*Irish Journal of Agricultural and Food Research* **49:** 165–170, 2010

# A note on the effect of calcium alginate coating on quality of refrigerated strawberries

N. Moayednia[1]†, M.R. Ehsani[1], Z. Emamdjomeh[2], M. Mazaheri Asadi[3], M. Mizani[4], A.F. Mazaheri[5]

[1]*Department of Food Science and Technology, Agricultural Faculty, Science and Research Branch, Islamic Azad University, Tehran, Iran*

[2]*Food Science and Engineering Department, Biosystem Engineering Faculty, Tehran University, Karaj Campus, Iran*

[3]*Biotechnology Centre, Iranian Research Organization for Science and Technology, Tehran, Iran*

[4]*College of Food Science and Technology, Islamic Azad University, Science and Research Branch Tehran, Iran*

[5]*Food Science and Technology Department, Mechanical and Industrial Engineering Faculty, Islamic Azad University, Qazvin Branch, Qazvin, Iran*

**An alginate-based edible coating was investigated for the preservation of the quality of strawberries during cold storage (5 °C). Strawberries were immersed, successively, in sodium alginate and calcium chloride solutions to generate a surface coating of calcium alginate. The quality of coated and non-coated strawberries was evaluated by weight loss, visible decay, titratable acidity, total soluble solids and reducing sugar concentration over a 14-day storage period. Results showed that coating with calcium alginate had no significant effects on weight loss or physicochemical parameters when compared to control fruit, but it did result in the postponement of visible decay during refrigerated storage.**

*Keywords*: alginate; coating; quality; strawberries

## Introduction

Strawberries are unique, with highly desirable taste and flavor and are an excellent dietary source of ascorbic acid and a simple source of energy from sugar (Perez *et al*., 1997; Wang and Galletta, 2002). However, they are highly perishable and have high physiological activity post harvest (Han *et al*., 2004). As a consequence, they have short ripening and senescent periods that make marketing a challenge (Garcia, Martino and Zaritzky, 1998a). The storage

†Corresponding author: nmoayednia@gmail.com

life of strawberries is often terminated by fungal infection (El Ghaouth *et al*., 1991).

Edible coatings have long been known to protect perishable food products from deterioration by retarding dehydration, suppressing respiration, improving textural quality, helping retain volatile flavor compounds and reducing microbial growth (Debeaufort, Quezada-Gallo and Voilley, 1998). Recently, alginate has been used as one of the polysaccharide-based edible coatings that could maintain the quality and extend the shelf life of fresh products in the food industry (Mancini and McHugh, 2000). Alginate has unique colloidal properties and its ability to form strong gels or an insoluble polymer upon reaction with multivalent metal cations, like calcium, makes it suitable for use as a fruit coating material (King, 1983).

The objectives of this work were to evaluate the ability of a calcium alginate coating to extend the shelf life of strawberries stored at refrigerator temperature after commercialization, in comparison with non-coated fruit and to examine the influence of this type of coating on quality attributes, such as weight loss, visible decay, pH, titratable acidity, soluble solids and reducing sugar concentration.

## Materials and methods

Fresh strawberries were purchased in a local market on the same day the coating experiments were carried out. Sodium alginate (Sigma-Aldrich Pty. Ltd, Singapore) and calcium chloride (Merck Co., Germany) salts were applied to form a calcium alginate gel (Rojas-Graü *et al*., 2007a).

Sodium alginate and calcium chloride solutions (both of them 2% w/w) were prepared by dissolving these salts in distilled water, followed by heating the alginate solution at 70 °C, while stirring, until the solution became clear (Rojas-Graü *et al*., 2006, 2007a,b). Both solutions were then sterilized at 121 °C for 15 min (Krasaekoopt, Bhandari and Deeth, 2004).

*Sample preparation*

Strawberries, of uniform size, shape and color, and without any signs of mechanical damage or fungal decay, were selected and sanitized by immersion in a sodium hypochlorite solution (10 mg/L) for 4 min. They were then rinsed and dried by natural convection at 25 °C prior to cutting. Each strawberry was cut vertically into two halves to prepare one as a control and the other as a coated sample.

The treatments for control halves involved dipping into distilled water for 2 min while treated halves involved (1) dipping into sodium alginate solution for 2 min, (2) allowing 1 min for draining off the residual solution and then (3) submerging the fruit for 2 min in the solution of calcium chloride (Olivas, Mattinson and Barbosa-Cánovas, 2007).

Both halves of each strawberry were weighed (after their treatment), numbered and put in separate plastic containers. Control and coated samples were stored in a refrigerator (5 °C) for 14 days for subsequent analysis. A total of 50 individual fruits were involved.

*Evaluation of quality attributes*

Ten coated fruit halves and their own control halves were removed from the refrigerator on each of days 1, 3, 7, 10 and 14 of storage and used for analysis.

At first control and coated samples were weighed, to determine weight loss, and then inspected for visible decay; samples were then were homogenized in a blender for the determination of pH, titratable acidity, total soluble solids and reducing sugar concentration. All physicochemical determinations were conducted in triplicate.

The weight loss (percent) was calculated relative to initial weight (Olivas *et al.*, 2007). Samples were considered infected when a visible lesion (brown spots and a softening of the injured zone) was observed. The results were expressed as the percentage of infected fruit (Garcia *et al.*, 1998a).

The titratable acidity of samples (control and coated individually) was determined using a 10 g aliquot of homogenate made up to 100 mL with distilled water, which was titrated with 0.1 N NaOH to an end point of 8.1 (AOAC, 1995). Titratable acidity was expressed as percentage citric acid. The pH was determined using a pH meter (Hanna Instruments 8521) and a 10 g aliquot of homogenate made up to 100 mL with distilled water. The concentration of reducing sugars was determined according to the Fehling method (AOAC, 1995) and the expressed relative to glucose. The total soluble solids was determined in a refractometer (Hegerstelit, Germany).

*Statistical analysis*

SPSS software (Version 12.0, SPSS Inc., US) was used for all statistical analysis: analysis of variance, t-test and Duncan's multiple range test. A significance level of 0.05 was used for all tests

## Results and Discussion

Calcium alginate coating adhered well to the strawberry surface and gave the fruit surface a bright and shiny appearance. All the strawberries gradually shrank during 14 days of storage, especially the control fruit.

*Visible decay*

The evolution of the incidence of decay in coated strawberries stored at 5 °C was reduced significantly ($P<0.05$) relative to control fruit (Figure 1). The initial signs of mold development in uncoated strawberries were evident after 7 days of storage, and after 14 days of storage 78% of uncoated strawberries were infected by molds. In contrast, the incidence of decay for coated fruit was only 23% at day 14. There are many situations where coatings may actually increase incidence of decay, such as when the spore load on the fruit from the field is high, or sanitary conditions in the packing shed are poor (Blake, 1966). Moreover, there are situations when coating may be so restrictive to gas exchange that it induces physiological disorders on the skin, possibly by inducing

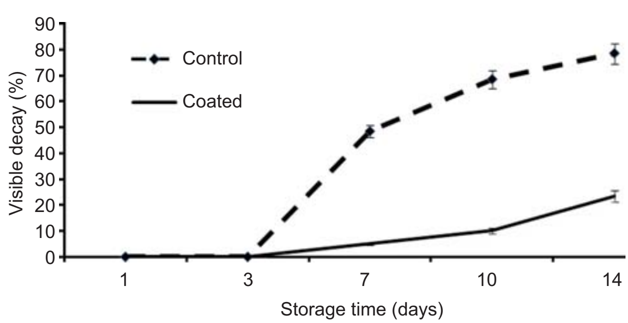


*Figure 1. The incidence of visible decay for control and calcium-alginate coated fruit samples after 1, 3, 7, 10 and 14 days of storage at 5 °C (vertical bars = s.e.).*

fermentation and the accumulation of toxic metabolites. This situation may lead to cellular death of tissue and increase the incidence of visible decay (Risse *et al*., 1987).

*Weight loss*

Weight loss during storage was observed for all samples. Fruit coated with calcium alginate had almost the same weight loss as control samples at all time points during the storage period (Figure 2). For the example, after 14 days of storage, both the control and coated strawberries had lost ~11% of initial weight. Because alginate is a hydrocolloid it does not perform very well as water vapor barrier with high water-activity foods due to their high hydroscopic nature. In this context, Olivas *et al*. (2007) reported that calcium alginate coating on apple slices worked effectively as a water vapor barrier during 10 days storage period at 5 °C. They indicated that alginate coatings prevented water loss by producing a high relative humidity at the surface of sliced apples, thus reducing the gradient to the exterior.

Some other coatings, such as those based on chitosan, on the surface of fruits like strawberry and red raspberry have been shown to delay migration of moisture from the fruit into the environment, thus reducing weight loss during storage (Garcia *et al*., 1998a; Han *et al*., 2004).

*Physicochemical properties*

The titratable acidity was between 0.65 and 0.75 percent for both control and treated samples throughout the storage period (Table 1). These values are close to the lowest value mentioned in the literature (0.6 to 2.3%; Montero *et al*., 1996). The pH of all samples ranged between 3.8 and 4.4, which is above the average for ripe strawberries (pH = 3.3). There was no significant change in either titratable acidity or pH of control and coated fruit during storage. Furthermore, no significant differences in titratable acidity or pH were detected between control and coated strawberries on any day during storage. The present results are similar to the those reported by Cordenusi *et al*. (2003) for fresh strawberries and Vargas *et al*. (2004, 2006) for fresh and coated (chitosan-based) strawberries. Contrary to the present findings, Tanada-Palmu and Grosso (2005), El Ghaouth *et al*. (1991) and Garcia *et al.* (1998a,b) reported significant decreases in titratable acidity of strawberries as a function of storage time when coatings were based on wheat gluten, chitosan and starch, respectively. According to these authors the decrease

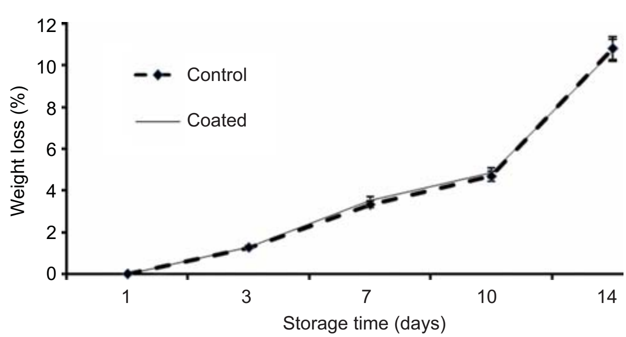


*Figure 2. Weight loss of control and calcium-alginate coated samples after 1, 3, 7, 10 and 14 days of storage at 5 °C (vertical bars = s.e.).*

**Table 1. Mean values‡ (s.d.) for titratable acidity, pH, total soluble solids and reducing sugars in control and calcium alginate coated strawberries during storage at 5 ºC**

| Parameter | Treatment | Storage day | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 3 | 7 | 10 | 14 |
| Titratable acidity (%) | Control | 0.65 ± 0.26 | 0.63 ± 0.26 | 0.66 ± 0.17 | 0.71 ± 0.17 | 0.75 ± 0.08 |
| | Coated | 0.59 ± 0.21 | 0.63 ± 0.21 | 0.61 ± 0.19 | 0.62 ± 0.14 | 0.72 ± 0.08 |
| pH | Control | 4.06 ± 0.34 | 4.08 ± 0.32 | 4.05 ± 0.27 | 4.05 ± 0.09 | 3.93 ± 0.11 |
| | Coated | 3.97 ± 0.34 | 4.34 ± 0.61 | 3.97 ± 0.20 | 3.95 ± 0.14 | 3.87 ± 0.07 |
| Total soluble solids (g/kg) | Control | 129.8 ± 55.9 | 136.6 ± 42.4 | 126.0 ± 22.8 | 118.6 ± 17.6 | 109.8 ± 8.8 |
| | Coated | 117.5 ± 45.9 | 131.3 ± 40.2 | 119.6 ± 18.5 | 115.3 ± 17.9 | 102.8 ± 10.4 |
| Reducing sugars (%) | Control | 5.98 ± 2.52 | 5.57 ± 1.91 | 6.68 ± 1.35 | 6.05 ± 1.55 | 5.65 ± 1.47 |
| | Coated | 5.55 ± 2.33 | 5.52 ± 1.60 | 6.28 ± 1.24 | 5.00 ± 1.44 | 5.17 ± 1.47 |

‡ There were no significant (P>0.05) differences between means, for a given variable, within columns (t test) or among the means in any row (Duncan's test).

in acidity reflected the development of maturity of the fruit during storage in the refrigerator.

An acceptable strawberry flavor is achieved with total soluble solids of 70 g/kg and maximum reducing sugar concentration of 8%. While the results show that there were some fluctuations in the soluble solids and sugar concentrations for both control and coated fruit (Table 1) during storage there was no statistically significant change (P>0.05) for either of these components. Moreover, no significant difference in total soluble solids or sugar concentration was observed on any day during the 14 days of storage which is consistent with findings reported by Vargas (2004, 2006) for fresh and chitosan-based coated strawberries. On the contrary, Tanada-Palmu and Grosso (2005) reported a significant increase in total soluble solids and a reduction in sugar concentration in control and wheat-gluten-based coated strawberries after 16 days of refrigerated storage; Cordenunsi *et al*. (2002) attributed these changes to degradation of cell walls and the high invertase activity of strawberries, respectively.

It is concluded that coating strawberries with calcium alginate has no effect on physicochemical properties during storage but does preserve fruit quality by reducing the incidence of infection in comparison with uncoated fruit.

## References


AOAC. 1995. Official Methods of Analysis, 16th edition. Association of Official Analytical Chemists, Washington, DC, USA.

Blake, J.R. 1966. Some effects of paraffin wax emulsions on bananas. *Queensland Journal of Agricultural and Animal Sciences* **23:** 49–56.

Cordenunsi, B.R., Nascimento, J.R.O., Genovese, M.I. and Lajolo, F.M. 2002. Influence of cultivar on quality parameters and chemical composition of strawberry fruits grown in Brazil. *Journal of Agricultural and Food Chemistry* **50:** 2581–2586.

Debeaufort, F., Quezada-Gallo, J.-A. and Voilley, A. 1998. Edible films and coatings: tomorrow's packagings: a review. *Critical Reviews in Food Science and Nutrition* **38:** 299–313.

El Ghaouth, A., Arul, J., Ponnampalam, R. and Boulet, M. 1991. Chitosan coating effect on storability and quality of fresh strawberries. *Journal of Food Science* **56:** 1618–1620.

Garcia, M.A., Martino, M.N. and Zaritzky, N.E. 1998a. Starch-based coatings: effect on refrigerated strawberry (*Fragaria ananassa*) quality. *Journal of the Science of Food and Agriculture* **76:** 411–420.

Garcia, M.A., Martino, M.N. and Zaritzky, N.E. 1998b. Plasticized starch-based coatings to improve strawberry (*Fragaria ananassa*) quality and stability. *Journal of Agricultural and Food Chemistry* **46:** 3758–3767.

Han, C., Zhao, Y., Leonar, S.W. and Traber, M.G. 2004. Edible coatings to improve storability and enhance nutritional value of fresh and frozen strawberries (*Fragaria* x *ananassa*) and raspberries (*Rubus ideaus*). *Postharvest Biology and Technology* **33:** 67–78.

King, A.H. 1983. Brown seed extracts (Alginates). *Food Hydrocolloids* **2:** 115–188.

Krasaekoopt, W., Bhandari, B. and Deeth, H. 2004. The influence of coating materials on some properties of alginate beads and survivability of microencapsulated probiotic bacteria. *International Dairy Journal* **14:** 737–743.

Mancini, F. and McHugh, T.H. 2000. Fruit–alginate interactions in novel restructured products. *Nahrung* **44:** 152–157.

Montero, T.M., Mollá, E.M., Esteban, R.M. and López-Andréu, F.J. 1996. Quality attributes of strawberry during ripening. *Scientia Horticulturae* **65:** 239–250.

Olivas, G.I., Mattinson, D.S. and Barbosa-Cánovas, G.V. 2007. Alginate coatings for preservation of minimally processed 'Gala' apples. *Postharvest Biology and Technology* **45:** 89–96.

Pérez, A.G., Olıás, R., Espada, J., Olıás, J.M. and Sanz, C. 1997. Rapid determination of sugars, nonvolatile acids, and ascorbic acid in strawberry and other fruits. *Journal of Agricultural and Food Chemistry* **45:** 3545–3549.

Risse, L.A., Chun, D., McDonald, R.E. and Miller, W.R. 1987. Volatile production and decay during storage of cucumbers waxed, imazalil-treated, and film-wrapped. *Hort Science* **22:** 274–276.

Rojas-Graü, M.A., Avena-Bustillos, R., Friedman, M., Henika, P., Martín-Belloso, O. and McHugh, T. 2006. Mechanical, barrier and antimicrobial properties of apple puree edible films containing plant essential oils. *Journal of Agricultural and Food Chemistry* **54:** 9262–9267.

Rojas-Graü, M.A., Raybaudi-Massilia, R.M., Soliva-Frotuny, R.C., Avena-Bustillos, R.J., McHugh, T.H. and Martin-Belloso, O. 2007a. Apple puree-alginate edible coating as carrier of antimicrobial agents to prolong shelf-life of fresh-cut apples. *Postharvest Biology and Technology* **45:** 254–264.

Rojas-Graü, M.A., Tapia, M.S., Rodríguez, F.J., Carmona, A.J. and Martín-Belloso, O. 2007b. Alginate and gellan based edible coatings as support of antibrowning agents applied on fresh-cut Fuji apple. *Food Hydrocolloids* **21:** 118–127.

Tanada-Palmu, P.S. and Grosso, C.R.F. 2005. Effect of edible wheat gluten-based films and coatings on refrigerated strawberry (*Fragaria ananassa*) quality. *Postharvest Biology and Technology* **36:** 199–208.

Vargas, M., Albors, A., Chiralt, A. and González-Martínez, C. 2006. Quality of cold-stored strawberries as affected by chitosan–oleic acid edible coatings. *Postharvest Biology and Technology* **41:** 164–171.

Vargas, M., Gillabert, M., González-Martínez, C., Albors, A. and Chiralt, A. 2004. Efecto de la aplicación de un film a base de quitosano en la calidad de fresas durante el almacenamiento. Actas del III Congreso Español de Ingeniería de Alimentos, [cd-rom], 746–753.

Wang, S.Y. and Galletta, G.J. 2002. Compositional change in *Colletotrichum* (Anthracnose) infected strawberry fruit. *Acta Horticulturae* **567:** 815–819.

*Received 18 January 2010*