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Effect of edible coatings on some quality characteristics of sweet cherries

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Abstract: Gelatine (G), carboxy-methylcellulose (CMC) and soy protein isolate (SPI) edible films were prepared at three different concentrations (1, 3 ,5%; 2, 3, 4%; and 3, 5 ,7% respectively) and heated at two different application temperatures (60 and 80ºC) before coating sweet cherry (*Prunus avium* L., cv. 'Sweetheart') fruit. Glycerol was used as a plasticiser, and each film was characterised for their resistance to water, acid and alkali. Standard fruit quality characteristics including changes in stem colour, moisture loss, fruit soluble solids content (SSC) and titratable acidity (TA) were monitored during storage at 2ºC. The SPI films were more resistant to water and alkali, while the most resistant to acid were gelatine films. CMC and SPI films showed increased resistance with increasing concentrations, while no concentration effect was observed for G films. Amongst the different films heated at 60ºC, the gelatine film ensured the lowest moisture loss during storage, while amongst films heated at 80ºC CMC was the most effective at reducing water loss. Fruit SSC for all coated cherries decreased during storage for two weeks, irrespective of the coating. The TA of the fruit coated with CMC and SPI decreased during cold storage and also with increasing concentration. However, there were no significant trends observed for gelatine coated samples. Results obtained in this study indicate that there is great potential to counteract moisture loss, the main parameter associated with quality loss in cherries by application of simple films after harvest.

Keywords: Edible films, coatings, cherry, gelatin, SPI, CMC, quality, storage

Introduction

There is increasing consumer interest in reducing or replacing non-biodegradable food packaging which has renewed interest in the development of edible / biodegradable films or coatings (Wang *et al*., 2007). There are many successful techniques (such as controlled atmosphere, modified atmosphere packaging, plastic film packaging, etc.) which have become standard practice, however edible coatings / films are of great interest and continue to be extensively studied for their potential ability to maintain the quality of fresh fruits and vegetables (Debeaufort *et al*., 1998; Wu *et al*., 2002; Olivas and Barbosa-Canovas, 2005; Burtoom, 2008). The great range of potential film-forming biopolymers includes proteins (Gennadios *et al*., 2002) and polysaccharides (Gennadios, 2002), which are useful in food application due to their ability to establish polymer interactions and create a continuous network responsible for the functional properties of films (Olivas and Barbosa-Canovas, 2005). Film-forming proteins such as gelatin (G), sodium caseinate (SC), soy protein isolates (SPI), whey protein isolates (WPI), and polysaccharides such as carboxymethyl cellulose (CMC), methylcellulose (MC) and hydroxypropyl methylcellulose (HPMC) are commercially available at relatively low cost (Wang *et al*., 2007), and are therefore prime candidates for application on minimally processed and whole fruits.

Sweet cherries are a commodity of great economic importance in many production areas around the world (Romanazzi *et al*., 2003). Cherries are a good source of antioxidants, anthocyanin, phenolic compounds and melatonin, which may help to relieve arthritis, gout and even fight cancer and heart disease (McLellan and Padilla-Zakour, 2005). These possible health benefits have generated significant interest in fresh cherries and cherry products. The characteristic taste of sweet cherries is to a large extent due to the balance of sugars and acid composition. The predominant organic acid in cherries is malic acid, however a range of organic acids including citric, succinic, fumaric and quinic acids are also present in many varieties (Girard and Kopp, 1998; McLellan and Padilla-Zakour 2005). The main sugars in sweet cherries are glucose and fructose, with sucrose and sorbitol being only minor sugar components (Girard and Kopp, 1998).

Sweet cherry fruit are highly perishable and their quality rapidly deteriorates after harvest, and often the fruit does not reach the consumer at optimal quality

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after extensive transport and marketing (Remon *et al*., 2003; Martinez–Romero *et al*., 2006). Cherries are particularly susceptible to deterioration if they are not carefully handled and stored. The optimum storage conditions for sweet cherries are at 0°C with 90 to 95% RH (McGlasson *et al*., 2009). Almost 80% of the weight of cherries comprises of water and therefore any exposure of the fruit caused by rough handling during harvesting or postharvest operations can deleteriously affect final consumer fruit quality. Cherries are particularly prone to flesh cracking, pitting and bruising during its growth, harvest and during postharvest handling and storage.

The main causes of sweet cherry deterioration are weight loss, colour changes, softening, surface pitting stem browning and loss of acidity (Bernalte *et al*., 2003). These quality changes are due to the high respiration rate of the cherry fruit which results in a very short shelf-life (Alonso and Alique, 2004). The appearance of fresh cherries is also a critical quality assessment to consumers. A 'fresh' shiny appearance with a green stem, free from brown discolouration is highly desirable (McGlasson *et al*., 2009).

Various edible films and coatings have been applied to cherry fruit and include aloe vera gels (Martinez-Romero *et al*., 2006), fatty acid derivatives (Yaman and Bayoundurlu, 2002; Alonso and Alique, 2004), and chitosan (Aider and de Halleux, 2008). However no single coating formulation has provided a sufficiently effective treatment to maintain fruit quality during storage. As simple edible coatings provide an economical and relatively easy to adopt method, with potential applications immediately after harvest in the packing shed, the aim of this study was to characterise three types of edible films and evaluate their effects on moisture loss, TSS and TA of sweet cherries.

Materials and Methods

Materials

Sweet cherries (*Prunus avium* L., cv Sweetheart) were obtained from a local commercial orchard in Orange, NSW (Australia) and transported and stored at 0ºC until treatment, within two days. Gelatin (G) (Ward McKenzie), soy protein isolates (SPI) (ADM), carboxymethyl cellulose (CMC) (medium viscosity, Sigma), and glycerol (Sigma) were used.

Methods

Preparation of film solutions

Films were prepared according to Wang *et al*. (2007). Specifically G (1, 3, 5%, w/w), SPI (5, 7, 9%, w/w), and CMC (2, 3, 4%, w/w), were solubilised with distilled water. Glycerol was added as plasticizer to each solution at a constant glycerol: powder ratio of 1:2 (w/w). Glycerol solutions (glycerol and distilled water) were preheated at the designated heating temperature for 5 minutes. All solutions were stirred continuously on a magnetic stirrer hotplate, until powders were completely dissolved. Solutions were placed in 60 and 80°C water bath, held for 30 minutes and subsequently cooled to 40°C.

Application of films to cherry fruit

Uniform cherry fruit that were free of defects were selected at random and immersed in film solutions for two minutes, then transferred to labelled aluminium foil containers for storage at 2ºC at high relative humidity. Each container contained eight cherries and was considered a replicate. The experiment was replicated three times.

Physical assessment of film formation

Five ml of each of the film solutions were pipetted into level circular Teflon-coated muffin pans and dried for 24 h at 50 ± 5% RH and 23 ± 2°C. Air bubbles were removed where necessary. The formed films were peeled from the casting pans prior to testing.

Film resistance to water, acid and alkali

Resistance to water, acid, and alkali were determined as previously described (Wang et al., 2007). Pre-dried film samples at 24 h at 50 ± 5% RH and 23 ± 2°C were dried in an oven at 100 ± 10°C for 24 h. Oven-dried film samples were trimmed into small strips of constant size and weight. Each dried sample (0.05-0.20 g) was then immersed in 4 ml of either: distilled water, hydrochloric acid (pH 4.0) or sodium hydroxide (pH 10.0), and placed inside small bottles for 24 h. Film samples were then re-dried at 100 ± 10°C for 24 h. Sample weights were determined and re-dried samples were calculated. Resistances were calculated as:

$$Resistance = \frac{Initial\ weight - final\ weight}{Initial\ weight} \times 100\%$$

This experiment was replicated four times.

Effect of coatings on cherry fruit moisture loss

The fresh weights of cherries were measured every two days and moisture losses were calculated as:

$$Moisture\ loss\ \%\ on\ day\ X = \frac{Weight\ (day\ 0) - weight\ (day\ X)}{weight\ (day\ 0)} \times 100\%$$

(Where X is the day of which the measurement was taken, ranging from 0 to 12).

Effects of coatings on cherry fruit total soluble solids content (TSS)

Cherry juice was extracted, filtered, and soluble solids content (Brix %) was measured using a digital refractometer (Atago Palette PR-32α).

Effects of coatings on cherry fruit titratable acidity (TA)

Cherry juice was extracted, filtered, and titratable acidity was measured by titration according to Aider and de Halleux (2008).

Effects of coatings on cherry stem browning

Stem browning was subjectively visually assessed and rated on a four point scale [1 = no browning, 2 = slight browning, 3 = moderate browning (< 25% green), 4 = severe browning (> 25% brown plus severe shrivel)].

Statistical Analysis

Statistical significance of results was determined by performing one and two way ANOVA using SPSS 16.0 for Windows.

Results and Discussion

Fresh cherry fruit are a relatively high value commodity, which have a short storage and shelf-life. Considering the importance of postharvest in the supplying cherries onto the world markets, there are surprisingly few postharvest cherry experiments in the literature (Esti *et al*., 2002; Romano *et al*., 2006), particularly using edible films.

One of the major limiting factors of cherry storage is stem browning. This is where the cosmetic desiccation of the stem is a large consumer factor in assessing cherry fruit quality. Although there were some statistically significant differences in stem browning between coating at both the 60°C and 80°C treatment temperatures (Table 1), these differences between the different films and application temperatures were commercially negligible, with all fruit stems being between Scores 1 and 2 – slight browning / desiccation. There was no difference between the difference concentrations of the same coatings. This illustrates that all the different coatings were equally effective in maintaining stem condition during two week storage at 2°C.

The eating quality of cherries is highly dependent on fruit SSC where fruit with high SSC are highly valued by consumers. Cristosto *et al*. (2003) showed

Table 1. Effect of different films (concentration, type and application temperatures) on subjective assessment in browning of 'Sweetheart' cherry fruit stems after two weeks of cold storage in air at 2°C

60°C application			80°C application		
Type	Conc.(%)	Score	Type	Conc. (%)	Score
CMC [1]	2	2.0	CMC [1]	2	2.7
	3	2.0		3	2.4
	4	2.1		4	2.4
G [1]	1	1.9	G [1,2]	1	2.5
	3	1.9		3	2.1
	5	2.1		5	2.3
SPI [2]	3	2.2	SPI [2]	3	2.2
	5	2.5		5	2.3
	7	2.2		7	2.1

For each temperature treatment, coating types with different superscript numbers are significantly different (p≤0.05).

that at least with the variety 'Bing' a SSC of at least 16%, without regard for TA, is considered desirable. The effect of the different coatings on the final SSC of the cherries after two weeks storage at 2°C is presented in Table 2. The results show that there were some differences in SSC content between the different coatings when applied at 60°C, but no differences between coatings were observed when applied at 80°C. Within each film type there were few differences between the different concentrations of the films, except with the 60°C application of SPI, where 5% concentration of SPI resulted in significantly higher SSC than the other levels of SPI. Whilst the SSC of the fruit treated with CMC at 80°C was highest following treatment with the lowest level of CMC (2%), and lowest SSC with the highest level of CMC (4%).

Table 2. Effect of different films (concentration, type and application temperatures) on 'Sweetheart' cherry fruit SSC% after two weeks of cold storage in air at 2°C

60°C application			80°C application		
Type	Conc.(%)	SSC%	Type	Conc. (%)	SSC%
CMC [1]	2	15.1	CMC	2	17.2 [a]
	3	15.3		3	15.1 [b]
	4	14.6		4	13.2 [c]
G [2]	1	17.5	G	1	16.6
	3	17.3		3	15.9
	5	16.2		5	15.8
SPI [1,2]	3	15.3 [b]	SPI	3	16.0
	5	17.9 [a]		5	15.9
	7	15.0 [b]		7	15.4

For each temperature treatment, coating types with different superscript numbers are significantly different (p≤0.05).
Within each coating type values with different superscript letters are significantly different (p≤0.05).

TA is important consumer variable as the balance of SSC and TA relates to overall taste and consumer acceptability. In this experiment, the different type of coatings or coating temperature did not affect the level of TA in the cherry fruit after storage (Table 3). All fruit had similar TA after storage, except within the CMC treated fruit at 60°C, where the 4% CMC treated fruit had the lowest level of TA (as compared to the other 60°C CMC treated fruit).

Moisture loss from the cherry fruit (as measured by weight loss over time) showed that there were no consistent differences between the coating types (Table 4). There was no significant difference between the SPI coatings applied at 60°C to the other

Table 3. Effect of different films (concentration, type and application temperatures) on 'Sweetheart' cherry fruit TA (mg/100 g of L-malic acid) after two weeks of cold storage in air at 2^{o}C

60^{o}C application			80^{o}C application		
Type	Conc.(%)	TA	Type	Conc. (%)	TA
CMC	2	0.32^{a}	CMC	2	0.33
	3	0.32^{a}		3	0.30
	4	0.27^{b}		4	0.28
G	1	0.29	G	1	0.33
	3	0.36		3	0.31
	5	0.36		5	0.36
SPI	3	0.35	SPI	3	0.32
	5	0.32		5	0.30
	7	0.31		7	0.29

Within each coating type values with different superscript letters are significantly different ($p \leq 0.05$).

Table 4. Effect of different films (concentration, type and application temperatures) on water loss in 'Sweetheart' cherry fruit after two weeks of cold storage in air at 0^{o}C

60^{o}C application			80^{o}C application		
Type	Conc. (%)	Water loss (%)	Type	Conc. (%)	Water loss (%)
CMC ^{1}	2	0.72	CMC^{1}	2	1.88^{a}
	3	0.72		3	0.68^{b}
	4	0.77		4	0.27^{b}
G ^{2}	1	0.38^{b}	G^{2}	1	0.56
	3	0.48^{ab}		3	0.36
	5	0.66^{a}		5	0.54
SPI ^{1,2}	3	0.86	SPI^{2}	3	0.59
	5	0.84		5	0.70
	7	0.93		7	0.49

For each temperature treatment, coating types with different superscript numbers are significantly different ($p \leq 0.05$).
Within each coating type values with different superscript letters are significantly different ($p \leq 0.05$).

coatings, but the G coating had a lower level of water loss over the storage period, as compared to CMC coating. However the water loss in cherries with the films applied at 80^{o}C showed there was no difference between the G and SPI coatings. Within the coating types, there was no consistent treatment difference with the difference concentrations of coatings in relation to water loss. The only significant difference within the coatings applied at 80^{o}C was within the CMC films, where the highest concentration of CMC resulted in the lowest water loss. However in the 60^{o}C temperature application the only significant difference was observed in the G coating, where the lower concentrations of G resulted in lower water loss. A typical pattern of water loss from the cherry fruit is presented in Figure 1, which illustrates the rapid loss of water from the cherry fruit during the initial stages of storage, but then this level plateaued during the storage period at 2^{o}C.

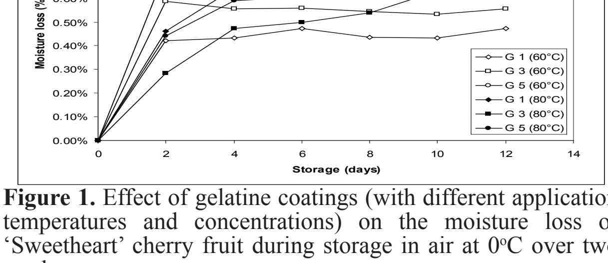

Figure 1. Effect of gelatine coatings (with different application temperatures and concentrations) on the moisture loss of 'Sweetheart' cherry fruit during storage in air at 0^{o}C over two weeks

Chemical resistance to different various solvents, such as water, acid and base, is an important physical property of edible coatings. The chemical resistance of the different coatings to water, acid and base solutions is presented in Table 5. The results show that across coating types the SPI had higher resistance to water than CMC and G. Gelatin films were the most resistant to acid, while SPI were significantly more resistant to the base solution.

Table 5. Chemical resistance of the different edible films to acid, base and water treatment

Type	Conc. (%)	Resistance (%) Water	Type	Resistance (%) Acid	Type	Resistance (%) Base
CMC^{1}	2	26.42 ^{b}	CMC^{1}	23.21 ^{a}	CMC^{1}	24.45 ^{a}
	3	32.06 ^{a}		19.12 ^{b}		19.50 ^{b}
	4	21.81 ^{c}		18.14 ^{b}		17.37 ^{b}
G^{1}	1	30.70 ^{a}	G^{2}	19.73 ^{a}	G^{1}	20.49 ^{a}
	3	31.26 ^{a}		16.15 ^{b}		16.97 ^{b}
	5	20.80 ^{b}		18.24 ^{ab}		21.97 ^{a}
SPI^{2}	3	22.46 ^{a}	SPI^{1}	25.94 ^{a}	SPI^{2}	15.93 ^{a}
	5	16.68 ^{b}		19.07 ^{b}		12.69 ^{b}
	7	17.06 ^{b}		19.07 ^{b}		13.47 ^{b}

For each solvent, coatings types with different superscript numbers are significantly different ($p \leq 0.05$).
Within each coating type values with different superscript letters are significantly different ($p \leq 0.05$).

Within CMC based coatings, films made from higher concentration solutions had higher mean resistance, although the differences observed were significant only for resistance to water. In contrast, although for some G films of different concentrations some significant differences in resistance to solvents were observed, there were no clear trends linking concentration with resistance. This finding is in agreement with Wang *et al*. (2007) who have observed no significant differences or trends in concentrations of up to 8%. For SPI films, the lowest concentrations were significantly less resistant to water, acid and base solutions; however, increasing the SPI concentration from 5 to 7% did not have a significant effect on the films' resistance.

Conclusion

The results indicate that there is further scope to develop edible coatings for cherry fruit. Cherries are an ideal candidate for the application of edible coatings due to their perishable nature and high value. The application of edible coatings could easily be integrated in the current handling system and would provide additional shelf-life benefits to the fruit. However more work is required to optimise coating type, concentration etc and further examine their effects on other important quality attributes such as decay development and firmness loss.

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