (Oh et al. 2025; Godara et al. 2025). Postharvest firmness is influenced by enzymatic remodeling of cell walls, water loss via transpiration, and mechanical damage, which contribute to fruit softening (Rivera et al. 2022; Chen et al. 2015). In the present study, firmness was affected by storage ($p < 0.0001$), film ($p < 0.01$), and their interaction ($p < 0.0001$). Firmness decreased after 14 days of storage in all groups: control (71.1%), EX0 (64.6%), EX5 (34.2%), and EX10 (39.1%). The greatest loss of firmness was observed in unwrapped berries and in berries wrapped in films without ROE, visible as areas of greater deformation (Fig. 1C). Films containing extracts maintained higher firmness, although not to the same level as on day 0 (Table 2). In strawberries, coatings of sodium alginate, carboxymethylcellulose, glycerol, calcium chloride, and citric acid containing onion waste extracts promoted higher firmness than the uncoated

control during storage at 4°C for 14 days. Thivya et al. (2021) added shallot peel extracts to sodium alginate and carboxymethylcellulose films to wrap samples of fresh-cut apples and potatoes and then stored them at 4°C for 5 days. The firmness of the fresh-cut products decreased in all samples during storage, but the extract-based films outperformed those without extracts, thus preserving higher levels of this trait.

CONCLUSIONS

Blueberry fruits wrapped in films containing red onion extract and stored at 3.5°C for 14 days darkened and reddened more than those wrapped in films without extract or unwrapped, potentially due to epicuticular changes induced by the onion extract. Antioxidant capacity (ferric reducing antioxidant power) was maintained more effectively by films containing the extract than by the control film after 14 days of storage. The films had no effect on the total soluble solids and antioxidant content of the berries. Storage time affected blueberry firmness. Films with red onion extract (5 or 10%) maintained this trait at a higher level after storage than films without the extract or the unwrapped control. Overall, red onion-based films extended the shelf life of blueberries by delaying the decline in firmness, but other parameters, such as berry color and composition, were either negatively affected or unaffected. Practical application of biofilms containing red onion peel extract requires obtaining repeatable results in further experiments with plant materials (onion cultivars), production methods, a wider range of blueberry cultivars, and consumer assessment of fruit quality.

Author contribution statement

CRC – A – Research concept and design, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

PH – B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, F – Final approval of the article

KA – A – Research concept and design, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

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