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IMPACTS OF ALOE VERA GEL COATING ON POSTHARVEST QUALITY AND STORAGE PERIOD OF APPLE (*MALUS DOMESTICA*)

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Abstract

The study was carried out at the Horticulture Departmental Laboratory of Balochistan Agriculture College, Quetta, to assess the postharvest quality and storage of apples coated with Aloe vera (ALV) at concentrations of 0%, 5%, 10%, and 15% under room temperature. Data on fruit quality and biochemical aspects were evaluated at 10 day intervals (0, 10, 20, 30, and 40 days). Data were analyzed using a Completely Randomized Design with a Factorial arrangement, Analysis of Variance (ANOVA), and the LSD test at P ≤ 0.05. The organoleptic evaluation results at T_4 (15%) achieved maximum values (Colour 2.5), (Taste 5.0), (Flavor 3.0) and (Aroma 4.35) while minimum value noted in untreated fruits at 40 days. In terms of overall acceptance, the lowest mean value was found at the end of the storage period in T_1 and T_2 (1.0), followed by T_3 (2.0) and T_4 (5.0). The physical quality characteristics showed higher weight loss in T_1 (12.15%) and the minimum in T_4 (11.00%) at 40 days. Fruit size displayed reducing trend as the 40 day T_1 (8.92), T_2 (7.93) followed by T_3 (6.45) and T_4 (5.71) progressed. Specific gravity of the stored apple was (1.00) in T_1 followed by T_2, T_3 and T_4 respectively. The highest disease incidence was observed in T_1 and T_2 (4.0) followed by T_3 (3.2) and T_4, (2.1), decay percentage was highest in T_1 (3.30%) and lowest in T_4 (1.30%) at 40 days. The average decrease in the fruit weight at day 40 was (143g, 142.3g, 138.9g) in T_2, T_4, T_3 and (123.9g) T_1. The maximum firmness mean value was achieved in T_4 (9.43 N) followed by T_3 (9.40 N), T_2 (8.70 N) and T_1 (7.67 N). T_4 revealed higher index for marketability (0.6%) and T_1 showed least (0.37%) at 40 days of shelf life. pH of overall treatments was (3.5) at 0 day, T_1 increased to (6.25) and T_4 was (6.01) at day 40. Overall TSS was (17.00 °Brix) at the beginning of the storage period at the day 40 lowest value was recorded (14.01 °Brix) in T_3, and T_2, was observed highest (15.10 °Brix). The average mean for EC was recorded (40.00) at 0 day of shelf period. The maximum EC observed in T_4 was (48.41%) and lowest was (21.790%) in T_1. The higher fruit TA was recorded in T_3 (0.65%) followed by T_2 (0.59), T_1 and T_4 (0.61%) at day 40. The maximum TSS/TA ratio was found in T_2 (1.64), while the minimum was recorded at T_3 (1.38) at 40 days. A 15% (ALV) concentration was effective in extending the storage period of apples, enhancing shelf life, reducing fungal spoilage, and improving postharvest quality.

Keywords: *Aloe Vera gel coating (ALV), Postharvest quality, Shelf life, Storage period*

INTRODUCTION

The apple or *(Malus domestica)* is a domesticated tree and one of the most extensively grown tree fruits in the Rosaceae family. Originating from both hemispheres, Malus species are found in temperate regions (1). Apples are highly valued due to their abundant nutritious content, delicious crisp texture, and harmonious blend of sweet and sour flavour. China produced over 40% of the world's apple cultivars, more than any other country, with the United States coming in second (2). Pakistan cultivates a wide variety of apples, including red apples, golden apples, kashmiri, kaja, kala kulu mushadi, amri, and gacha. Balochistan, Mustung, Ziarat, Kalat,

Pashin Killa Saifullah, Quetta, Loralai, Killa Abdullah are the principal apple growing districts. In all of these districts, Ziarat is situated in the middle (3, 4).

Apple is the second most eaten fruit in the world after bananas, include a variety of nutrients as well as non-nutrients including minerals, vitamins and dietary fiber. An excellent source of polyphenols, apples include flavonols, monomeric flavanols, anthocyanins, oligomeric flavanols, dihydrochalcones, and derivatives of hydroxybenzoic and hydroxycinnamic acids. (5). Polyphenols found in apples, and their juice extracts have already been examined in a number of human trials, with encouraging results regarding their health benefits (6). Consuming at least one apple per day, for example, has been shown to lower the 95% confidence interval for the odds ratio (¼0.65) and prostate cancer risk is 0.39-1.09 (7). Since several research has evidenced the pharmacological activities (antioxidant, antimicrobial, anti-cancer, anti-diabetic, anti-inflammatory, etc.) of fruits and vegetables, it has been recommended that eating apples daily can help prevent a variety of chronic diseases, including chronic, obstructive asthma, pulmonary disease, and various types of cancers.(8, 9).

In the agricultural sector of underdeveloped countries, 30 to 40 percent of the entire crop is lost or ruined before it is consumed because post-harvest management is lacking." Approximately 392 to 486 million tons of fruits and vegetables are produced worldwide. Reduced qualitative and statical losses of horticultural goods ensures that the total produced is fit for consumer use, especially when taking into account postharvest techniques and technology. Mastering sanitary farming methods ought to be top focus if you want longer postharvest lifespans (10). The storage temperature and duration have linear association in relation to changes quality and shelf life of fruits. The weight of fruit is lost during storage gradually; and with the weight loss, the fruit colour and other nutritional quality traits are simultaneously influenced (11).

Aloe vera extract is frequently used in edible coatings to enhance the quality of perishable items like fruits and vegetables after harvest. Aloe vera is a semi-tropical shrub with therapeutic qualities. Aloe vera also produces a different kind of gel called yellow latex, or exudate, which provides additional benefits for the plant such polysaccharides, lignins, phenolic compounds, glycoproteins, vitamins, saponins, and enzymes (12, 13). This gel has no taste, colour, or smell. This natural substance replaces synthetic preservatives like sulphur dioxide in a safe and eco-friendly manner. The researchers claim that this gel functions by combining a number of mechanics (14).

MATERIALS AND METHODS

Fresh, healthy, uniform size, homogeneous in color, free from disease, injuries, and mature fruits of the Apple cultivar (Royal gala) were harvested from a commercial Apple orchard of Ziarat, Balochistan by using the local harvesting bag and then packed in a cotton for further analysis. The proper arrangements were made for transportation to the horticulture departmental laboratory Balochistan Agriculture College, Quetta to study the various fruit quality parameter and further analysis. Leaves of Aloe Vera were obtained from a nearby nursery. The gel was extracted and separated fibers via sterile muslin cloth. Hence, the resulting ALV gel extract was clean and clear and stored in an air-tight glass for further usage.

The concentration of ALV gel extract (5% = 50 ml, 10% = 100 ml, 15%= 150 ml) is diluted up to 1000 ml of deionized water. The ALV gel extract applied to coat the fruits, by immersing for 5 minutes in predefined concentrations (T_1 Control, T_2 5%, T_3 10%, and T_4 15%) the untreated fruits were tagged as control. The data on the different parameters were investigated after 10 days interval at ambient temperature. The fruits were taken for data analysis from 0, 10, 20, 30, and 40 days at the time of storage for data collection this experiment was aimed at having four treatments with three replications. The data was executed (carried out) with factorial CRD (Complete randomized design).

PARAMETERS STUDIED

FRUIT PHYSICAL QUALITY CHARACTERISTICS

Fruit samples were weighed before the experiment began and at the conclusion of each day-long storage term. Using the following formula, percentage calculations were performed on the basis of fresh weight during that storage interval, with the difference between the original and final fruit weight being considered as the total weight loss.

$$\text{Fruit weight loss (\%)} = \frac{\text{initial weight (g)} - \text{final weight (g)}}{\text{Final weight (g)}} \times 100$$

For calculating the firmness of fruit samples, a digital penetrometer (QA supplies, fruit pressure tester FT – 327) was utilized. It represented the pressure required to penetrate a plunger of a specific size into the fruit pulp, and the average reading was then calculated in the fruit such pressure is measured in N. Fruit size (in cm) was calculated from the measurement of apple length and apple width as brief below: Fruit (10) apples from every replication) length and width was measured with the help of Venire caliper (Digital Caliper, D-K, 15190-01-00, Germany) in cm and average was calculated.

Fruit weight (in grams) was determined by method given by peryam and piligram (15). Fruit was weighed individually of each treatment by using the digital weighing balance (Model-ATOAG, Japan) then average was calculated.

For the assessment of fruit visual appearance, each replication was randomly put in front of the expert panel. The findings were expressed in a score ranging from 1- 9 (where 1= bad and unusable, 3 =decent quality with usability limit, 5= reasonable marketable quality, 7= very good quality & 9= excellent quality and fresh appearance) as expressed by Ibrahim and Qaoud (16). The average was taken from the panel and expressed in the score.

The fruit was found marketable to be of high quality and free from rot, disease and physical injury. During all the days of data processing, the marketability of each replication was checked by Hasan *et al.,* (17). Marketability was estimated and conveyed in a percentage by the given formula:

$$\text{Marketability index (\%)} = \frac{\text{Number of healthy fruit}}{\text{Total fruit}} \times 100$$

Every fruit from all the experimental unit was visual tested for any signs of disease. The fruit was treated as a diseased fruit with some signs of disease such as spots, pathogen formation, etc. The frequency of the disease was represented in a score of 1-5 (1 = zero, 2 = 5%, 3 = 5- 10 percent, 4 = 10-25% & 5 = 25 percent of fruit covered with disease symptoms) as defined by Babalar *et al.,* (18).

1. Normal (free from decay on the surface of fruit).
2. Trace (decayed fruit surface up to 5%).
3. Slight (decayed fruit surface up to 5-20%).
4. Moderate (decayed fruit surface up to 20-50%).
5. Severe (decayed fruit surface more than 50%).

Fruit decay symptoms, all the fruits, from each replication were visually tested. Decayed fruit was known to display some fruit that displayed rotting symptoms. The percentage of fruit decay was expressed using score 1-5 scale viz, 1 = non 2 = slight, 3 = moderate, 4 = moderately sever by the method of Kader *et al.,* (19).

ORGANOLEPTIC EVALUATION (SCORE)

In order to determine organoleptic properties such as color, taste, overall acceptance, flavor and aroma the fruit were assessed using a scale of 1-9, method of Peryam and Piligram (15). The examination Performa after organoleptic properties of fruit was filled by a jury of five judges. For each treatment, the total score was considered. Organoleptic properties have been tested on the basis of a scale of 1-9, i.e.1= bad (found, 3 = average (usability limit), 5 = decent (marketability limit), 7 = really good, 9 = excellent and fresh. The average score was recorded for each producer, organoleptic assessment of the score table for apple as seen in table organoleptic evaluation of apples.

BIOCHEMICAL COMPOSITION

To determine the total soluble solids (TSS) °Brix, juice from each replication was used. Using the digital refractometer, two readings were obtained from each experimental unit (DR, 201-95, Germany). Finally, the noted TSS for each replication were summed and expressed in degrees °Brix (20).

Titrable Acidity (TA) was assessed with the method of Amin *et al.,* with minor modifications (21). For this purpose, 10ml juice of apple was taken in a beaker and mixed together with 20ml distilled water. After that, 2-3 drops of phenolphthalein indicator were mixed in beaker. Finally, the prepared solution of (apple juice + distilled water + phenolphthalein) was titrated against 0.1 N (normal) solution of NaoH till light pink color

appeared. The ml of NaoH were noticed and finally TA was measured and expressed in percentage by using the following formula:

$$\text{TA (\%)} = \frac{\text{ml of 0.1 NaoH} \times 0.00678 \times 100}{\text{ml of juice used}}$$

The gathered information was statistically examined. The significant level of the differences was determined using the analysis of variance, and Duncan's Multiple Range Test (DMRT) was used to compare the treatment groups in accordance with the guidelines provided by Gomez and Gomez (22).

In each sample, TSS/TA ratio was determined by dividing the TSS by the respective values of TA (21).

To measure pH, 20 millilitres of juice were placed in a beaker, and a digital pH metre (JANWEY 3510, Barioworld Scientific Limited, Dunmow) was used. Fruit sample hardness was measured using a digital penetrometer (QA supplies, fruit pressure tester FT – 327)

Electrolyte leakage (%) of fruit was measured with the help of method expressed by Mazumdar and Majunder with some modifications (23). For this reason, with the help of a cork borer, five equivalent small discs like piece of apple fruit were removed, these pieces were dipped in 50 ml distill water in a glass beaker. The first reading of electrical conductivity (EC) was measured at room temperature after 30 mints with the help of a digital EC meter (CD- 430, Lutron, inst. CO. UK). Then the solution was boiled in microwave oven. After cooling down, again second reading of electrical conductivity
(EC-2) was taken. Finally, the ion leakage was measured with the help of following formula and expressed in percentage:

$$\text{Electrolyte leakage} = \frac{\text{Ec1} \times 100}{\text{EC2}}$$

STATISTICAL ANALYSIS

All the information collected were tested by (CRD) Completely Randomized Design with Analysis of Variance (ANOVA) by two-factor factorial through statistics 8.1 for Microsoft windows. The LSD was employed at $P \leq 0.05$ for all means of treatments (24).

RESULTS AND DISCUSSION

ORGANOLEPTIC EVALUATION

An arbitrary scale from 1-9 was used to test the sensory evaluation likewise aroma, flavor, color, taste and over all acceptance. The technique of Peryam and Pilgrim was used (15).

COLOR

The colour of the apples stored at different temperatures assessed by a panel of judges using 10 points hedonic scale varied for storage duration as well as by storage temperatures. Three semi-trained judges used the Hedonick scale to grade the fruit samples under various treatments based on their color organoleptic qualities as described by Land and Shepherd (25).

In the following study, changes in the color of Royal gala was evaluated and treated with 5%, 10% and 15% Alv concentration. Highly significant difference was observed for days and significance variation was recorded among treatments. However, non-significant observations were seen for the interaction between days and treatments at the given 5% level of significance.

The mean result of interaction related to rate of change in colour with treatments and storage period expressed in graph. The maximum scoring for colour was given by panelists for all treated and untreated fruits (9) at the pre-storage. It was observed during storage period, the colour was decreased continuously. At the day 10, T_2, T_3, and T_4 showed higher mean value (8.66) followed by T_1 (5.0). The maximum mean observed in T_4 (7.0) followed by T_3 (6.5) and T_2 (6.2) respectively; while, minimum mean was recorded in T_1 (5.0) at day 20. At the end of storage duration, the colour showed less mean value as compared to pre-storage. At day 40 the higher recorded value was observed in T_4 (2.5) followed by T_2 (1.97), T_3 (1.97) and T_1 (1.0) (Fig. 1a).

TASTE

The data concerning different treatment of the Aloe Vera gel on apple is presented in data analysed statistically at 5% level of significance showed highly significant results for shelf period and different treatment of apple. While their interaction showed significant result.

Royal Gala apple displayed highly significant observations among the storage duration and treatments. However significant observation was recorded interaction between them. The maximum mean for quality trait of taste (9.0) was recorded at the pre storage day of the study while lowest mean (1.70) was seen at the final day of storage. The higher mean value was found in 15% ALV treated apple (5.0) followed by 10% (3.70) and 5% (3.0) while the minimum mean value was recorded in untreated (1.70) after 40 days of storage.

Schick and Toivonen explained the main reason for the quality change during the storage and concluded that ALV layer can help reduce dehydration (25). Sugars 44 and organic acid both influence the sourness and sweetness of cherry fruits, so the change in flavour is due to a decrease in acidity (26) (Fig. 1b).

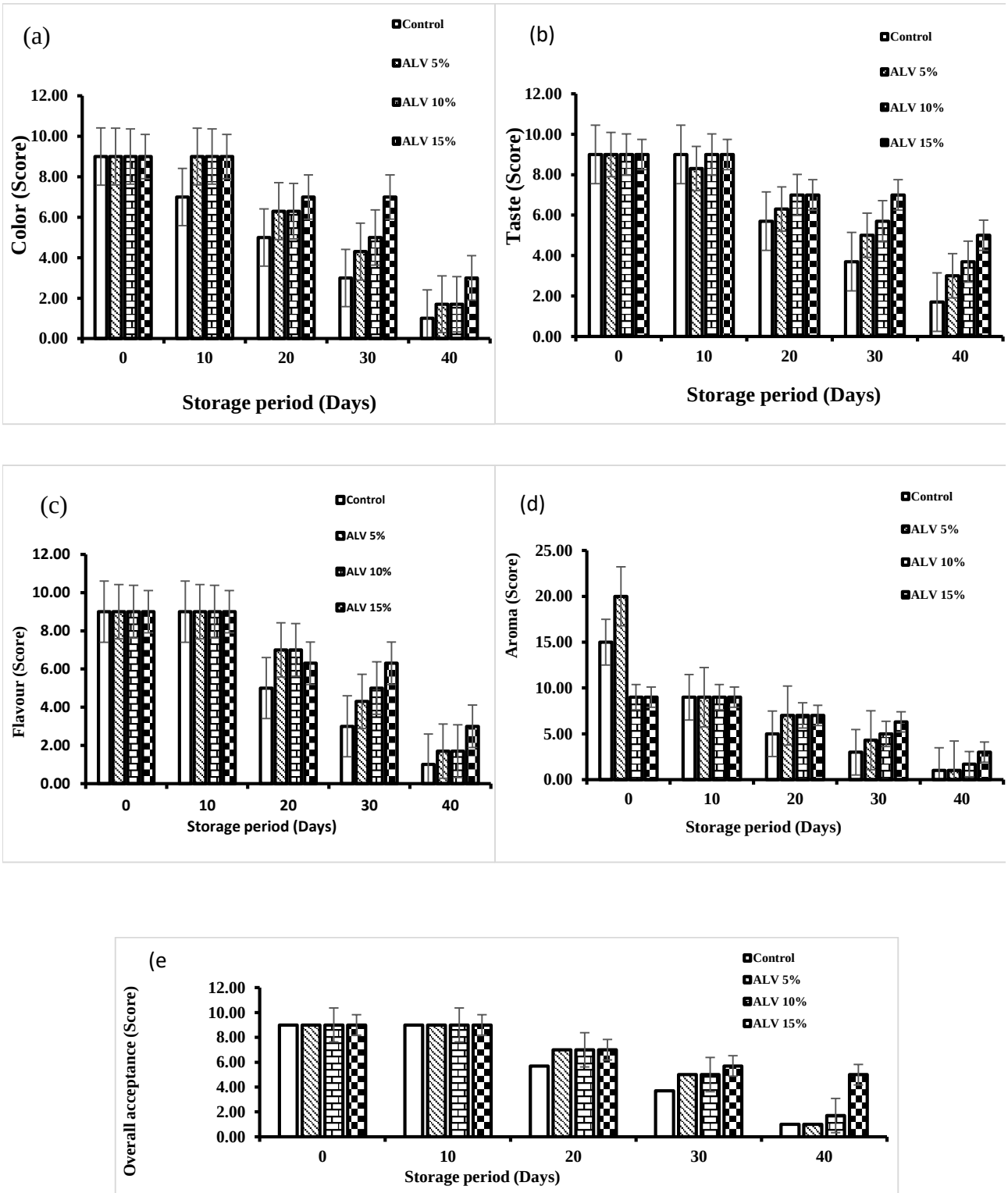

Fig. 1 (a-e). Interaction related to rate of change in colour, taste, flavor, aroma and overall acceptance with treatments and storage period

FLAVOUR

In the following study, changes in the flavour of Royal gala was evaluated under storage and treated with 5%, 10% and 15% ALV concentrations. It has been observed that the storage period was highly significant. However, significant observations were seen for treatments and interaction between days and treatments at the given 5% level of significance.

The mean result of interaction related to change in flavour with treatments and storage period expressed in graph. The maximum score of flavour was (9) in treated and untreated fruits during pre-storage period. The overall treatments decreased continuously in flavour during storage period. At 10-day, the same result is being observed similar to 0 day. The maximum mean observed in T_4 (6.30) followed by T_3 (5.0), T_2 (4.30), while, minimum mean was recorded in T_1 (3.0) at day 30. At the final day of storage period, the flavour was much less when compared with the pre-storage day. Likewise, as per the treatment means, the higher flavour rate was recorded in T_4 (3.0) followed by T_2 and T_3 was (1.70) and the lowest in T_1 (1.0) receptively (Fig. 1c).

AROMA

Regarding aroma, the results showed highly significant variation among different ALV concentrations and storage days. However, the interactive comparison of storage days and ALV concentrations was non-significant. The maximum mean fruit aroma 9.00 was recorded at the initial day of the study and minimum mean 1.0 was noticed at the end of the storage duration. Furthermore, at day 40 the maximum fruit mean aroma was recorded in T_4 (4.35) followed by T_3 (2.18), T_2 (1.01) and the lowest in T_1 (1.0) respectively. The aroma displayed reducing trend as the storage days progressed. Results showed that the quality of aroma was high during the initial storage days (Fig. 1d).

Although the intensity of Apple aroma increases during ripening. The main reason behind changing in the taste quality during the storage is dehydration. Bitterness and sweetness of fruits influenced changes as well as organic acid, so change in taste was because of decrease in acidity level (27).

OVERALL ACCEPTANCE

A significantly decrease observed during the storage of all samples at 5% level of significance. The highly significant results for shelf period and treatments while interaction among them showed significant. The mean value was found at the 0 day was (9.00) in all treatments. The lowest mean value was found at the end of the storage in T_1 and T_2 (1.0) followed by T_3 (1.70) and T_4 (5.0).

Texture, flavour, and colour all had a major impact on how palatable fruit was overall when it was in storage. Fruit quality was impacted by the accelerated deterioration process that occurred during storage as time went on. Furthermore, it was proposed that the general acceptability of fruit in storage was contingent upon the fruit's Aloe Vera gel content, which was found to be more stable and highly acceptable for postharvest storability (Fig. 1e).

FRUIT PHYSICAL QUALITY CHARACTERISTICS

WEIGHT LOSS

The highly significant effect of weight loss (%) of apple (Royal gala) on all treatments (T_1, T_2, T_3, and T_4) accordingly. On contrary, the combined interaction of days/treatments was found non-significant on the weight loss (%) of apple (Royal gala). It has been statistically proved that weight of apple (Royal gala) was significantly affected by the application of ALV coatings at storage conditions.

However, maximum increase in fruit weight was observed in control on an average to treated fruits in all treatments. Maximum fruit weight loss was observed in control that was about 2-folds higher than other treatments at the end of storage period. At the pre-storage day, the fruit weight loss was recorded 0 in all treatments.

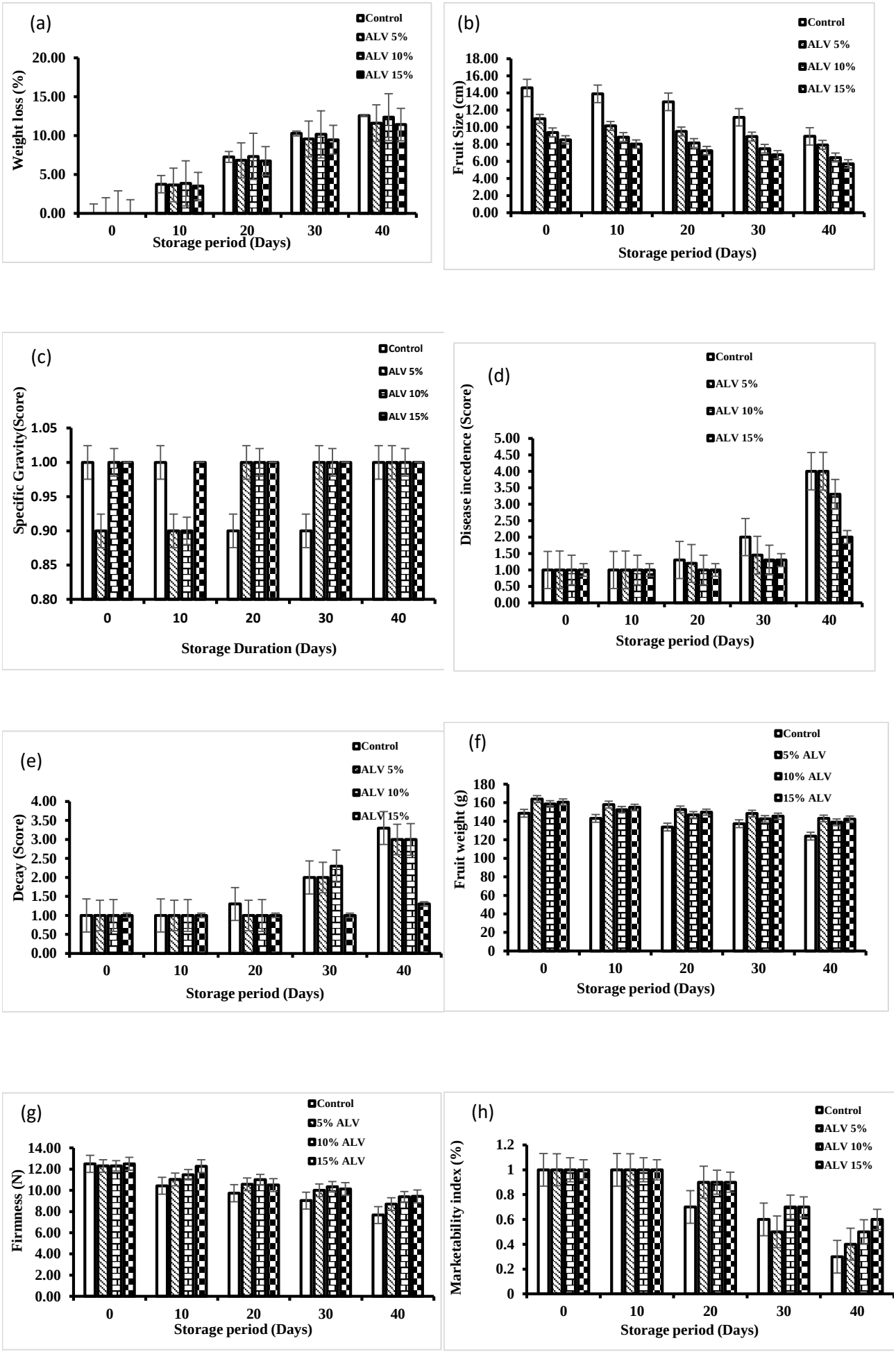

Fig. 2 (a-h). Effects of storage period on different characteristics of physical quality of fruit

As with the progress (advancement) in ambient storage duration, the apple fruit weight loss increased as higher weight loss mean was observed in control apples (12.15%) and the minimum in 15% ALV treated apples (11.00%) at 40-day (Fig. 2a).

Weight loss is having key role in the postharvest technology as it is linked with choice of customer. As the ALV coating postponed the loss of moisture and decreased the rate of respiration, these impacts are associated to the reduction of weight loss as in other edible coatings (27). Fruit weight loss is mostly related to skin-based respiration and transpiration. Coatings are often composed of lipids and polysaccharides to minimize water loss (29).

FRUIT SIZE

Data subjected to statistical analysis regarding fruit size of Apple on different treatment during ambient shelf period exhibited highly significant results among shelf period, treatment and interaction between them.

There was decrease in the fruit weight loss irrespective of the treatment and days. The fruit size can be measured by length and width of sample with the help of Vernier caliper. Decrease in size of sample was occur due to water loss and rate of transpiration which directly depend on storage period and temperature. The highest mean fruit size T_1 (14.58) is followed by T_2 (10.98), T_3 (9.38) and T_4 was (8.52) at the pre-storage day of the study. Furthermore, the size displayed reducing trend as the storage day T_1 (8.92), T_2 (7.93) followed by T_3 (6.45) and T_4 (5.71) progressed. Results showed that the size of fruit was high during the initial storage days (Fig. 2b).

SPECIFIC GRAVITY

The data obtained concerning the effect of ambient shelf period on specific gravity when statistical analysis performed, and the results have no significant differences for shelf life period and treatments. The specific gravity of stored apple found no changed significantly in treatments as well as storage period. The specific gravity of the stored apple (1.00) found in T_1 followed by T_2, T_3 and T_4 respectively. The key factor which directly affect specific gravity was, weight loss, transpiration, temperature, shelf life period and the chemical interaction which occur in apple (Fig. 2c).

DISEASE INCIDENCE

Results revealed that regarding disease incidence, effect of treatments on disease incidence in Royal gala was non-significant while storage period was found highly significant. However, the combine effect of storage days and treatments were non-significant.

The graph unveiled that there was no disease incidence at the pre-storage day. It was observed that during the initial days there were no disease symptoms in treated fruits. As the storage period progressed, the disease incidence gradually elevated for all treatments as mean values observed same (1.00) for pre storage. At 40 days of storage, a gradually increased in disease symptoms noticed in all treatments. The disease incidence was maximum at the end of storage duration in all treatments. The highest disease incidence was observed in T_1 and T_2 (4.0) followed by T_3 (3.2) and T_4, (2.1) in treated fruits at the end of storage duration, respectively. Apple is representing the trend of disease incidence in fruits treated with different concentrations of ALV during storage period (Fig. 2d).

Fruit treated with calcium chloride and AV gel coating had a lower disease incidence because there was less respiration and microbial growth, which prevented the fruit from decomposing. (30). Aloe Vera gel produced an un-favorable environment for the activity of microorganisms (31).

DECAY PERCENTAGE

The decay percentage was taken as per scale. As per statistical analysis at 5% level of significance, percentage of decaying in apple fruit exhibited highly significant difference for storage days, treatments and interaction among them.

Among treatments, no decaying was observed on all samples including treated fruits during the pre-storage periods in Royal gala variety of apple. No decaying ratio was found at 10 days (1.0) in T_1, T_2, T_3 and T_4 respectively. At the day 20, the mean values recorded for decaying symptoms in T_1 was 1.45 and T_2, T_3 and T_4 was same mean value 1.0. At 40 day storage, uncoated fruits demonstrated highest decay rate was recorded at T_1 (3.30%) when compared with other treatments while the lowest decay mean rate was observed for T_4 (1.30%) during the period of storage (Fig. 2e).

Skin browning and pitting are common symptoms of declining infection (32). Visual observations revealed that high moisture storage reduce the occurrence of pitting in fruit, most likely by delaying the water loss (33).

FRUIT WEIGHT

Result pertaining to the weight of single fruit as effected by distinct time interval recorded in graph. Significant variations were found in the weight of signal fruit based on the analysis of variance.

In case of different treatment but non-significant were observed for time interval and interaction between treatment and interval. The result presented in graph that T_2 (164g) followed by T_4, T_3, and T_1 respectively at the initial days of storage. At 40 days of storage, a gradual decrease was seen on all treatments. The decrease was maximum at the end of the storage duration on all treatments. The average decrease in the fruit weight was (143g, 142.3g, 138.9g) in T_2, T_4, T_3 and (123.9g) in T_1 (Fig. 2f).

FIRMNESS

Results of statistical analysis represented for firmness in different treatment of apple were highly significant for shelf period and non-significant for days, treatment .and interaction among them. The maximum mean value was found in T_1, T_4, (12.50) flowed by T_2, T_3, (12.3) in apple at 0 day. While, at the end of shelf period, maximum mean value was recorded for T_4, (9.43 N) followed by T_3 (9.40 N), T_2 (8.70 N) and T_1 (7.67 N) showed in graph.

Edible coatings like ALV has the potential to delay the softening, might be because of the influence of ALV extract coating on fruit that behave as a barrier (hurdle) for O_2 uptake ultimately delays the metabolic process as well as ripening process. Comparable to those had been investigated early (34). The firmness of sample is affected by ALV gel coating. The ALV coating reduced fruit firmness loss and was clearly more effective over the late storage period. ALV gel also acts as a barrier against enzyme's that degrade cell walls. Furthermore, because ALV gel coated fruits lose less water, the turgor pressure of the cell wall remains constant, resulting in superior quality (Fig. 2g). It is assumed that because the fruits have less oxygen exchange, ethylene synthesis is slowed, and therefore physical water loss via the peel pores of the commodities is reduced (35).

MARKETABILITY INDEX

According to analysis of variance different concentration of Aloe Vera gel on apple showed highly significant differences among the shelf life and interaction between the shelf life and concentration of Aloe Vera gel. However, graphically results represented that T_4 revealed higher index for marketability (0.6%) followed by T_3 (0.5%) and T_2 (0.4) during the 40 days of shelf life. T_1 showed least marketability index (0.37%) at 40 days of shelf life (Fig. 2h).

FOR BIOCHEMICAL CHARACTERSTICS

pH OF APPLE JUICE

Analysis of variance for the effect of numerous treatments were exhibited significant results for treatments and storage had a highly significance variance while; there was non-significant effect on interaction of treatments x storage on pH of Royal gala apple. That the ALV coated treatments significantly influenced in fruits as per uncoated fruits. The mean showed a gradual increase in the pH level from day 0 to day 40. pH of T_1 was (3.5) at 0-day, which increased to (6.25). While T_2 increased from (3.5) to (6.00) from initial to the day of termination respectively. Likewise, pH of T_4 was noted (3.5) which increased to a level of (6.01) from day 0 to day 40. After 30 days pH of the both treated and un-treated was decrease gradually. All of the layered and

uncoated fruits' pH values (grew) increased with time during postharvest storage as a result of the ingestion and hydrolysis of pectin, organic acids, and starches, which produced free simple and acids development. (39). The Aloe Vera gel covering served to delay the ripening and respiration of the fruit, allowing it to keep its more acidic pH and use less acid. Similar outcomes were also discovered by Lowings PH & Cutts DF (40). Who confirmed that the pH levels in grapes decreased as time went on during storage and that this occurred because of the increase in pH. In terms of the pH of the fruit and other qualitative characteristics of apple fruit, aloe vera gel was discovered to be more beneficial during storage (Fig. 3a).

TOTAL SOLUBLE SOLIDS (TSS °BRIX)

Total soluble solids contents are usually categorized as sugar content. It is discussed to as the degree ^{0}Brix. During the observational periods related to the TSS of Royal gala apple fruits displayed highly significant differences for treatments as well storage period and interaction between storage period x treatments.

Graph exhibited that as with the time, storage period proceeded so as irregular continuous rise was noticed in all cultivars of apple fruit in TSS. Highest TSS content was seen in 5% treated apple (15.10 °Brix) at day 40; while, lowest was recorded in all treatment (17.00 °Brix) at the beginning of the storage period. Moreover, lowest mean value was observed in 15% (13.67 °Brix) at day 10, followed by T_2 and T_3, while the T_4 (14.67 °Brix) was seen at the 10 day. At the day 40 lowest value was recorded (14.01 °Brix) in T_3, followed by T_1 and T_4, while the T_2, was (15.10 °Brix) (Fig. 3b).

A TSS alterations were significantly influenced by ALV gel, with the fruits treated with ALV gel showing a small reduction in comparison to the control treatment. These changes might be linked to decreased ethylene production, which causes fruit to mature later (41). The metabolic conversion of starch into sugar and other soluble solids during storage may be the cause of the elevated TSS concentration. These fruits were also losing water, as seen by the higher TSS level in the untreated control (42).

ELECTROLYTE LINKAGE

According to statistical analysis of variance at 5% significance level, treatment of apple showed highly significant differences for shelf period. However, the significant result was observed for treatment and combination of shelf period and treatment. The average mean for EC was recorded (40.00) at 0 day of shelf period. The maximum EC observe in T_4 was 48.41%, T_3 exhibited average (44.44%) and T_2 exhibited average (26.11%) at 40 day of shelf period. T_1 exhibited lowest EC which was (21.790%) as compared to others (Fig. 3c).

The EC in Apple reduced during storage, as seen in Graph. It might be related to a reduction in membrane leakage and a less advanced stage of senescence (43). It might be related to a decrease in water and ionic content. Electrical conductivity is reduced as a result of starch transition and cell structural changes, as well as fat content. Aday & Caner discovered similar results in cherry (44).

TITRABLE ACIDITY (TA%)

Sweet delicious apple displayed highly significant observations among the treatments, and significant observation was recorded among days for the interactions between them.

The maximum mean TA was recorded at the pre-storage day of the study was (0.87) at 10% treated and lowest mean (0.79) was seen on untreated. The higher fruit TA at 40 days was recorded in T_3 (0.65%) followed by T_2 (0.59) similarly, the lowest was observed in T_1 and T_4 (0.61%) respectively. Titrable acidity displayed declining pattern with advancement in storage intervals (Fig. 3d).

Generally, the TA of the fruits decreased after storage, with non-coated fruits declining quicker and to a greater amount. Minimum pH (higher TA) in aloe gel covered fruits indicated a reduction in organic acid metabolism (45). Throughout postharvest fruit senescence, it is reduced owing to oxidation (46, 47). Due to the prevention of senescence and degradation of organic acids in treated produce, ALV covering slows down its decrease (48). According to our findings, ALV coating application decreased oxidation and fruit senescence, resulting in increased TA content in treated apple fruit.

TSS/TA RATIO

Analysis of variance Table unveiled that the TSS/TA tested in Royal gala apple was highly significant in terms of ALV treatments, days and the interaction among them. It was observed from treatments mean that decreased ratio was found in 10% treated apple (1.24) at the 0 day and increased ratio was (1.39) at the 0 day. TSS/TA ratio gradually increased during the storage intervals, as minimum mean on behalf of treatments was found in T_3 (1.38), while higher was recorded at T_2 (1.64) 5% treated fruits during 40 days of the storage. One of the important factors in determining out what customers love about apple fruits is the ratio of TSS to acidity (Fig. 3e). Over the course of storage, the fruits' TSS/TA content increases. This increase could be explained by the breakdown of organic acids, which improves pH by lowering total acid concentration, or by the breakdown of complex carbohydrates, which yields hexose monomers for respiration (49).

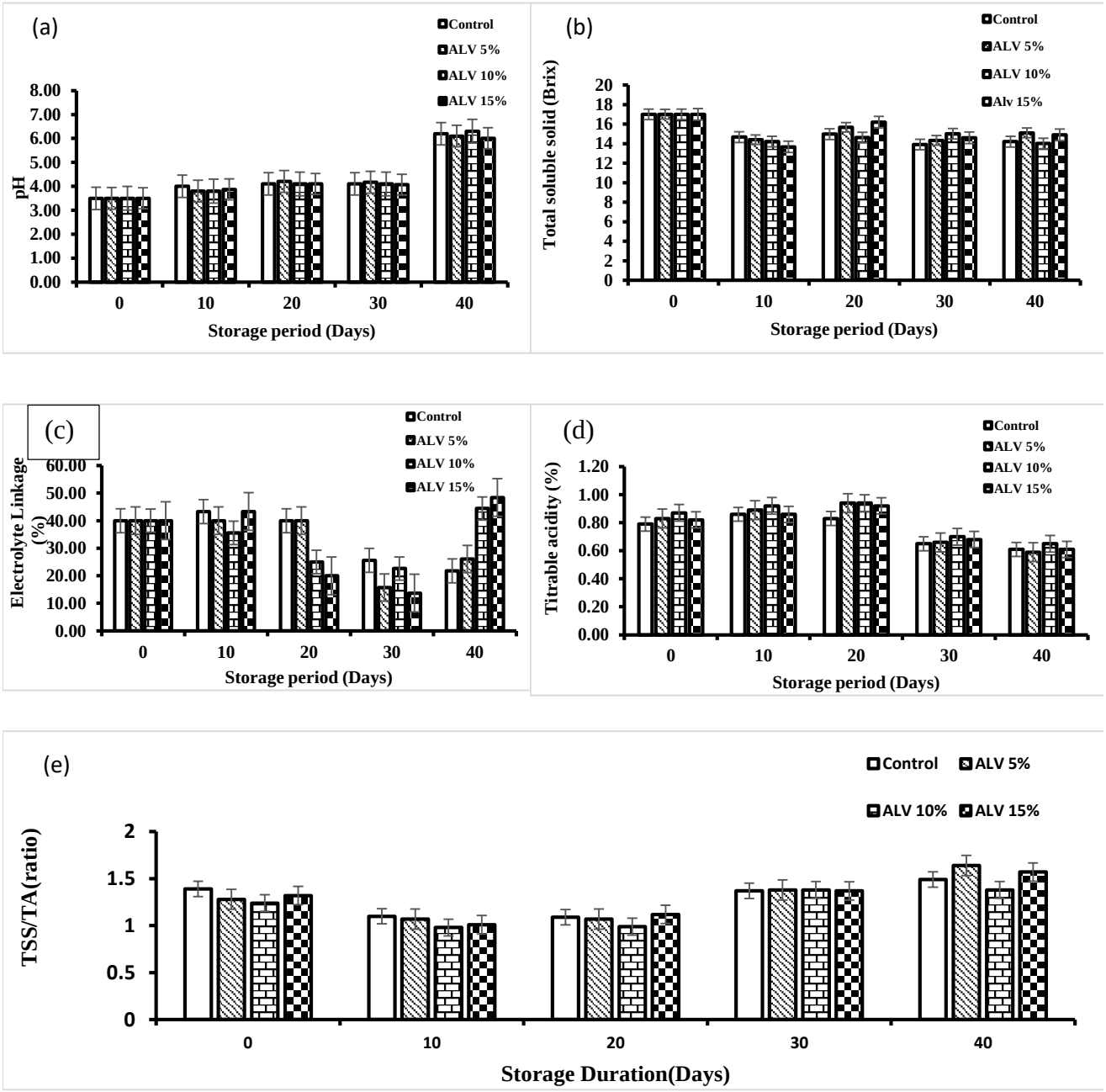

Fig. 3 (a-e). Effects of storage period on biochemical characteristics of fruit

CONCLUSION

It is clearly evident from the investigation that T_4 = 15% ALV extract application had a positive response for conserving the postharvest quality of Royal Gala variety of Apple under the ambient conditions. Furthermore, sensory and physiochemical quality attributes, sugars and chemical traits activity were improved under the ambient temperature. More evaluation on apple fruit in Pakistan, is still to be unveil and future studies will be more beneficial. The Aloe Vera is available very easily, cheap in price, reliable for the

usage with no chemical residuals and environment friendly. It is a new and novel coating technique that can be used in food industry as postharvest application for fruits.

Conflict of Interest:

Authors have no conflict of interest.

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