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Preserving Strawberry (*Fragaria Ananasa*) Using Alginate and Soy Based Edible Coatings

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Abstract Instant research project was an attempt to address the postharvest losses in strawberry using the concept of biodegradable edible coatings. Purposely, alginate and soy based coatings were developed at various levels (2, 2.5 and 3%) and assessed for the role in controlling the moisture loss and total solids in the coated fruit. From results, it was deduced that moisture loss was lowered to 4.86% in T_3 (Soy 3%) as compared to 13.45% in T_0 (Control) for strawberry kept at controlled climate chamber. Likewise, 2.5 and 3% combinations of soy and alginate based coatings were found efficient in maintaining overall solids content of the coated strawberry.Based on the findings, edible coatings are suggested as an innovative, cost effective and environmental friendly preservation technique that holds potential to be used on fresh perishable commodities.

Keywords: *strawberry, edible coatings, alginate, soy, shelflife*

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1. Introduction

Edible coatings have emerged as a promising tool to curtail high post-harvest losses in freshhorticultural commodities while conserving their nutritional and sensory attributes. Traditionally, these biodegradable coatings have been used to enhance the appearance of different fruits and vegetables. Over the years, their role towards extension of shelflife and improved quality of perishable commodities has been exploited. These biofilms usually forms an intact transparent edible layer that acts as a barrier to moisture migration, solute retention and oxygen permeabilityduring handling, processing and storage. The oxygen and lipid barrier properties at low to intermediate relative humidity are due to the formation of hydrogen bonds in the coating matrix (Huang *et al.*, 2012).

Presently, novelty in the edible coating technology has been tested for the control of browning and microbiological status of the coated fruits and vegetables. Over the years, the biodegradable coatings are considered as environment friendly, non-toxic and a safe choice for food applications (Zhang and Jiang, 2011).

Among various fruits, strawberry (*Fragaria ananasa*)is a fairly good source of vitamin C and flavonoids with appreciable amount of potassium, manganese, folate and dietary fiber. It is among the leading fruits rich in antioxidants (Giampieri*et al.*, 2012)often consumed as fresh or can be preserved and value added for jam, jellies and squashes production. Major strawberry varieties cultivated in Pakistan include *Noor, Duglus, Chandler, Tuftus, Karoz, Pajaro, Commander* and *Corona*.

The present research is an attempt to study the effect of edible coatings on the moisture loss reduction of the coated fruits. Moreover, in this experiment we have studied the fluctuations in the total soluble solids content of the treated fruit.

2. Methodology

2.1. Development of Edible Coatings

2.1.1. Alginate Based Coatings

Alginate coatings (2, 2.5 and 3%) were formulated following the method of Rojas-Grau *et al.* (2008). For the purpose, alginate powder was dissolved in distilled water and heated at 70°C with continuous stirring until clear film formation. Coating solution was then emulsified with sunflower oil (0.025g/100mL) followed by the addition of glycerol (1.5g/100mL)as plasticizer. Afterwards, N-acetyl L-cysteine (1g/100mL) was added along with the calcium chloride (2g/100mL water) required for cross linking of carbohydrate polymers.

2.2. Development of Soy Protein Based Coatings

Soy protein based edible coatings were prepared by following the procedure of Brandenburg *et al.* (1993). Soy protein (2, 2.5 and 3% solution) was dissolved in distilled water (100mL) followed by rigorous stirring after the addition of glycerol (2.5g) in the coating suspension. In order to denature soy protein, solution was heated at 90°C for 20 min in water bath.During the process, sunflower oil

(0.025g/100mL) was also added to improve water vapor barrier properties. Moreover, to prevent enzymatic browning, ascorbic acid (1g/100mL) was added in the coating mixture.

2.2.1. Application of Edible Coatings

After following desired unit operations and development of various edible coatings, procured fruits were randomly divided into various lots. For the purpose, uncoated treatment (control) alongwith different levels (2, 2.5 and 3%) of alginate and soy based edible coatings was applied by dipping the fruits for at least 2 min. Residual solution of each treatment was allowed to drip off for 1 min. and then coated fruits were dried for 15-20 min. Additionally, commercial wax was also used to compare with that of edible coated commodities.

2.2.2. Storage of Whole and Minimally Processed Fruits

After coating, fruit was stored in controlled climate chamber at 4±1°C temperature and 85% relative humidity. Likewise, the efficiency of commercial wax coating was also assessed for comparison purpose.

2.2.3. Moisture Loss

Moisture loss was measured by following the protocols mentioned in AOAC (2006). The moisture loss percentage relative to initial weight was calculated by weighing the samples at regular intervals during storage. Moisture loss percentage was calculated by using the following formula.

$$\text{Moisture Loss \%} = \left(\begin{array}{l}\text{Initial weight} \\ -\text{final weight} \;/\; \text{initial weight of sample}\end{array}\right) \times 100$$

2.2.4. Extraction of Juice

For juice extraction, 500g of each fruit was blended followed by filtration to remove solid contents. The obtained juice was subjected to determination of total soluble solids

2.2.5. Total Soluble Solids

Total soluble solids of the coated samples were directly recorded by using Digital Refractometer (RA-600 refractometer, Kyoto Electronics Manufacturing Co., Ltd., Japan) following the standard procedure of AOAC (2006). A drop of fruit juice was placed on the prism of refractometer and reading was noted. The results were expressed as °Brix.

3. Results and Discussion

3.1. Moisture Loss

It was observed from mean squares regarding moisture loss in edible coated strawberry kept at controlled climate chamber that significant variations were observed with respect to both treatments and storage. Moreover, their interaction was also found to be momentous.

From means (Table 1), it is found that the maximum loss in moisture was observed in T_0 (Control) as 13.45±0.46% followed by T_7 (Commercial wax) as 12.58±0.43%. However, the treatments T_3 (Soy 3%) and T_2 (Soy 2.5%) served as the best in minimizing the moisture loss as 4.86±0.17 and 5.22±0.18%, respectively. Moreover, for the treatments T_5 (Alginate 2.5%) and T_6 (Alginate 3%), moisture loss was recorded as 6.71±0.23 and 5.91±0.20%, respectively.

Table 1. Means for moisture loss (%) of strawberry treated with various coatings stored at controlled climate chamber

Days	Treatments								Means
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	
3 days	$3.78±0.10^{YZ}$	$2.55±0.06^{c}$	$1.71±0.04^{d}$	$1.58±0.04^{d}$	$2.73±0.07^{bc}$	$2.64±0.07^{c}$	$1.95±0.05^{d}$	$3.57±0.09^{Za}$	$2.57±0.09^{f}$
7 days	$10.51±0.27^{L}$	$4.91±0.12^{X}$	$3.82±0.10^{YZ}$	$3.16±0.08^{ab}$	$5.41±0.14^{W}$	$4.99±0.13^{WX}$	$4.18±0.11^{Y}$	$10.22±0.26^{LM}$	$5.90±0.20^{e}$
10 days	$15.19±0.38^{G}$	$6.61±0.17^{UV}$	$5.26±0.13^{WX}$	$4.92±0.12^{X}$	$7.51±0.19^{ST}$	$6.70±0.17^{U}$	$6.25±0.16^{V}$	$14.19±0.36^{H}$	$8.33±0.28^{d}$
14 days	$18.29±0.46^{E}$	$8.89±0.22^{P}$	$7.68±0.19^{R-T}$	$7.31±0.18^{T}$	$9.89±0.25^{MN}$	$9.12±0.23^{OP}$	$8.02±0.20^{QR}$	$17.39±0.44^{F}$	$10.82±0.37^{c}$
17 days	$21.54±0.54^{C}$	$9.54±0.24^{NO}$	$8.12±0.21^{Q}$	$7.76±0.20^{Q-S}$	$10.55±0.27^{L}$	$9.95±0.25^{MN}$	$9.21±0.23^{OP}$	$20.54±0.52^{D}$	$12.15±0.41^{b}$
20 days	$24.81±0.63^{A}$	$13.08±0.33^{J}$	$9.92±0.25^{MN}$	$9.31±0.24^{OP}$	$14.12±0.36^{H}$	$13.6±0.34^{I}$	$11.75±0.3^{K}$	$22.14±0.56^{B}$	$14.84±0.50^{a}$
Means	$13.45±0.46^{a}$	$6.51±0.22^{d}$	$5.22±0.18^{ef}$	$4.86±0.17^{f}$	$7.17±0.24^{c}$	$6.71±0.23^{d}$	$5.91±0.2^{e}$	$12.58±0.43^{b}$	

T_0= Control T_1= Soy 2% T_2= Soy 2.5% T_3= Soy 3%
T_4= Alginate 2% T_5= Alginate 2.5% T_6=Alginate 3% T_7= Wax.

Over the storage, alike dwindle in the moisture content was noticed that ranged from 2.57±0.09% at 3rd day increased further to 8.33±0.28 and 10.82±0.37% at 10th and 14th days, respectively. However, at the termination of 20 days study, moisture loss was observed as 14.84±0.50%. Likewise, among treatments, a similar increment in the loss was reported with the course of storage that ranged from 1.58±0.04 and 1.71±0.04% at 3rd day to 9.31±0.24 and 9.92±0.25% in T_3 (Soy 3%) and T_2 (Soy 2.5%), respectively. Whilst the maximum increase in moisture loss was found in T_0 (Control) as ranged from 3.78±0.10% at 3rd day to 15.19±0.38 and 21.54±0.54% at 10th and 17th days, respectively. Moreover, it progressed to 24.81±0.63% decline in the moisture content at the end of the said storage of 20 days. Likewise, for treatments T_5 (Alginate 2.5%) and T_6 (Alginate 3%) moisture loss differed from 2.64±0.07 and 1.95±0.05% at 3rd day to 13.60±0.34 and 11.75±0.32% at 20th days, respectively. In case of treatment T_7 (Commercial wax), moisture loss increased from 3.57±0.09% at 3rd day to 14.19±0.36, 20.54±0.52 and 22.14±0.56% at 10th, 17th and 20th day, respectively.

3.2. Total Soluble Solids

It was expounded from mean squares regarding total soluble solids in coated strawberry kept in controlled climate chamber that significant variations were observed with respect to storage and treatments. Moreover, their interaction was found to be non-momentous.

From means (Table 2), the maximum value for total soluble solids of edible coated strawberry kept at controlled climate chamber was observed in T_0 (Control) as 7.61±0.26°Brix followed by T_7 (Commercial wax) and T_1 (Soy 2%) as 7.57±0.26 and 7.37±0.25°Brix, respectively. Likewise, for T_5 (Alginate 2.5%) and T_4 (Alginate 2%), the recorded values for the trait were 7.36±0.25 and 7.39±0.25°Brix, respectively. The lowest value for the parameter was observed in T_3 (Soy 3%) as 7.20±0.24°Brix.

Table 2. Means for TSS (ºBrix) of strawberry treated with various coatings stored at controlled climate chamber

Days	Treatments								Means
	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	
0 day	7.33±0.20	7.19±0.24	7.16±0.24	7.14±0.24	7.18±0.24	7.17±0.28	7.17±0.25	7.19±0.27	7.19±0.24^{d}
3 days	7.41±0.21	7.26±0.23	7.20±0.23	7.16±0.24	7.24±0.24	7.23±0.30	7.21±0.24	7.25±0.29	7.25±0.25^{d}
7 days	7.55±0.21	7.34±0.21	7.24±0.21	7.19±0.24	7.31±0.24	7.28±0.33	7.26±0.22	7.34±0.34	7.31±0.25^{cd}
10 days	7.81±0.22	7.48±0.15	7.28±0.19	7.21±0.24	7.39±0.25	7.34±0.36	7.31±0.21	7.52±0.45	7.42±0.25^{bc}
14 days	7.94±0.22	7.54±0.15	7.31±0.19	7.24±0.24	7.43±0.25	7.38±0.37	7.33±0.20	7.62±0.51	7.47±0.25^{ab}
17 days	7.99±0.22	7.60±0.15	7.34±0.18	7.26±0.24	7.47±0.25	7.41±0.38	7.36±0.19	7.66±0.53	7.51±0.26^{ab}
20 days	8.11±0.22	7.70±0.15	7.38±0.16	7.28±0.24	7.60±0.25	7.50±0.44	7.41±0.16	7.73±0.58	7.59±0.26^{a}
Means	7.73±0.26^{a}	7.44±0.25^{bc}	7.27±0.25^{cd}	7.21±0.25^{d}	7.37±0.25^{bc}	7.33±0.25^{b}	7.29±0.25^{b-d}	7.47±0.25^{a}	

T_0= Control T_1= Soy 2% T_2= Soy 2.5% T_3= Soy 3%
T_4= Alginate 2% T_5= Alginate 2.5% T_6=Alginate 3% T_7= Wax.

Over the storage, a persistent increase in total soluble solids value was observed ranging from 7.19±0.24°Brix at initiation that progressed to 7.23±0.25 and 7.40±0.25°Brix at 3rd and 10th days, respectively. However, it increased to 7.49±0.25 and 7.57±0.26°Brix at 17th and 20th days, respectively.

Among treatments, increase in total soluble solids was reported with T_o (Control) and T_7 (Commercial wax) emerged as the least effective in maintaining the overall contents as varied from 7.21±0.25 and 7.20±0.25°Brix at 0 days to 7.98±0.28 and 7.92±0.28°Brix at the termination of 20 days trial, respectively. Likewise, increase in TSS of coated strawberry varied from 7.18±0.25, 7.15±0.25 and 7.13±0.25°Brix to 7.57±0.26, 7.30±0.26 and 7.27±0.25°Brix at 0 to 20 days in T_1, T_2 and T_3, respectively. For treatment T_4 (Alginate 2%), T_5 (Alginate 2.5%) and T_6 (Alginate 3%),values for total solids were 7.62±0.27, 7.58±0.27 and 7.33±0.26°Brix at termination of study, respectively.

4. Discussion

Instant research is in accordance with the previous work of Valero *et al.* (2013) who developed alginate and gallan based edible coatings and applied the resultant coatings on four different varieties. In their research, they were able to control moisture loss appreciably. Moreover, acidity losses, softening and color changes were delayed significantly by the use of coatings. In another study, Azeredo *et al.* (2012) worked on coating combination involving polysaccharides to produce edible films and coatings. In their investigation, combination between acerola puree and alginate was reinforced with cellulose or montmorillonite to form nanocomposite edible films and edible coatings. They deduced that coatings decreased fruit weight loss, moisture loss, decay incidence and ripening rates.

Recently Peretto *et al.* (2014) deduced that edible coatings had significant impact on the postharvest quality of strawberry kept at 10°C for 10 days with 90% RH. They inferred that coatings worked to reduce the moisture loss appreciably, with better firmness, color and stable antioxidant profile during storage. Furthermore, they were of the opinion that natural antimicrobial vapors when incorporated into the coating matrix helped increase total phenolics content and antioxidant activity of fruit at the end of the storage period. In another investigation Saucedo-Pompa*et al.* (2009) explored alginate based edible coatings and their effects on the overall quality and shelflife extension of avocado fruit. They evinced that coating application resulted in significant decrease in the moisture loss from the coated produce as compared to the uncoated one.

Instant results are in agreement with the work of Gol*et al.* (2013); they applied carboxymethyl cellulose and chitosan based coatings on strawberry. They deduced that coatings worked appreciably to extend the shelf life of perishable produce by maintaining the total soluble solids as compared to uncoated fruit. Moreover, coated fruits significantly delayed weight loss and senescence in the commodity. They suggested that use of coatings is imperative in extending the shelf-life and maintaining quality of strawberry fruit. In another investigation, Benitez *et al.* (2013) conducted efficacy of aloe vera based edible coatings at four different concentrationsin maintaining the quality of fresh-cut kiwifruit. It was inferred that aloe vera coating reduced respiration rates and microbial spoilage in coated fruits. Furthermore, aloe-vera coating improved the quality of stored kiwifruit slices. The best results obtained in the instrumental texture profile and in the preference panel test were with the 5% coating, indicating that this may be a healthy alternative coating for fresh-cut kiwifruit.

Earlier, Tanada-Palmu*et al.* (2006) used gluten based bilayer edible coatings on strawberry to extend shelflife and maintain desirable quality characteristics. They observed that coatings resulted in maintaining total solids of the coated fruit. Moreover, moisture loss and acidity variations were also controlled. The bilayer coating of wheat gluten and lipids (beeswax, stearic and palmitic acids) showed better results from the physico-chemical analysis compared to the control fruit.Sensory evaluation of the strawberries showed that the gluten and the composite coatings maintained the visual quality of the fruit during the storage time, and the taste of the strawberries with the gluten coating was acceptable to consumers.

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