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HORTICULTURE

EFFECT OF ALOE VERA GEL COATING ON POSTHARVEST FRUIT QUALITY OF STRAWBERRY FRUIT (*FRAGERIA ANANASSA*)

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ABSTRACT

Current study was conducted in 2019 at Post Harvest Research Center, Ayub Agricultural Research Institute, Faisalabad, Pakistan and Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan to address this problem of strawberry fruit where aloe vera gel coating was applied with different concentrations (0.1%, 1.5% and 2%) at 3°C to determine its possible effects on postharvest fruit quality and to increase the shelf life. Data were recorded on different fruit related parameters like fruit weight loss, fruit shape index, firmness, disease and decay %age, pH, TSS, titrateable acidity, vitamin-c content, reducing sugars, non-reducing sugars and total sugars. The results showed that application of 1.5% aloe vera gel significantly increased the shelf life as evidenced by minimum fruit weight loss (5.2%), higher fruit firmness (2.75%), less disease and decay (5.8%). However, TSS (8.16 °Brix), reducing sugars (2.98%), non-reducing sugars (2.59%) and total sugars (5.57%) were found maximum for control. Highest acidity (0.88%) and vitamin C contents (53.46 mg/100g) were found in fruits treated with 2% aloe vera gel. Moreover, lowest pH (4.41) was recorded in fruits coated with 2% aloe vera gel. Results of this study revealed that the potential of using aloe vera gel at 1.5% as a coating material proved to be better to prolong postharvest life as well as to maintain quality of strawberry fruits.

KEYWORDS: Strawberry; post-harvest; aloe vera gel; nutritional quality; physico - chemical trait; Pakistan

INTRODUCTION

Strawberry (*Frageria ananassa* L.) belongs to family rosaceae and is highly perishable fruit having unique flavor and taste. Its fruit is classified as an aggregate fruit due to its formation from the receptacle and not from the ovary. Fruit contains small seeds known as achene which are surrounded by fleshy receptacle (Chandler *et al.,* 2012). China is leading in production of strawberry followed by USA, Mexico, Egypt, Turkey and Spain. Strawberry is inhabitant of temperate climate. It is propagated though runners in October and gives fruits during April to May and then starts its vegetative growth and produces the runners in cool season (June to September). Strawberry can also be planted in warm climate areas (Sharq Pur, Sheikhupura, Gujranwala, Sialkot, Faisalabad, Multan etc.) during November which gives fruits during February to April. During April the temperature rises, and strawberry stops its vegetative growth and it does not produce the runners due to higher temperature. Pakistan produces almost 795 tons strawberry over an area of 387 hectare (GoP, 2019). Strawberry is delicious fruit that is not only consumed fresh but also as a flavoring fruit to dairy products like yoghurt, ice-cream, shakes and purees. It is also used in processing industries to make jellies, jams and squashes. This fruit is rich in minerals and antioxidants which boosts immunity. Hundred gram strawberries contain almost 200-324 mg phenolics, 28-51 mg vitamin C, 19-47 mg anthocyanins (Velde *et al.,* 2013).

Fully ripe fleshy fruits are perishable and this presents difficulties for fruit production, harvesting, transportation, storage and marketing. Strawberry is delicate fruit having shelf life up to4-5 days of storage at 0-4 °C (Jiang *et al.,* 2001). Postharvest handing is the major problem of strawberry deterioration, mechanical injury during handling and transportation results in microbial growth and decaying of entire fruit. Storage life of fresh strawberry is up to 10 days at 2-3 °C with relative humidity 85% (Lidstert *et al.,* 1990). According to Park *et al.* (2005) postharvest losses of strawberry are up to 40% from farm to fork. Fruit is

highly perishable, so has very short shelf life because of higher respiration rate, water loss and mechanical injury, Edible coating is gaining popularity to improve the storage life of strawberry and papaya (Vargas *et al.,* 2008). According to Bourtoom (2008) use of edible coatings minimizes the water loss, mechanical injury and decay percentage and also reserves the color and texture of fruits. Edible coatings are being utilized in different horticultural crops for the longer shelf period such as fig coated with thymol and chitosan (Mansoureh *et al.,* 2019), Indian jujubes coated with carnauba wax (Huiyun *et al.,* 2019). Usman *et al.* (2019) observed increased shelf life and less mechanical injury during transportation of apple when coated with β-glucan acid and wheat straw arabinoxylan. Among edible coatings, aloe Vera gel is gaining popularity for being easily accessible and cheap source to enhance the shelf life of different fruits. According to Moghaddasi and Res (2011), aloe vera gel comprised of 75 different nutrients and 200 energy boosting elements such as salicylic acid, minerals, vitamins, sugars and amino acids. Gel has certain properties such as antifungal, antibacterial and antioxidants. Masoud *et al.* (2019) investigated the combine effect of aloe vera gel and salicylic acid on quality, chilling injury and microbial load of "Thomson Navel' stored at 4°C. Objective of this study was to enhance the shelf life of strawberry. Marpudi *et al.* (2013) found minimum physicochemical changes of figs fruit when coated with aloe vera gel compared with control.

Strawberry produces in most of the cities along the river belts and transported to the other cities (Lahore, Islamabad, Peshawar, Rawalpindi etc.) The fruit is demaged due to mechanical injury and hot temperature during transportation. Present study was planned to evaluate different concentrations of aloe vera gel coating in improving shelf life of strawberry fruits.

MATERIALS AND METHODS

Fruit material

Healthy, uniform and disease-free strawberry fruits of cultivar Chandler were harvested at about 85% red color development stage from a local farm located in Tahsil Samundri, district Faisalabad Punjab Pakistan (31° 09′ 17.42″ N 72° 57′ 00.46″ E). The study was conducted during 2019 at Post Harvest Research Centre, Institute of Horticultural Sciences University of Agriculture Faisalabad. After harvesting fruits were packed in transparent perforated zip-lock bags (Packages Limited, Lahore-54760), stored in ice boxes to minimize the post harvest losses and shifted to work place by road transportation within approximately one hour travelling. To avoid the pressure and mechanical injury every pack consisted of 30 fruits.

Preparation and application of aloe vera gel coating

Fully extended healthy aloe vera leaves were harvested from three years age plant from experimental fruit orchard square # 32, University of Agriculture Faisalabad wrapped in brown paper bag and brought to laboratory. Leaves were rinsed thoroughly with tap water and then washed with distilled water to remove dust and inert matter on surface. Epidermis was removed from the leaves and cut into small pieces in order to prepare extract of aloe vera gel, leaves were first placed in vertical position for 15 minutes for good drainage of sap. Gel slices were removed and stored in dark jar in refrigerator until blending. After blending gel was filtered with thin cloth and packed in jar. Gel was heated at 70 °C for 40-45 minutes and then cooled at room temperature by adding ascorbic acid (2g/L). To maintain its pH at 4, citric acid was added at 4.5 g/L and again cooled for 15-20 minutes. Different weights (1g, 1.5g and 2.0g) of aloe vera gel were added to make final concentrations of 1%, 1.5 % and 2.0% (w/v) of study treatments plan as under:-

T_1 = Control
T_2 = 1% aloe vera gel
T_3 = 1.5% aloe vera gel
T_4 = 2% aloe vera gel

Strawberries coating

Aloe vera coating was applied by dipping fruit in coating mixture for 1 minute. After that fruit was air dried for 30 minutes and placed in punnets. Each punnet had 18-20 fruits. After application it was stored for 15 days at 3°C. Non-coated strawberries were stored in the same conditions as control.

Physico-chemical/biochemical analysis

Physico-chemical analysis was performed at different storage days, until total deterioration of the strawberry fruits. Weight loss (g) of coated strawberries during cold storage was measured by monitoring weight changes of fruits at different storages days. For determining biochemical parameters, fruit sample was grinded in grinders and then pulp was centrifuged at 10000rpm for 2 minutes. Fruit pH was recorded by using pH meter (HI 98107, Hanna instrument, Mauritius). The total soluble solids were quantified by digital refractometer (RX5000, ATAGO, Japan). Fruit acidity and vitamin C contents was measured by following Peyro *et al.* (2017) method, whereas sugars (reducing, non reducing and

total) were measured by considering Chandraju *et al.* (2013). Other quality parameters including total phenols (mg/100 mL) determined by Folin-Ciocaltue (FC) method described by Rebeiro *et al.* (2007), total anthocyanin (%) calculated by Şakar *et al.* (2008) and antioxidant capacity (% inhibition) were assessed by the method described by Ullah *et al.* (2013). Total dry matter was calculated by drying strawberries at 105 °C until constant mass.

Sensory evaluation

It was carried out by using Hedonic scale (1-5) to rate the selections for color, taste, flavor, and texture (Peryam and Pilgrim, 1957). Fruits were arranged according to replication for analysis. A panel of ten judges evaluated sensory assessment using the Hedonic scales as given below. For each replication, average score was recorded as 1 : Hedonic scale rating product, 2 : Variety, 3 : Date, 4 : Name of Judge and 5 : Signature.

Instructions: (Please read the instructions carefully before filling blanks

1. This is an organolaptic analysis form for the evaluation of strawberry fruit.
2. Please follow the numerical system for scoring the samples.
3. Please do not disturb the sequence of the samples provided. Please wash the tongue before testing next sample with water provided.

1. Dislike extremely
2. Dislike slightly
3. Like slightly
4. Like moderately
5. Like extremely

Statistical analysis

The experiment was laid out according to Completely Randomized Design (CRD) with four treatments which were replicated three times. The experimental data was analyzed for variance (ANOVA) using MSTAT-C (Steel *et al.,* 1997). The significant differences among treatment results were calculated and compared by subjecting mean values to Least Significant Difference test (LSD) at P ≤ 0.05.

RESULTS AND DISCUSSION

Physiochemical parameters

Total soluble solids (°Brix)

Results from data analysis showed significant difference among various concentration of aloe vera gel coating on TSS of strawberry fruit. Maximum TSS 8.16 °Brix was observed in uncoated fruits (control) of aloe vera gel followed by 1% of aloe vera gel with 7.73°Brix TSS (Table 1). Fruits that were applied with 2% aloe vera gel concentration showed minimum TSS (6.04 °Brix) as compared to others. Our results are in accordance with Tripathi and Dubey (2004) who studied less increase in TSS of berries coated with aloe vera gel compared with uncoated fruit. However, these results are in contradiction Sridevi *et al.* (2018) who found significant and gradual increase in TSS of pomegranate cv. 'Bhagwa' arils coated with 30% aloe vera gel as compared to control.

pH

Data showed that aloe vera gel coatings on strawberry fruit were non-significant (p≤0.05) from control. The highest value of pH (4.87) was observed in the untreated fruits (Table 1). While in fruits coated with 2% gel recorded to have minimum (4.41) pH. Our results are in line with Peyro *et al.* (2017) who found that pH of grapes remained non-significant when treated with salicylic acid and aloe vera gel.

Acidity (%)

Significant changes were observed in total titrateable acidity of strawberry fruit when coated with different concentrations of aloe vera gel (Table 1). Fruits that were coated with 1% aloe vera gel found to have minimum percentage of titrateable acidity (0.72%) at is at par with control fruits. Fruits coated with 2% aloe vera gel found to have maximum acidity percentage (0.88%). Arowora *et al.* (2013) studied that titrateable acidity of oranges remained non-significant by coating of aloe vera gel whereas Tripathi and Dubey (2004) found increase in titrateable acidity content of berries coated with aloe vera gel that is in line with our findings. In strawberry fruit major organic acid is citrate that is linked with titrateable acidity of the fruit. This acid contributes in the development of specific taste of the fruit (Arowora *et al.,* 2013).

Table 1. Sensory evaluation of strawberry fruit after different aloe vera gel treatments

Treatments	TSS (%)	pH	Acidity (%)	Vitamin C (mg/100g)	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)
T_1 = Control	8.16 a	4.87 a	0.72 b	47.31 b	2.98 a	2.59 a	5.57 a
T_2 = 1% aloe vera gel	7.73 ab	4.49 a	0.73 b	51.41 ab	2.49 bc	2.38 a	4.87 b
T_3 = 1.5% aloe vera gel	6.20 b	4.50 a	0.86 ab	51.66 ab	2.36 c	2.32 a	4.68 b
T_4 = 2% aloe vera gel	6.04 b	4.41 a	0.88 a	53.46 a	2.67 b	1.94 b	4.61 b

Vitamin C (mg/100g)

Data analyzed for vitamin C content of strawberry fruit revealed significant difference ($p \leq 0.05$) among various concentrations of aloe vera gel at (Table 1). Strawberry fruits that were coated with 2% aloe vera gel showed highest value for vitamin C content (53.46 mg/100g). Fruits treated with 2% aloe vera gel have maximum value for vitamin C contents (53.46 mg/100g) followed by fruits treated with 1.5% aloe vera gel (51.66 mg/100g).

Our results are in accordance with the previous study where oranges coated with aloe vera gel tend to have higher vitamin C content as compared to uncoated fruit stored at 12°C (Arowora *et al.,* 2013). Similar results were observed by Brishti *et al.* (2013), where papaya fruit coated with aloe vera gel have more value of vitamin C content (86.55 mg/100g) than control (61.10 mg) stored at 25-29°C with 82 ± 2% RH. This aspect can be attributed to aloe vera gel property of less oxygen permeability which is the major reason of vitamin C content degradation.

Reducing sugars, non-reducing sugars and total sugars (%)

Reducing, non-reducing and total sugars were found statistically different ($p \leq 0.05$) in strawberry fruits coated with different concentrations of aloe vera gel (Table1). Highest percentage of reducing (2.98%), non-reducing (2.59%) and total sugars (5.57%) was observed in untreated fruits. However, fruits treated with 1.5% aloe vera gel found to have lowest value (2.36%) for reducing sugars that was at par with 1% aloe vera gel. Similarly, aloe vera gel at 2% concentration gave significantly lowest value for non-reducing (1.94%) and total sugars (4.61%) compared to other treatments. Similar kind of observation was reported earlier with starch coated strawberries and the reason was attributed to higher rate of respiration observed in the uncoated fruits. In addition, aloe vera gel coating would have induced a modification in the internal atmosphere showing similar effect with sweet cherry fruit under modified atmosphere package conditions (Serrano *et al.,* 2006).

Juice contents (%)

Juice content percentage was significantly influenced by different concentrations of aloe vera gel coatings (Table 2). Highest percentage of juice content was calculated in treated fruits (control) (67.90%) that is statistically different from other treatment. Fruits treated with 1.5% aloe vera gel coating gave minimum percentage of juice contents compared to others. These results were in contradiction to the findings of Romero *et al.* (2006) who reported that aloe vera gel coating significantly decrease the moisture loss of sweet cherry fruits by creating barrier on fruit surface.

Dry matter (%)

Findings from present study revealed non-significant effect of aloe vera gel coatings on dry matter percentage of strawberry fruit (Table 2). Treatments with 1.5% and 2% aloe vera gel found at par with 14.22% dry matter content. Minimum value for dry matter (13.33%) was recorded at 1% aloe vera gel. These results may be due to the fact that aloe vera gel coating created a physical barrier on the fruit surface and at lower concentration this coating acted as permeable layer on fruit surface. These results were in line with the judgements of Morillon *et al.* (2002) who stated that aloe gel has hygroscopic properties which reduce the moisture loss by making a water barrier between fruit and surrounding environment. Aloe gel coating on table grapes, stored at 1°C and 95% humidity, significantly improved the dry matter content by reducing moisture loss and creating a barrier.

Total phenols (mg/100mL)

Total phenols of strawberry fruit tend to remaine unaffected by aloe vera gel coating during storage (Table 2). Maximum phenolic content (407.39 mg/100mL) was observed at 2% aloe vera gel followed by uncoated fruits and 1% aloe vera gel coating. Our results are in contradiction with Serrano *et al.* (2006) who studied that phenolic contents were in grapes coated with aloe vera gel during storage compared to uncoated fruits. Similarly, Qamar *et al.* (2018) reported that phenolic content in strawberry fruit cultivar 'Chandler' coated with aloe vera gel and chitosan tend to remain unaffected by coating during storage.

Total anthocyanins(%)

Data analyzed for total anthocyanin of strawberry fruit presented non-significant results for various coatings

Table 2. Effect of various aloe vera gel treatments of strawberry fruits

Treatments	Juice contents (%)	Dry matter (%)	Total phenols (mg/kg)	Total anthocyanin's (mg/kg)	Antioxidant capacity (mmol/kg)
T_1 = Control	67.90 a	13.46 a	407.09 a	251.95 a	2.48 a
T_2 = 1% aloe vera gel	66.18 ab	13.33 a	406.51 a	251.96 a	2.52 a
T_3 = 1.5% aloe vera gel	65.17 b	14.22 a	406.31 a	253.79 a	2.52 a
T_4 = 2% aloe vera gel	66.12 b	14.22 a	407.39 a	254.87 a	2.42 a

of aloe vera gel at 5% level of probability (Table 2). However, maximum value of retention for total anthocyanin was observed in fruits coated with 2% aloe vera gel followed by 1.5% Aloe coating. Anthocyanin constitute the blue and red color of different fruits and vegetables (Mullen *et al.,* 2002). Serrano *et al.* (2006) and Hassanpour (2015) observed fewer changes in anthocyanin of aloe vera gel coated grapes and raspberry during storage.

Antioxidant capacity (% inhibition)

Antioxidant capacity of strawberry fruit stored at 3°C showed non-significant difference among various treatments (Table 2). Antioxidant capacity of treatment 1% aloe vera gel and 1.5% aloe vera gel is maximum and are at par with each other (2.52% inhibition). However, minimum value for antioxidant capacity was observed in fruits treated with 2% aloe vera gel. Our results are in contradiction with Sogvar *et al.* (2016) and Hu *et al,* (2005) studied reduced antioxidant capacity in grapes coated with aloe vera gel. Aloe vera gel coating can enhance immunity of tissue against deterioration by improving the antioxidant capacity.

Fruit weight loss(%)

Results regarding impact of aloe vera gel coating on fruit weight loss of strawberry fruit during storage showed significant effect of aloe vera gel coating on strawberry weight loss. Highest fruit weight loss (11.5%) was recorded in untreated fruits. Minimum fruit weight loss (5.2%) was recorded in the fruits coated with 1.5% aloe vera gel while the 1% aloe vera gel and 2% aloe vera gel are at par with each other in fruit weight loss (9.2%) (8.1%) respectively (Fig.1). These findings are in line with the result of Chrysargyris *et al.* (2016), who also found significant effect of aloe vera gel coating on shelf life of tomato by controlling ethylene production. Our findings are also in accordance with Peyro *et al.* (2017) who found extended shelf life of grapes when coated with 2% salicylic acid + 20% aloe vera gel stored at 14°C.

Fruit firmness (kg)

Strawberry fruit coated with aloe vera gel represented significantly higher fruit firmness than untreated fruits (Fig.1)**.** Maximum fruit firmness (2.75 kg) was recorded in fruit treated with 1.5% aloe vera gel followed by 2% alovera gell where fruit firmness was recorded 1.4 kg. Whereas minimum fruit firmness was analyzed in untreated fruits (0.80 kg). Aloe vera gel was used as an edible fruit coating due to its potential in controlling dehydration, microorganism's penetration, lowering respiration rates and oxidative browning in table grapes and cherries (Marpudi *et al.,* 2011). Coating of aloe Vera gel alone or in combination with Arabic gel and shellac helped in maintenance of firmness and color of apple fruit (Chauhan *et al.,* 2011). This might be due to blockage of surface pores with gel coating. Coating improves quality by decreasing transpiration rate, respiration and mechanical injury during postharvest handling. Firmness can be preserved through modification and controlling the internal atmosphere of fruit (Meighani *et al.,* 2015).

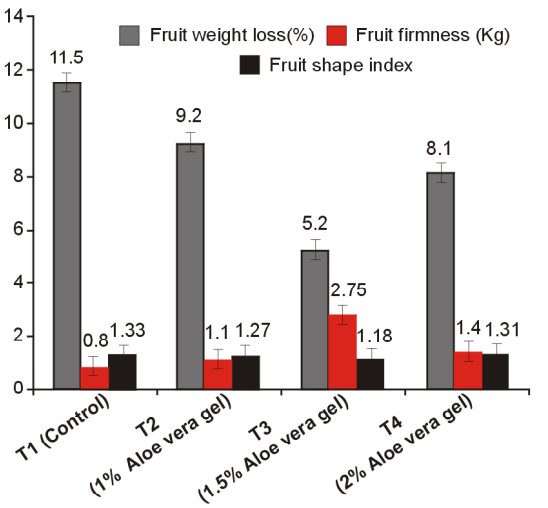

Fig. 1. Effect of various aloe vera gel treatments on fruit weight loss, fruit firmness and fruit shape index in strawberry

Fruit shape index

Data related to fruit shape index analyzed statistically at 5% level of probability shown in Fig.1. Minimum fruit shape index 1.18 (change in fruit shape and size) observed in fruits treated with 1.5% level of aloe vera gel whereas highest fruit shape index (1.33) recorded in untreated fruits. Zefari *et al.* (2013) also suggested that aloe vera gel is useful for the retention of fruit size in strawberry fruit. This might be due to its property of creating barrier against that reduces moisture loss and prevents fruit shriveling (Vargas *et al.,* 2006).

Disease, decay and damage(%)

Aloe vera gel concentrations at 1.5% and at 3°C significantly (P≤0.05) reduced the disease, decay and damage incidence. Highest percentage (11.27) of disease, decay and damage incidence was recorded from fruits without gel coating followed by aloe vera gell coating 1% (10.2%) (Fig.2). Strawberry fruit is gaining popularity among peoples due to its nutritious value but rapid weight loss and fruit decay during supply chain is one of major drawback in postharvest supply chain (Atress *et al.,* 2010). Aloe vera gel or chitosan coating

Table 3. Sensory evaluation of strawberry fruit after different aloe vera gel treatments

Treatments	Color (Score)	Taste (Score)	Flavour (Score)	Texture (Score)
T_1 = Control	2.25 a	1.50 c	1.750 b	1.25 c
T_2 = 1% aloe vera gel	3.00 a	3.00 b	3.5 a	2.75 ab
T_3 = 1.5% aloe vera gel	4.25 a	3.70 ab	2.5 ab	3.75 a
T_4 = 2% aloe vera gel	4.00 a	4.5 a	2.00 b	2.25 bc

reduced respiration rate, weight loss, and microbial decay and preserved firmness, vitamin C content and other quality parameters, thus delaying ripening and the progress of fruit decay due to senescence or microbial attack (Nasrin *et al.,* 2017).

Sensory evaluation of strawberry

Color

Fruit color of strawberry fruit showed non-significant difference among various treatments of aloe vera gel coatings (Table 3). However, maximum score (4.25) was obtained where aloe vera gel was applied at 1.5% concentration followed by 2% aloe vera gel (4.00). This might be due to less physiological changes and retention of color during storage due to coatings. Our results are in contrary with Qamar *et al.* (2018) who studied significant effect of aloe vera gel and chitosan coating on strawberry fruit color.

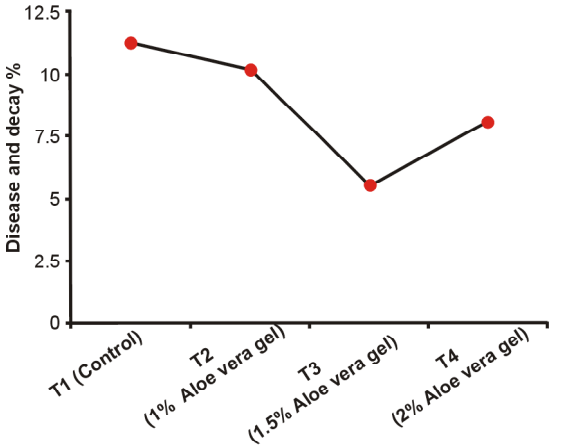

Fig. 2. Effect of various aloe vera gel treatments on disease and decay percentage

Taste

Taste of any fruit is the combination of various organic acids and sugars content. Taste can be associated with the salts of nucleotides and amino acids (Yamaguchi and Ninomiya, 2000). Among different treatments, 2% aloe vera gel found statistically different from treatment 1% aloe vera gel and without aloe vera gel. Fruit with 2% coating tend to have highest score (4.5) for taste followed by 1.5% aloe vera gel (3.70) which was at par with 1% (3) aloe vera gel coating respectively (Table 3).

Flavour

The maximum mean score for strawberry fruit was found in treatment with 1% aloe vera gell (AVG) (3.5) that was statistically at par with 1.5% (AVG) whereas minimum score (1.75) was observed in control where no coating was applied (Table 3). Flavour is comprised of taste and aroma. Our results are in line with Qamar *et al.* (2018) who found maximum preservation of aroma and flavor in fruits coated with aloe vera gel and chitosan as compared to control. Similarly, in table grapes, aloe vera gel coating had positive impact on sensory characters of fruits compared to uncoated grapes where unpleasant flavour developed during storage (Serrano *et al.,* 2006).

Texture

In present study, highest score (3.75) for texture was observed in strawberry fruits coated with 1.5% aloe vera gel followed by 1% aloe vera gel coating (Table 3). Minimum score for texture was observed in fruits that were uncoated or treated as control. These results are in accordance with the findings of Morillon *et al.* (2002), who stated that aloe coating significantly affected the firmness loss of table grapes when stored at 1°C and 95% RH. As firmness is directly related to fruit texture thus it ultimately preserves fruit texture for a longer period.

CONCLUSION

It was concluded that strawberry fruits treated with aloe vera gel had longer shelf life as compared to untreated fruits, so aloe vera gel have the potential to minimize the post-harvest losses in strawberry fruits. The results showed that application of 1.5% aloe vera gel significantly increased the shelf life as evidenced by minimum fruit weight loss (5.2%), higher fruit firmness (2.75%), low disease and decay (5.8%), TSS (8.16 °Brix), reducing sugars (2.98%), non-reducing sugars (2.59%) and total sugars (5.57%). However, highest acidity (0.88%), lowest pH (4.41) and vitamin C contents (53.46 mg/100g) were found in fruits treated with 2% aloe vera gel.

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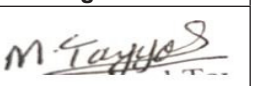
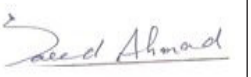
1.	Touqeer Haider	Conducted the experiment	
2.	Saeed Ahmad	Supervisor	
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