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Physical properties and sensory acceptability of gum arabic-coated cherry tomato fruit during storage

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Abstract

Cherry tomato is a small climacteric fruit with a short shelf life ranging from 5 to 7 days due to postharvest diseases, accelerated ripening, and senescence, all of which cause losses in quantity and quality. An edible coating can be used to extend the shelf life of fresh fruits by acting as a barrier against the transfer of oxygen, carbon dioxide, moisture, aroma, and volatile compounds during storage. This research focused on the effect of gum arabic on the physical properties and sensory acceptability of cherry tomatoes during cold storage at 13 and 25˚C. Weight loss, firmness, and colour (L*, C*, and h*) of control and coated cherry tomato fruits were measured during storage at 13 and 25˚C, as well as the sensory acceptability of samples after 16 days at 13˚C. Coating cherry tomatoes with gum arabic (2-5% w/w) significantly decreased weight loss while maintaining firmness and colour during storage. In sensory evaluation, the coated samples obtained the same or significantly higher acceptability scores than the control samples, especially in appearance, texture, and overall acceptance.

1. Introduction

Cherry tomato (*Solanum lycopersicum* var. cerasiforme) is a small climacteric fruit (<20 g for standard cherry tomato and 20-50 g for cocktail cherry tomato) with a bright red colour, rich beneficial nutrients, delicious flavour and a firm texture (Ergun *et al.*, 2006; Causse *et al.*, 2011; Aragüez *et al.*, 2020). The consumption of cherry tomato fruits has increased since they contain high levels of sugar and phytochemicals such as beta-carotene, lycopene, quercetin, and polyphenols (Pinheiro *et al.*, 2013).

During postharvest, respiration of fruits and vegetables continuously occurs, as well as oxidation and enzymatic reactions in plant cells (Rojas-Graü *et al.*, 2009), resulting in a short shelf life ranging from 5 to 7 days depending on the time of harvest and storage temperature (Guerreiro *et al.*, 2016). Moreover, ethylene is an important hormone leading to fruit ripening with changes in biochemical, physical, and physiological properties of tomatoes (Zapata *et al.*, 2008). These biochemical changes directly affect phenolic compounds and sensory qualities, especially the flavour and texture of the fruits (Khalil *et al.*, 2020). Storage at a low temperature is one of the simple techniques to delay respiration rate and ethylene production, resulting in the increased shelf life of tomato fruits. However, it is recommended that tomatoes should be stored in cold storage (10°C or higher) after harvest to avoid chilling injury (Roberts *et al.*, 2002; Zapata *et al.*, 2008).

Edible coatings made of biomolecules can be used as semipermeable membranes to reduce the respiration rate and delay ripening (Aday and Caner, 2010). A thin layer of edible materials, such as protein, polysaccharides, and lipid, is usually used to coat the surface of fruits and vegetables by dipping or spraying followed by air-drying (Vargas *et al.*, 2008; Tahir *et al.*, 2018). These edible films act as a barrier against the transfer of oxygen, carbon dioxide, moisture, aroma, and volatile compounds of fruits during storage (Sharma *et al.*, 2018).

Gum arabic or acacia gum (E 414 EC) is the air-dried exudation from the stem and branches of *Acacia Senegal* and *Acacia seyal* (Lopez-Torrez *et al.*, 2015; Tahir *et al.*, 2019). It is widely used as a stabilizer, thickener, emulsifier, gelling agent, and edible coating in

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food and pharmaceutical products (Lopez-Torrez *et al.*, 2015; Sulieman, 2018). The backbone and side-chain of gum arabic are 1, 3-linked β-D-galactopyranosyl units with 1, 6-linkage (Lopez-Torrez *et al.*, 2015). Its molecule mainly contains a high number of polysaccharides (97%), such as D-galactose, L-arabinose, and L-rhamnose, with a few proteins (<3%) (Montenegro *et al.*, 2012). There are recent studies of gum arabic-based edible coatings on several fresh fruits and vegetables, for example, guava (Murmu and Mishra, 2017; 2018), mature green papaya (Ali *et al.*, 2016), mango (Khaliq *et al.*, 2015), strawberry (Tahir *et al.*, 2018), and tomato (Ali *et al.*, 2010; Ali *et al.*, 2013).

This research aimed to investigate the effect of a coating of gum arabic on the physical properties and sensory acceptance of cherry tomato fruits during storage at 13±2 and 25±2°C.

2. Materials and methods

2.1 Materials

Fresh cherry tomatoes (*Solanum lycopersicum* var. cerasiforme) at the light red stage of ripening (USDA, 1991) were purchased from Siam Makro Public Company Limited, Bangkok, Thailand and transferred to the laboratory within 1 hr of purchase. Sodium hypochlorite ($CaCl_2O_2$) was purchased from Suksapanpanit, Bangkok, Thailand. Gum arabic (food grade) and sodium hydroxide (NaOH; analytical grade) were purchased from Chemipan Corporation Co., Ltd., Thailand.

2.2 Sample preparation and treatment procedures

The cherry tomato fruits were visually sorted for uniformity in size, as well as for the absence of blemishes and fungal infection. The fruits were thoroughly washed with 0.05% (w/w) $CaCl_2O_2$ for 3 mins, followed by distilled water for 3 mins, and air-dried at 27±2°C for 30 mins (Al-Juhaimi *et al.*, 2012).

Gum arabic solutions at concentrations of 1, 2, 3, 4, and 5 % (w/w) were prepared by dissolving 2, 4, 6, 8, and 10 g of gum arabic in 198, 196, 194, 192, and 190 g distilled water, respectively. The formulations were selected according to preliminary experiments. The solutions were heated at 40°C and continuously stirred for 60 mins on a hotplate magnetic stirrer (Model: HTS-1003, LMS, Japan), then filtered using a vacuum flask with filer paper no.4 (90 mm in diameter) to remove undissolved impurities before cooling at 27±2°C for 1 hr (Al-Juhaimi *et al.*, 2012). Then, 1 N NaOH was used to adjust the pH of the solutions to 5.6 (Ali *et al.*, 2013).

The fruits were immersed in deionized water (control) or each coating solution for 2 mins. The whole fruit surface was coated uniformly and air-dried at 27±2 °C for 1 hr. The coated fruits were packed in perforated polyethylene bags (9 fruits/bag). Half of the samples were stored in a chamber at 13±2°C and 35-40% RH for 16 days. At this storage temperature, the data was collected at 0, 4, 8, 12, and 16 days of storage. The other half of the samples were stored in a chamber at 25±2°C and 35-40% RH for 8 days. At this storage temperature, the data was collected at 0, 2, 4, 6, and 8 days of storage.

2.3 Weight loss

Weight loss corresponding with water loss at different days of storage at 13±2 and 25±2°C was measured to determine the effectiveness of the gum arabic coating as a moisture barrier. The weight of three samples in each treatment was monitored and the weight loss per cent relative to initial weight was calculated according to Aragüez *et al.* (2020).

2.4 Firmness

The firmness of samples was measured using a texture analyser, TA.XT2i (Stable Micro Systems Ltd., U.K.). A force using a cylinder stainless probe of 2 mm diameter was applied to the sample placed on the HDP/CFS (Crisp Fracture Support Rig and corresponding platform, SMS). Three samples from the triplicate were used for firmness measurements as described by Yun *et al.* (2015) at 25±2°C. The maximum force (g.force) was recorded as the firmness of the fruit.

2.5 Colour

The colour of the skin surface was determined using the CIELAB colour parameters by a Hunter colourimeter (Color Quest 45/0, Hunter Associates Laboratory, Inc., Reston, V.A., U.S.A.) at 25±2°C according to Sumonsiri (2017). Three samples per treatment were measured in each replicate. CIE L*C*h* colour parameters (L*: lightness, C*: chroma, and h*: hue angle) for 10° vision angle and D65 illuminant were measured.

2.6 Sensory acceptance

Three selected samples with the lowest weight loss, as well as appropriate texture and colour, were evaluated for sensory acceptability based on appearance, colour, texture (by touching and pressing using a finger), and overall acceptance compared to the control sample by 30 untrained panellists screened from juniors and seniors in the Faculty of Applied Science, King Mongkut's University of Technology North Bangkok, Thailand. All samples were stored at 13±2°C for 8 days before sensory evaluation. They were randomly labelled with a 3-digit number for identification and presented in random order.

The sensory attributes of samples were rated using a nine -point hedonic scale from 9 to 1, where 9 represented "like extremely" and 1 represented "dislike extremely".

2.7 Statistical analysis

All analysis was run in triplicate with three subsamples. Significant differences among averages were analysed with analysis of variance (ANOVA) and Duncan's multiple range test (DMRT) at a 95% confidence level using IBM SPSS Statistics 25 (IBM Corporation, Armonk, NY).

3. Results and discussion

3.1 Weight loss

Weight loss is commonly found in fresh produce due to respiration and vapour pressure gradients between the fruit or vegetable and the environment, resulting in wilting and consequently low consumer acceptance (Ali *et al*., 2010). Table 1 presents the weight loss of cherry tomato fruits coated with different concentrations of gum arabic during storage at 13±2 and 25±2°C. Concentrations of gum arabic, storage temperature, and storage time significantly affected the weight loss of the cherry tomato fruits ($p<0.05$). All fruit samples showed a gradual weight loss during storage. As the concentration of gum arabic increased, the weight loss of samples tended to decrease at both storage temperatures. At the end of storage in this research, the samples with the lowest weight loss were the cherry tomato fruits coated with 4% and 5% gum arabic. Edible coatings theoretically act as semipermeable barriers against gas and water movement into the atmosphere (Olivas *et al*., 2003). Similar results were observed when gum arabic was used as an edible coating for tomatoes (Ali *et al*., 2010), cucumbers (Al-Juhaimi *et al*., 2012), strawberries (Tahir *et al*., 2018) and mangoes (Khaliq *et al*., 2015; Daisy *et al*., 2020).

3.2 Firmness

Firmness is one of the important properties used to indicate the freshness of fruits and vegetables (Sharma *et al*., 2018). Table 2 shows the firmness of cherry tomato fruits coated with different concentrations of gum arabic during storage at 13±2 and 25±2°C. Concentrations of gum arabic, storage temperature, and storage time significantly affected the firmness of the cherry tomato fruits ($p<0.05$). Coated fruit samples tended to be firmer and soften at a slower rate than uncoated fruits during storage. Firmness loss occurs in the structure of the cell wall where pectin is degraded by the pectic enzyme and changed into protopectin (Sharma *et al*., 2018). Gum arabic coating can provide structural rigidity to the fruit surface (Tahir *et al*., 2020). Moreover, pectin chains can be depolymerized or shortened by pectinesterase and polygalacturonase during ripening (Yaman and Bayoindirli, 2002). The same trend was also found in the gum arabic coating on tomatoes (Ali *et al*., 2010), cucumbers (Al-Juhaimi *et al*., 2012), mangoes (Khaliq *et al*., 2015), guavas (Murmu and Mishra, 2018) and blueberries (Tahir *et al*., 2020).

3.4 Colour

Colour is an important physical factor that is used to indicate the flavour and freshness of fresh and processed fruits and vegetables during purchase (Parthare *et al*.,

Table 1. Weight loss of cherry tomatoes coated with 0-5% w/w gum arabic during storage.

Gum arabic concentration	Days of storage at 13±2 °C			
(% w/w)	4	8	12	16
Control	1.84±0.05^{a}	5.86±0.16^{a}	9.03±0.34^{a}	12.01±0.88^{a}
1	1.69±0.05^{b}	5.29±0.10^{b}	8.71±0.33^{a}	10.95±0.85^{b}
2	1.58±0.06^{b}	5.24±0.18^{b}	7.61±0.44^{b}	10.57±0.23^{bc}
3	1.43±0.05^{c}	4.75±0.20^{c}	7.16±0.18^{b}	9.78±0.16^{c}
4	1.61±0.08^{b}	4.70±0.30^{c}	5.81±0.50^{c}	10.64±0.20^{bc}
5	1.43±0.10^{c}	4.79±0.16^{c}	5.71±0.49^{c}	9.81±0.15^{c}
Gum arabic concentration	Days of storage at 25±2 °C			
(% w/w)	2	4	6	8
Control	2.81±0.14^{a}	4.86±0.11^{a}	5.60±0.16^{a}	8.59±0.49^{a}
1	2.71±0.15^{a}	4.70±0.21^{a}	5.55±0.36^{a}	7.28±0.29^{b}
2	2.47±0.13^{ab}	4.43±0.24^{b}	5.55±0.28^{a}	7.43±0.37^{b}
3	2.44±0.16^{ab}	3.97±0.22^{c}	5.67±0.28^{a}	7.77±0.15^{b}
4	2.29±0.10^{bc}	3.97±0.03^{c}	4.88±0.23^{b}	6.08±0.09^{c}
5	2.02±0.19^{c}	4.12±0.13^{bc}	4.57±0.17^{b}	6.07±0.22^{c}

Values are presented as mean±SD (n = 3). Values with different superscripts within the same column on the same day of storage are significantly different at $p<0.05$.

Table 2. Firmness (g.force) of cherry tomatoes coated with 0-5% w/w gum arabic during storage.

Gum arabic concentration	Days of storage at 13±2 °C				
(% w/w)	0	4	8	12	16
Control	397.13±50.50^{c}	373.41±43.34^{c}	321.58±33.44^{c}	338.07±39.27^{b}	358.31±26.23^{b}
1	348.65±41.22^{c}	321.66±46.37^{c}	323.90±18.38^{c}	342.94±35.35^{b}	332.68±14.57^{b}
2	395.78±49.45^{c}	360.61±45.37^{c}	329.71±16.74^{c}	317.67±15.06^{b}	319.79±25.32^{b}
3	425.75±27.59^{bc}	356.96±9.64^{c}	325.68±11.05^{c}	368.00±34.58^{b}	335.25±14.97^{b}
4	471.94±11.02^{b}	483.21±11.04^{b}	460.20±47.39^{b}	361.72±16.54^{b}	352.79±14.67^{b}
5	579.07±8.68^{a}	551.37±19.59^{a}	538.03±49.67^{a}	452.84±28.28^{a}	434.04±10.93^{a}
Gum arabic concentration	Days of storage at 25±2 °C				
(% w/w)	0	2	4	6	8
Control	428.50±11.58^{c}	383.09±45.97^{b}	367.81±24.06^{b}	365.04±20.33^{b}	323.32±28.46^{b}
1	470.83±19.39^{bc}	545.43±31.75^{a}	520.63±15.88^{a}	530.80±30.57^{a}	509.35±11.16^{a}
2	530.67±51.16^{ab}	536.03±2.33^{a}	541.62±10.37^{a}	525.36±15.56^{a}	503.70±34.12^{a}
3	598.49±44.36^{a}	544.66±29.93^{a}	550.10±17.71^{a}	529.34±25.85^{a}	540.80±50.57^{a}
4	588.19±14.16^{a}	541.13±44.69^{a}	534.21±12.41^{a}	541.82±26.20^{a}	525.31±32.61^{a}
5	577.67±73.93^{a}	559.17±39.18^{a}	543.59±28.45^{a}	538.33±24.45^{a}	515.51±11.74^{a}

Values are presented as mean±SD (n = 3). Values with different superscripts within the same column on the same day of storage are significantly different at *p*<0.05.

2013). Colour parameters (L*, C* and h*) of cherry tomato fruits coated with different concentrations of gum arabic during storage at 13±2 and 25±2°C are shown in Tables 3-5. At 13±2°C, there was no significant difference between uncoated and coated samples in all parameters (p≥0.05). However, a significant difference between samples (p<0.05) was found in C* at the end of storage (Table 4) and h* during storage (Table 5). The coated fruits had a slower colour change when compared to the uncoated ones, which could be due to the delay in the ripening process (Tahir *et al.*, 2020). During ripening, chlorophyll is degraded while carotenoids, especially lycopene, are accumulated (Ali *et al.*, 2010). A similar trend was observed by coating gum arabic on tomato (Ali *et al.*, 2010) and mango fruits (Khaliq *et al.*, 2015).

3.5 Sensory acceptance

Since coating cherry tomatoes with 1-2% gum arabic did not show much difference when compared to the control sample. Gum arabic with concentrations of 3-5% was selected for the acceptance test. Figure 1 shows the acceptance scores of the control and cherry tomatoes coated with 3-5% gum arabic after 8 days of storage at 13±2°C. There was no significant difference (p≥0.05) in colour acceptance between samples, but the samples with 4-5% gum arabic coating obtained significantly higher acceptance scores in appearance, texture, and overall

Table 3. Lightness (L*) of cherry tomatoes coated with 0-5% w/w gum arabic during storage.

Gum arabic concentration	Days of storage at 13±2 °C				
(% w/w)	0^{ns}	4^{ns}	8^{ns}	12^{ns}	16^{ns}
Control	34.84±0.86	33.16±0.58	31.65±0.56	31.79±0.15	30.62±1.35
1	34.86±0.55	34.64±0.91	32.08±2.01	31.42±1.85	29.76±1.82
2	36.07±2.65	33.92±2.34	31.88±1.65	32.27±1.00	30.93±0.03
3	35.64±1.05	35.18±3.44	34.81±3.73	32.39±3.84	32.09±0.53
4	33.76±0.76	34.34±0.72	33.80±0.72	32.37±0.13	31.17±0.47
5	33.85±1.05	34.01±0.64	32.77±1.63	31.71±1.12	31.18±0.33
Gum arabic concentration	Days of storage at 25±2 °C				
(% w/w)	0^{ns}	2^{ns}	4^{ns}	6^{ns}	8^{ns}
Control	29.82±0.25	29.15±0.88	32.59±0.79	33.63±0.17	33.71±0.68
1	29.30±0.39	28.38±0.08	33.72±0.29	34.85±0.07	34.22±0.56
2	29.54±0.77	28.81±0.52	32.86±1.26	33.78±0.96	33.53±0.57
3	30.22±1.03	29.27±0.15	33.74±0.72	34.10±0.35	33.33±0.82
4	29.57±0.09	29.01±0.12	33.41±1.08	32.94±1.27	34.17±1.64
5	29.34±0.33	28.80±0.07	33.74±1.05	34.08±0.19	33.96±0.16

Values are presented as mean±SD (n = 3). ^{ns}not significantly different at *p*<0.05.

Table 4. Chroma (C*) of cherry tomatoes coated with 0-5% w/w gum arabic during storage.

Gum arabic concentration (% w/w)	Days of storage at 13±2 °C				
	0[ns]	4[ns]	8[ns]	12[ns]	16[ns]
Control	34.46±3.08	31.79±0.80	31.12±2.86	31.36±1.64	30.70±1.37
1	29.27±4.32	29.21±0.82	33.20±4.46	30.58±3.06	30.89±3.14
2	27.92±0.58	27.67±3.43	33.03±2.21	34.16±2.76	30.98±2.14
3	30.36±4.93	29.56±3.09	29.56±3.09	32.86±6.90	30.14±1.64
4	29.30±4.08	27.05±5.59	27.41±0.75	31.40±3.62	27.64±1.46
5	30.03±2.57	26.72±0.16	28.04±0.11	28.74±2.21	27.98±0.98
Gum arabic concentration (% w/w)	**Days of storage at 25±2 °C**				
	0[ns]	2[ns]	4[ns]	6	8
Control	25.67±0.68	24.43±0.78	23.26±1.88	24.42±0.26[b]	23.30±0.67[c]
1	25.78±1.78	25.37±0.58	25.71±1.14	25.98±0.32[a]	24.81±1.14[b]
2	26.82±0.78	24.81±0.38	25.99±0.75	26.45±0.21[a]	26.17±0.21[a]
3	25.67±0.89	25.37±0.89	27.43±2.41	25.98±1.30[a]	25.03±0.75[ab]
4	26.78±0.67	25.73±0.64	27.72±1.26	25.86±1.16[a]	26.31±0.35[a]
5	25.33±1.63	24.78±0.48	25.56±1.71	26.84±0.23[a]	26.02±0.78[a]

Values are presented as mean±SD (n = 3). Values with different superscripts within the same column on the same day of storage are significantly different at p<0.05. [ns]not significantly different at p<0.05.

Table 5. Hue angle (h*) of cherry tomatoes coated with 0-5% w/w gum arabic during storage.

Gum arabic concentration (% w/w)	Days of storage at 13±2 °C				
	0[ns]	4[ns]	8[ns]	12[ns]	16[ns]
Control	40.03±1.29	40.95±2.34	39.27±1.68	38.73±0.87	39.33±1.27
1	41.04±1.06	39.06±0.36	39.94±0.24	38.94±0.83	39.88±0.67
2	40.78±1.43	39.97±1.37	39.76±0.47	39.67±1.02	39.19±0.33
3	38.75±0.62	38.51±0.72	38.66±0.83	40.00±0.39	39.28±0.92
4	40.94±0.84	40.07±0.58	39.84±0.69	39.72±1.37	38.71±1.64
5	42.07±0.61	40.07±2.31	39.62±1.75	39.84±1.24	39.05±1.29
Gum arabic concentration (% w/w)	**Days of storage at 25±2 °C**				
	0	2	4	6	8
Control	39.34±1.84[a]	38.52±2.27[a]	38.72±1.73[a]	39.15±0.38[a]	38.16±1.34[a]
1	36.42±0.60[b]	35.96±0.85[ab]	37.72±1.53[a]	37.72±0.86[ab]	36.32±1.31[ab]
2	38.93±1.43[ab]	34.70±1.00[b]	37.28±0.64[a]	36.57±0.44[b]	35.06±1.25[b]
3	38.67±1.85[ab]	36.44±1.23[ab]	38.20±1.00[a]	37.49±1.71[b]	35.45±1.56[b]
4	36.78±0.23[b]	34.13±0.65[b]	37.28±1.58[a]	35.78±0.62[c]	36.59±0.64[ab]
5	36.82±1.31[ab]	35.84±1.62[ab]	35.20±0.78[b]	35.46±0.67[c]	34.66±1.36[b]

Values are presented as mean±SD (n = 3). Values with different superscripts within the same column on the same day of storage are significantly different at p<0.05. [ns]not significantly different at p<0.05.

acceptance when compared to the control sample. This suggests that 4-5% gum arabic can be successfully used as an edible coating to preserve the physical qualities of cherry tomatoes during storage. Similar to weight loss, firmness, and colour, the gum arabic coating can act as a barrier and prevent quality loss, leading to better sensory attributes when compared to the uncoated sample. Similar observations were found in coating gum arabic on Anna apples (El-Anany *et al*., 2009), tomatoes (Ali *et al*., 2010), cucumbers (Al-Juhaimi *et al*., 2012) and Gola guava fruits (Anjum *et al*., 2020).

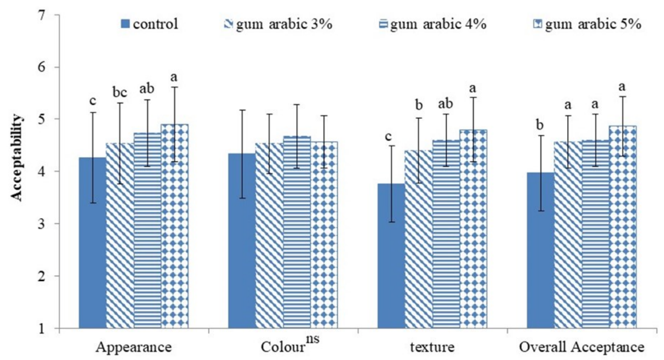

Figure 1. The acceptance scores (n = 30) of the control and cherry tomato samples coated with 3-5% w/w gum arabic after 8 days of storage at 13±2°C. Error bars are defined as standard deviations. Bars with different notations are significantly different at p<0.05. [ns]not significantly different at p<0.05.

4. Conclusion

Gum arabic coating could be used to preserve the quality loss of cherry tomato fruit for up to 16 and 8 days at 13±2°C and 25±2°C, respectively. The recommended concentrations of gum arabic are 4-5% (w/w) since these concentrations could preserve the physical properties of the products while achieving higher acceptance scores than the uncoated samples.

Conflict of interest

The authors declare no conflict of interest.

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