Indian Journal of Agricultural Sciences **81** (5): 407–12, May 2011

Effect of *Aloe vera* coatings on fruit quality and storability of strawberry (*Fragaria* × *ananassa*)

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Received: 3 August 2010; Revised accepted: 22 March 2011

ABSTRACT

Plant-based edible coatings provide an alternative to wax coating or chemical treatments for extending the post-harvest life of fresh fruits and vegetables. The effect of different concentrations of *Aloe vera* gel coatings on refrigerated strawberry quality and shelf-life was studied with the aim to extend the shelf life of strawberries without hampering the sensory attributes. Under cold storage uncoated fruits showed increase in weight loss, colour changes, loss of firmness and quality deterioration during the storage (16 days). However strawberries treated with *Aloe vera* gel (1: 3 ratio) significantly reduced weight loss (9.99±2.1% compared to 13.79±0.13% in control), maintained colour, firmness, quality characteristics (TSS of 8.4° Brix compared to 7.0 ° Brix in control, acidity of 1.37% compared to 0.83% in control and ascorbic acid of 45±0.4 mg/100 g compared to 30±0.5 mg/100 g in control) and ultimately extended storability up to 16 days when stored at 5°C and R H 95%. The sensory analysis for taste, aroma and flavours further confirmed the findings. *Aloe vera* has medicinal and antioxidant properties; therefore use of such plant based alternative to post harvest chemical treatments could not only have large acceptance among consumers but could also find commercial application.

Key words: *Aloe vera*, Coating, Strawberry, Quality, Safety

Strawberry (*Fragaria* × *ananassa* Duch) is one of the most delicious berry fruit due to its quality, nutritional value and appearance. Skin colour is the main quality index of the fruit, which is related to fruit ripening. Colour is mostly affected by anthocyanin concentration and sugar acid ratio at harvest. Strawberries are soft and delicate fruits with high respiration and softening rates, making the storage and marketing of fruits challenging in domestic and international market. Due to its high metabolism, strawberries must be kept at 4.5°C, which can extend its quality for 6 or 7 days. Fruit firmness is also an important quality attribute and is directly related for the enhancement of the storability potential and induction of greater resistance to decay and mechanical damage (Barret and Gonzalez 1994). Strawberry fruits deteriorate rapidly after harvest and in some cases do not reach consumers at optimal quality after transportation and marketing. The use of edible coatings can be an alternative to improve the shelf-life (Santos 1997). Edible coatings are traditionally used to improve food appearance and maintenance of quality. These can provide an alternative to extent the post harvest life of the fresh fruits and vegetables (Park 1999). They act as barrier of spoilage during processing, storage and handling, and do not only retard food deterioration and enhance its quality but are also safe due to natural biocide activity or incorporation of the anti microbial compounds (Peterson *et al.* 1999). Potential of edible coatings to maintain and extent the shelf life of fresh products and to reduce the amount of disposable non bio degradable packing materials were widely studied by Rose (1992) Park (1999) and Amarante and Banks (2001). The main reasons of strawberry deterioration are weight loss, colour changes, softening, surface pitting, stem browning and loss of acidity and TSS. Several pre- and post-harvest technologies have been used to control decay, but post harvest use of chemicals and fungicides is restricted in most countries and consumers demand for plant-based and edible coatings without pesticide residues. Different compounds have mainly been used as edible coatings to prevent commodity weight loss including wax, milk protein celluloses, lipids, starch, zein, and aliquate (Cha and Chinan 2004). Chitosan and whey based coatings are generally used to increase the shelf life of strawberries (Han *et al*. 2004; Tanada-Palmu and Grosso 2005, Tanada-Palmu *et al.* 2000; Vargas *et al*. 2006). Currently there is an increasing interest in the use of *Aloe vera* gel in the food industry as it is being used as a functional food drink, ice cream and beverages. *Aloe vera* gel, the pulp of A*loe vera* plant, is commonly used for curative purposes in humans

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and animals (Grindlay and Reynolds 1986). Saks and Barkai-Golan (1995) found the anti fungal capability of *Aloe vera* gel and its potential as an alternate to chemical fungicides. Coating with *Aloe vera* gel reduces stem browning and dehydration of fruits during storage without loss of taste, aroma and flavours (Martýnez-Romero *et al*. 2006). The main aim of this work was to study the effect of *Aloe vera* coatings on change in physico chemical parameters related to fruit quality during cold storage.

MATERIALS AND METHODS

Strawberry fruits var. Chandler was harvested from a commercial farm at Hisar. Fruits of uniform size, colour, free of physical damage and fungal infection were selected, washed/treated in chlorinated water (0.25 g/L) according to Garcia *et al*. (1998a, 1998b) and dried using tissue paper. About 500 g fruits were analysed for initial physical and chemical properties. The coating of fruits was performed at 20°C by immersing the fruits for 5 minutes in *Aloe vera* solution. To optimize dilution of aloe vera gel for edible coating, it was diluted with distilled water in 1: 3 (T1), 1: 2 (T2) and 1: 1 (T3) ratios. To compare the effect, fruits without any coating were kept as control (T4). Pharmaceutical quality *Aloe vera* gel (100% pure) was used. After the surface coating, strawberry fruits were air-dried to remove any surface moisture. Randomly selected 20 fruits, from same treatment, were packed in punnets (average weight 200 g) and stored at 5°C at 95% relative humidity. Samples of both treated and control were taken out after 2, 4, 6, 8,10,12,14 and 16 days of cold storage for phsyico-chemical analysis.

To determine weight loss, strawberries were weighed at the beginning of the experiment just after coating and the air drying, and thereafter each day during the storage period. Weight loss was expressed as percentage loss of the initial total weight of 20 fruits corresponding to each measurement and the experiment was performed in triplicate.

Texture analysis for testing the firmness was performed using a texture analyzer TA HD Plus (Stable Microsystem, UK). Firmness was measured as the maximum penetration force (N) reached during tissue breakage and determined with a 5 mm diameter flat probe. The penetration depth was 5 mm and cross head speed was 5 mm/s. 20 fruits in each treatment were tested for texture analysis. Results were means±SE of determination made for each individual fruit (n=100).

Strawberry surface colour was evaluated with a Hunter Labscan Colorimeter (Hunter Laboratory Inc., Reston, VA). L, a and b values indicating lightness (L), red colour (a), yellowness (b) were taken at different locations of 20 fruits from each treatment.

One punnet (20 fruits) from each treatment (after measurement of firmness and colour) was used to get homogenate using a blender for estimation of TSS, acidity, ascorbic acid and reducing sugars. TSS of the homogenates was determined using hand held refractometer (ERMA, Japan) and expressed in °Brix. Titratable acidity and ascorbic acid were calculated using AOAC (2000) methods, which were determined from a 10 g aliquot of the homogenate made up to 100 ml. Titratable acidity was expressed in g citric acid per 100 g fresh weight.

Sensory evaluation was done on Hedonic scale as per the method of Amerine *et al.* 1965. Sensory analysis to compare the quality of treated and control strawberry fruits was carried out by 10 trained adults. The panel was trained in a pre test in which strawberry with extremely low or high attributes (colour, firmness, flavour and visual appearance) were evaluated. For each treatment and sampling date, judges were served with two strawberry fruits from each lot. Briefly, panelists were instructed to cleanse their mouth with distilled water, chew the fruits and evaluate the sample using the binary response of yes or no.

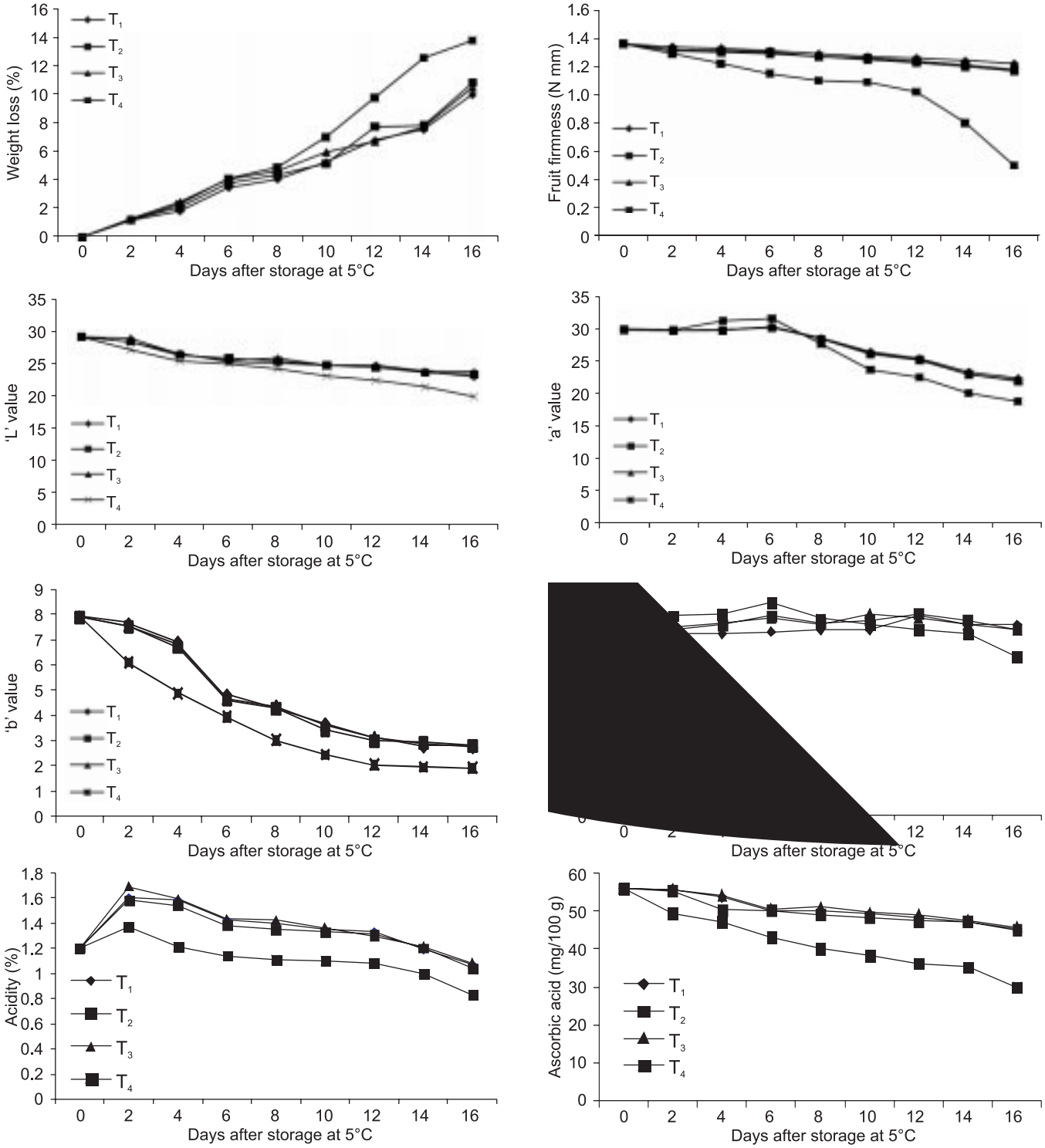
RESULTS AND DISCUSSION

Effect on physiological loss in weight

Aloe vera gel coating significantly (P>0.05) reduced weight loss of strawberry fruits during storage at 5°C and 95% relative humidity compared to control (Fig 1). After a storage period of 16 days, fruit loss in control was 13.79±0.13% while the loss of weight in *Aloe vera* treated strawberry were 9.99±0.21 in T1 (*Aloe vera* 1: 3), 10.91±0.20 in T2 (*Aloe vera* 1: 2) and 10.51±in T3 (*Aloe vera* 1: 1). *Aloe vera* coatings retarded the moisture loss in all the treated fruits. These results are similar to those obtained with other edible coatings such as chitosan, wheat glutin (Tanada-Palmu and Grosso 2005, Vargas *et al.* 2006). The mechanism of these positive effects of edible coatings of *Aloe vera* gel to reduce the physiological weight loss of fruits is based on their hygroscopic properties, which enable formation of a barrier to water diffusion between fruit and external environment thus avoiding its external transference (Morillon *et al.* 2002). These composite coatings of polysaccharide lipids are known to increase water barrier efficiency, which, in turn help for achieving more reductions in of weight loss of fresh commodities (Perez-Gago *et al.* 2002). On the other hand *Aloe vera* mainly contains polysaccharides (Ni *et al*. 2004); however, it was highly effective as a moisture barrier without lipid incorporation. Martinez *et al.* (2006) also reported reduction in weight loss due to *Aloe vera* gel coatings in strawberry.

Effect on fruit firmness

For all control and *Aloe vera* coated strawberry fruits firmness decreased as function of storage time. However, *Aloe vera* treatments were significantly effective in maintaining strawberry firmness compared to control. No significant changes were observed in different levels of *Aloe vera* treatments (1.19±0.2/mm) at the end of storage (Fig 2). One of the main factors used to determine fruit quality and post



Figs 1–8 **1.** Percentage of weight loss during cold storage at 5°C of *Aloe vera* coated and control strawberry. Data are mean±S.E. **2.** Fruit firmness changes (N mm $^{-1}$) during cold at 5°C of *Aloe vera* coated and control strawberry. Data are mean±S.E. **3.** Changes in colour indicating 'L' value during cold storage at 5°C of *Aloe vera* coated and control strawberry. Data are mean±S.E. **4.** Changes in colour indicating 'a' value during cold storage at 5°C of *Aloe vera* coated and control strawberry. Data are mean±S.E. **5.** Changes in colour indicating 'b' value during cold storage at 5°C of *Aloe vera* coated and control strawberry. Data are mean±S.E. **6.** Changes in TSS of fruit changes during cold **storage** at 5°C of *Aloe vera* coated and control strawberry. Data are mean±S.E. **7.** Changes in acidity during cold storage at 5°C of *Aloe vera* coated and control strawberry. Data are mean±S.E. **8.** Changes in ascorbic acid content during cold storage at 5°C of *Aloe vera* coated and control strawberry. Data are mean±S.E.

harvest shelf life is the rate and extent or amount of loss of firmness during storage of soft fruit, such as strawberries. Fruit softening is attributed to the degradation of cell wall components, mainly pectin, due to action of specific enzymes such as polyglacturonase. The composite coatings have shown a good result with respect to the retention of fruit firmness probably because this coating slowed down metabolism and prolonged the storage life, an effect shown by El Gaouth *et al.* (1991 a) using Chitosan coatings in strawberries**.**

Effect on colour values of fruits

The main colour changes were observed for L, a and b colour which reduced during storage period; however significant differences were found between control and *Aloe vera* treated fruits ($P>0.05$). Both control and *Aloe vera* treated (coated) strawberries initially showed a decrease in L value. Upon subsequent storage *Aloe vera* treated fruits had high L value compared to control. However among different *Aloe vera* treatments T1 (1: 3 ratio) ratio was found effective to maintain the L value significantly (Fig 3). However after the first day of storage control samples developed more 'a' value, ie redness compared to treated fruits. During prolonged storage decrease in redness was rapid in fruits stored without any pretreatment. Among the *Aloe gel* treatments T1 (1: 3 ratio) was found more effective to maintain the colour of the fruits. 'b' value indicating the vivid colour was noted by significant lower value in control samples as compared with treated fruits of strawberry fruits. Differences in external colour between coated and uncoated samples during the storage period at 25°C were more acute than those reported by Garcia *et al.* (1998a) and Zang and Quantick (1998). Edible coatings reduce the respiration rate of fruits. The highest storage temperature used in this study increased respiration and gave rise to more significant differences between coated and uncoated samples.

Effect on total soluble solids (TSS) of fruits

Total soluble solids significantly ($P>0.05$) increased with storage time in all treatments (Fig 6). However in control increase was rapid from day 2 itself and reached the maximum 9.4 Brix at 6th day of storage thereafter there was decrease in TSS i.e., 7.0° Brix at 16th day of cold storage. In case of treated strawberries TSS was found 8.4 Brix in T1 (*Aloe gel* 1: 3), 8.2 in T2 (*Aloe gel* 1: 2) and T3 (*Aloe gel* 1: 2), respectively at the end of storage study.

Table 1 Mean of the attributes in the sensory evaluation for the shelf-life of *Aloe vera* gel coated strawberry stored at 5°C during 16 days

Parameter	Treatment	Storage period at 5°C (Days)				
		2	4	8	12	16
Appearance	*Aloe vera* gel 1: 3	7.6	7.5	7.4	7.4	7.3
	Aloe vera gel 1: 2	7.3	7.2	7.1	7.1	7.0
	Aloe vera gel 1: 1	7.4	7.1	7.0	7.0	6.9
	Control	6.6	6.6	5.7	5.5	5.0
CD (P=0.05)		0.191	0.191	0.259	0.191	0.192
Firmness	*Aloe vera* gel 1: 3	7.4	7.2	7.3	7.1	7.1
	Aloe vera gel 1: 2	7.5	7.2	7.1	7.0	7.0
	Aloe vera gel 1: 1	7.3	7.2	7.1	7.1	7.0
	Control	7.0	6.5	6.0	5.9	5.5
CD (P=0.05)		0.235	0.156	0.199	0.175	0.191
Colour	*Aloe vera* gel 1: 3	7.6	7.5	7.4	7.3	7.2
	Aloe vera gel 1: 2	7.5	7.3	7.2	7.2	7.1
	Aloe vera gel 1: 1	7.4	7.2	7.1	7.1	7.0
	Control	7.1	6.9	6.0	5.6	5.0
CD (P=0.05)		0.302	0.191	0.191	0.191	0.191
Taste	*Aloe vera* gel 1: 3	8.0	7.6	7.5	7.3	7.2
	Aloe vera gel 1: 2	7.8	7.5	7.2	7.0	7.0
	Aloe vera gel 1: 1	7.7	7.5	7.3	7.2	7.0
	Control	7.2	6.9	6.3	5.7	5.0
CD (P=0.05)		0.191	0.221	0.175	0.191	0.191
Over all acceptability	*Aloe vera* gel 1: 3	7.6	7.4	7.2	7.1	7.1
	Aloe vera gel 1: 2	7.6	7.2	7.1	7.1	6.9
	Aloe vera gel 1: 1	7.7	7.2	7.1	7.0	7.0
	Control	7.5	6.3	5.9	5.5	5.0
CD (P=0.05)		NS	0.191	0.175	0.191	0.191

Scores for appearance, firmness, colour, taste, and overall acceptability; 1: Dislike extremely; 2, dislike very much; 3, dislike moderately; 4, dislike slightly; 5, liked/disliked; 6, liked slightly; 7, like moderately; 8, liked very much; 9: liked extremely

Effect on acidity of fruits

Titratable acidity increased significantly (P>0.05) in first two days of storage in all the treatments and untreated control strawberries, thereafter, a rapid decrease was noticed in all the treatments including control fruits. However the decrease was rapid in control. At end of storage (16 days) the titrable acidity was found to be 0.83% and 1.37, 1.26 and 1.08 in T1 (1: 3), T2 (1: 2) and T3 (1: 1) respectively (Fig 7). The decrease in acidity indicates attainment of maturity in strawberry fruits, irrespective of their pre-treatments. Similar trends showing the decrease of acidity in coated and uncoated strawberry fruits have been reported by El Gaouth *et al.* 1991a for chitosan based formulation and by Garcia *et al.* 1998a, 1998b for starch based coatings.

Effect on Ascorbic Acid (Vitamin C) contents

Ascorbic acid content of the fruits significantly (P>0.05) decreased with the storage time in all the treatments (Fig 8). Ascorbic acid decreased with storage period, however, but fruits coated with *Aloe vera* showed minimum decrease for the period of 16 days storage (45±0.4 mg/100 g in treated and 30±0.5 mg/100 g in untreated fruits. The *Aloe vera* coating has delayed ripening of strawberry during storage as indicated by retention in titratable acidity, minimal changes in TSS and ascorbic acid content.

Sensory evaluation of strawberry

The sensory evaluation of strawberry fruits showed that during initial days of storage appearance, colour and brightness of the treated as well as control (Table 1) fruits were acceptable for consumption but at the end of the study period fruits in control were rejected due to their dull colour and overripe conditions. Coatings significantly (P>0.05) improved the shelf life of strawberry by maintaining appearance, firmness, colour, taste scoring > 7.0 which indicates that the consumers would prefer *Aloe vera* coated fruits. Among the treated fruits T1 (1: 3 ratio) was the best in terms of consumer's acceptability. From the results of sensory evaluation for taste of strawberries, *Aloe vera* coatings had no negative effect (P>0.05) on flavour, taste, firmness and appearance of strawberry scoring. Results indicate that *Aloe vera* coatings can be used to coat strawberry fruits for quality maintenance and improving shelf life. Particularly, *Aloe vera* 1: 3 ratio was mostly liked by judges and consumers as well.

It can be concluded that *Aoe vera* gel applied as agri based coating in fruits is beneficial for retarding the ripening process of strawberry fruits. It acts as a barrier to moisture loss; thereby reduces the weight loss and maintains fruit firmness. *Aloe vera* delays colour change, maintains quality attributes like acidity, ascorbic acid and TSS and improves storability significantly. Results on sensory analysis confirm the beneficial effect in terms of taste, aroma and appearance. Further this treatment can be tested for other fruits to observe its effect on quality maintenance, safety and commercial application on large scale.

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