Research Article

Shelf life assessment of apple fruit coated with aloe vera gel and calcium chloride

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Abstract
An experiment was performed on effect of aloevera gel and calcium chloride coating on the shelf life of apple fruit. All the samples were stored for 75 days and analyzed at 15 days of storage interval. Sample T0 was used as a control (untreated), T1 with 10 percent aloevera gel coating, T2 with 20 percent aloevera gel coating, T3 with 2 percent calcium chloride, T4 with 10 percent aloevera gel and 2 percent calcium chloride coating and T5 with 20 percent aloevera gel and 2 percent calcium chloride coating. All the samples were analyzed both for physicochemical and organoleptic attributes that include total soluble solids (TSS), ascorbic acid, titratable acidity, sugar/acid ratio, pH (Power of Hydrogen ion concentration), weight loss, firmness, decay index, color, flavor, texture and overall acceptability. Highest mean value for TSS was found in T0 (13.91) while the lowest mean value was found in T4 (12.62). Highest mean value for acidity was found in T4 (0.59) while lowest mean value was found in T0 (0.52). Highest mean value for sugar/acid ratio was found in T0 (27.95) while lowest mean value was found in T4 (21.72). Maximum pH value was showed by T0 (4.93) while minimum pH value was showed by T4 (4.34). Maximum Ascorbic Acid content was found in T4 (7.93) while minimum Ascorbic acid was found in T0 (6.82). Highest weight loss was found in T0 (10.08) while lowest mean value was found in T4 (5.41). Highest mean value for firmness was found in T4 (6.51) while minimum firmness was showed by T0 (5.85). Highest decay index was found in T0 (11.57) while lowest mean value was found in T4 (3.80). Maximum score for color was showed by T4 (7.08) while minimum score was observed in T0 (5.76). For flavor, maximum score was found in T4 (7.10) while minimum score was showed by T0 (5.78). Maximum score for texture was found in T4 (7.03) while minimum score was observed in T0 (5.83). Highest mean value for overall acceptability was found in T4 (7.06) while minimum value was recorded in T0 (5.75). Increase was observed in the physicochemical attributes that include TSS from 12.31 to 14.07°brix, sugar/acid ratio from 18.94 to 31.96, pH from 4.29 to 5.12, weight loss from 0.00 to 14.36% and decay index from 0.00 to 13.75%. Decrease was observed in titratable acidity from 0.65 to 0.44%, ascorbic acid from 8.46 to 5.40mg/100g and firmness from 6.41 to 5.43kg/cm². All the organoleptic attributes decreased during storage. Color decreased from 8.70 to 4.20, flavor from 8.63 to 4.11, texture from 8.66 to 4.33 and overall acceptability from 8.63 to 4.20. It was concluded that sample T4 with 10% aloe vera gel and 2% CaCl₂ followed by T3 with 2% CaCl₂ was considered as the best sample on the basis of physicochemical and organoleptic quality.

Keywords: Aloe vera gel; Apple; Ascorbic Acid; calcium chloride; Decay index; Firmness; pH; TSS; Titratable Acidity
Introduction

Apple (*Pyrus malus*) commonly placed in the family Rosaceae which is considered the popular fruit of the world. South Western Asia was the origin of apple. In Pakistan, production of apple is limited towards the northern peaks of Baluchistan, Punjab and Khyber Pakhtunkhwa [1]. In Pakistan the entire territory under apple production was 111.6 thousand hector which incorporates 0.1 in Sindh, 0.3 in Punjab, 101.9 thousand hector in Baluchistan and 9.2 hector in Khyber Pakhtunkhwa [1].

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In Asia, approximately 7500 cultivars of apples were found. In 2005 total production of apple were 2.5 million tons throughout the world in which China ranked 1st with 35%, America second with 7.5%, Iran third and Pakistan on number 11. In apple, the water content is 84.6%, starch 13.8g, fiber 0.8g, lipids 0.3g, protein 0.4g and ascorbic acid is 8mg. Apple contain minerals 0.3g/100g in which sodium 0.3mg/100g, iodine 2µg, magnesium 6mg/100g, calcium 7mg/100g, phosphorus 12mg/100g and potassium 145mg/100g [3].

Apple has been broadly utilize for its therapeutic attributes, "an apple a day keeps the specialist away" it has cholesterol-lessening impact for a long time especially in Europe. Apple have flavonoids, phenolic compound, Fiber, Protein, Calcium, phosphorus, iron, Vitamin A and vitamin C help to prevent cancer, colon disease, obesity, stress [4, 5].

Recently there are various procedures use for the improvement of post-harvest storage life of apple fruit. Edible coating is one of the popular techniques use for maintaining the shelf life of the apple. Edible coating creates a thin film of consumable material which protects the desired food commodity. Edible coating material contain natural substances e.g. polysaccharides, wax coating and protein [6]. It creates bright appearance on fruits, which decrease the risk of microbial decay and improve fruit color, reduce water loss and increase shelf life [7].

Previous studies showed that calcium has several beneficial effects and reduce respiration rate which delay the ripening and senescence process and retain the fruit shelf life. Calcium plays a vital role in the stabilization and strength of the cell structure firming agent of the fruit. In fruits and vegetables, Calcium has been widely used as firming agent and preservative for fresh-cut and overall commodities [8]. In previous literature, 0.5–3% concentrations of calcium salts were used [9]. The addition of calcium salts boosted the strength of calcium and pectin bonds, which rigid the cell wall structure [10, 11]. Due to calcium availability, the cohesion of the cell wall increased which delayed the senescence and ripening of fruit. Storage life is improved and softening is delayed in calcium treated fruits as compared to untreated fruits [10].

Previous Study showed that Aloe vera gel has found to be used as an edible coating material for the preservation of commodities and can be used as a substitute for postharvest treatments [12]. Aloe vera has been reported for its antimicrobial and therapeutic activities and medicinal properties [13]. Aloe vera gel was found as covering material which avoids moisture loss, control respiration, reduced fruit softening, senescence, microorganism proliferation and delay oxidative browning in various commodities, such as papayas, grapes and cherries [14]. Recently, the Aloe vera gel has been used as a coating material for pineapple [15], grapes [16] and papaya [17].

Materials and methods

The experiment was performed in Food Science laboratory, University of Agriculture, Peshawar. Apple (*Pyrus malus*) fruits were harvested at the stage of physiological maturity and were carefully
shifted laboratory, University of Agriculture, Peshawar in cotton boxes. Bruised and damaged fruits were wasted and were rinsed with running tap water and dried using a gentle blower.

### Treatments

| Storage duration | S0: Control |
|------------------|-------------|
| T0: Control      | S1: 15      |
| T1: Aloe Vera gel 10% | S2: 30 |
| T2: Aloe Vera gel 20% | S3: 45 |
| T3: Calcium Chloride 2% | S4: 60 |
| T4: Aloe Vera gel 10% + 2% CaCl₂ | S5: 75 |
| T5: Aloe Vera gel 20% + 2% CaCl₂ |

### Preparation of aloe vera gel

For the preparation of gel, leaves of Aloe Vera which were matured and disease free were collected from the ornamental nursery of the Horticulture Department for gel extraction and transferred to the food science laboratory of the host university. Aloe Vera leaf have four layers i.e. outer (rind), second layer consists a sap like liquid surrounded by gel, third layer is the inner side of the leaf which contained mucilage gel and the fourth one is the real Aloevera gel residing part. In order to extract Aloevera gel, these leaves were first placed in erect position for a time period of 15 mints. This procedure is used for the drainage of sap. Small slices of the leaves were cut and the pieces were removed from the both sides of slices. The slices of the gel were removed from the lower layer in slices and stored in dark jar in refrigerator to prevent it from spoilage [18]. The matrix (parenchyma) from the Aloe Vera gel was removed certainly at cortex and mixed by means of blender. The gel was filtered by using a thin cloth and gel was collected in jar. The gel was heated at 70°C for 45 minutes and then placed at ambient temperature for cooling by pouring 2gL⁻¹ of ascorbic acid. For maintaining its pH at 4 then 4.5gL⁻¹ of citric acid was added and again cooled to 23°C for 15 minutes [14].

### Preparation of sample

Different concentrations of Aloe Vera (0, 10% and 20%) were prepared. 6 lots of apple fruits (T₀, T₁, T₂, T₃, T₄ and T₅) were made. T₀ was left untreated serving as a control for checking the result of application of Aloe Vera gel and CaCl₂ on Apple fruits. 10% edible coating of Aloe Vera Gel was applied on T₁ while application of 20% Aloe Vera Gel coating was done on T₂. T₃ were treated with 2% Calcium chloride (CaCl₂). T₄ were treated with 10% Aloe Vera Gel and 2% Calcium chloride (CaCl₂) and T₅ were treated with 20% Aloevera gel and 2% Calcium chloride (CaCl₂) for approximately 5 minutes, then using a fan blower surface of apple fruits were dried and then they were kept in refrigerator for 75 days. Fruits of each treatment were checked for reporting different biometric observations. Whole data was analyzed at regular interval of fifteen days storage.

### Physiochemical analysis

TSS, Titratable acidity, Sugar / acid ratio, pH, ascorbic acid content, Weight loss, firmness, Decay incidence were determined using recommended method of AOAC [19].

### Organolyptic evaluation

Selected samples of apple fruit treated with aloe vera gel and calcium chloride were evaluated organolaptically for color, flavor, texture and overall acceptability by the panels of 10 judges. The evaluation was carried out by using 9 points hedonic scale of Larmond [20].

### Statistical Analysis

The data was analyzed statistically by using (CRD) Two Factorial by and means were separated by LSD test at 5% level of significance as described by Steel and Torrie [21].
Results and discussion

Physico-chemical properties

TSS
A significant (p<0.05) increase was observed during storage of all samples. Highest mean value was found in T0 13.91 and T5 13.40. The lowest mean value was found in T4 12.62 and T3 12.75 in (Table 1). The data analysis revealed that coating material and storage duration was found significant at 5% level for TSS of the stored apple samples. Increased in TSS might be due to conversion of starches into sugars due to high respiration. Aloe Vera gel was found to reduce the respiration due to the production of thick layer on the fruit surface. Increased in fruit TSS during storage that converted starches in to sugars because the total soluble solids comprised 75% of sugars. Similar study was also reported by [17] described that Aloe Vera gel had found significant for the fruit TSS due to the minimum respiration and catabolic activities in nectarines. Brishti et al., (2013) Aloe Vera gel retained the total soluble solids due slowdown respiration and ethylene production in papaya during storage. Due to a thin layer of Aloe Vera gel, it also helps in minimizing the conversion process of starches and respiration to maintain the total soluble solids of fruit. Calcium chloride maintains total soluble solids, because calcium involved in cell integrity which inhibit the failure of turgor pressure. [23]. Changes in the polysaccharides present in fruit also responsible for maximum TSS [24, 25]. So, it is suggested due to inhibitory effect of calcium, it helps in retaining of total soluble solids in fruits.

Acidity
A significant (p<0.05) decrease was observed during storage of all samples. Highest acidity was found in T4 0.59 and T3 0.57. Minimum acidity percentage was found in T0 0.52 and T3 0.53 in (Table 2). The application of Alovera gel decreased moisture loss and the rate of respiration. However, during the respiration organic acids are consumed which was decreased by the coating of Aloe Vera gel. Calcium played a vital role in the reduction of oxidation reaction which slowdown the metabolic activities of fruit during storage [4] and minimized the loss of acidity rate in commodity and decrease in acidity percentage due the availability of good atmosphere provided by Aloe Vera gel coating which minimized the respiration and metabolic activities. Aloe Vera gel resists the high respiration rate and retained the titratable acidity [17].

Sugar acid ratio
A significant (p<0.05) increase was observed during storage of all samples. Highest mean value was found in T0 27.95 and T3 25.99. Minimum sugar acid ratio was found in T4 21.71 and T3 22.55 in (Table 3). The increased in sugar acid ratio might be due to the coating material of Aloe Vera gel which reduced the ripening process when compared with uncoated fruits in sweet cherry and in starch coated strawberry. Increased in sugar acid ratio might be due the availability of good atmosphere provided by Aloe Vera gel coating which minimized the respiration and metabolic activities in sweet cherry in control storage conditions [26]. During storage increased in sugar acid ratio was observed in treated fruits as compared to untreated in oranges. Fruit also contained the living cells which consumed the organic acids present in the fruit for their survival during storage. [27]. The decreased in acidity percentage might be due to the accumulation of sugars which increased the fruit TSS and minimized the sugar acid ratio [28].

pH
A significant (p<0.05) increase was observed during storage of all samples. Highest mean value was found in T0 4.93 followed by T3 4.85. The lowest mean value was found in T4 4.34 followed by T3 4.44 in (Table 4).

During the postharvest storage, the pH values raised with the passage of time in all the coated and uncoated fruits due to the consumption and hydrolysis of organic
acids, starches and pectin resulting free acids and simple development [24]. The fruit ripening and respiration was also delayed by the coating of Aloe Vera gel which helped in minimum consumption of acids and retained more acidic pH. Similar results were also found by [29] who verified that during storage, the pH values increased with the passage of time which reduced the acids level in grapes. However, Aloe Vera gel coating was found more valuable during the storage in terms of fruit pH and other quality aspects of apple fruit.

**Ascorbic acid (mg/100g)**
A significant (p<0.05) decrease was observed during storage of all samples. Highest mean value was found in T₄ 7.93 followed by T₃ 7.56. The lowest mean value was found in T₀ 6.82 followed by T₅ 7.01 in (Table 5).

During postharvest, the declined in ascorbic acid occurred due to various biological process in fruit which speedup the ripening process and reduced the ascorbic acid level of fruit. The Aloe Vera gel had found their ability to reduce the postharvest losses of quality attributes which lower the ascorbate oxidase and phenol oxidase enzymes activity [30]. Calcium chloride effect was also good due to the lower oxidation process of fruits and retained the more ascorbic acid level in fruits. [31] Also described same phenomena for the reduction of ascorbic acid due to oxidation process during fruit storage.

**Weight loss (%)**
A significant (p<0.05) increase was observed during storage of all samples. Highest mean value was found in T₀ 10.08 followed by T₃ 8.80. The lowest fruit weight loss was showed by T₄ 5.41 and T₃ 5.78 in (Table 6).

The coating of Aloe Vera gel and calcium chloride created a thin layer on the surface of fruits which resulted minimum weight loss was occurred. The barrier was developed by Aloe Vera gel which reduced the evaporation from the surface of fruit and thus retained more fruit weight [17] also carried the similar study on nectarine by applying 2.50% of Aloe Vera gel and suggested that coating material helped in the maintenance of fruit weight and increased its postharvest storability. Therefore, it is concluded from the present study that both the coating materials may helped in the reduction of fruit weight loss during storage through minimum respiration rate.

**Firmness (kg/cm²)**
A significant (p<0.05) decrease was observed during storage of all samples. Highest mean value was found in T₄ 6.51 followed by T₃ 6.23. Minimum fruit firmness was showed by T₀ 5.85 followed by T₅ 5.88 in (Table 7).

The fruit firmness is one of the important factor which showed the stability of fruit and decreased with the passage of time due to conversion of insoluble pectin into soluble form during storage [35]. Ripening process decreased by the application of Aloe Vera gel and calcium chloride coating due to minimum respiration rate from the surface of fruit [36]. Calcium pectate played a vital role in cell wall integrity when interacted with pectin and maintained the fruit firmness [37]. Hence Aloevera and CaCl₂ maintain fruit firmness of apple.

**Decay index (%)**
A significant (p<0.05) increase was observed during storage of all samples. Highest mean value was found in T₀ 11.57 followed by T₃ 7.60. The lowest mean value was found in T₄ 3.80 followed by T₃ 4.41 in (Table 8).

Disease incidence in fruit treated with Aloevera gel and calcium chloride coating showed minimum decay loss due to less respiration and microorganism growth and protected the fruit from decay [14, 38]. Unfavorable environment was created by Aloe Vera gel for microorganism activities [39]. Results regarding decay loss was also reported by [13, 40] who reported that proliferation of microorganisms were found minimum in grapes and sweet cherry coated with Aloe Vera gel due to the antimicrobial properties which revealed
minimum decay loss. Unfavorable environmental conditions were created by Aloe Vera gel coating for microbial and fungal activities.

**Organoleptic evaluation**

Samples of apple fruit treated with aloevera gel and calcium chloride studied for flavor, color, texture and overall acceptability by the recommended method larmond [20]. Panel of 10 judges were consigned to score then among 9-1. Principally like and dislike was symbol zed with 9 and 1 respectively.)

**Color**

A significant (p<0.05) decrease was observed during storage of all samples. Highest mean value was found in T₄ 7.08 followed by T₃ 6.86. The lowest mean value was showed by T₀ 5.76 and T₃ 6.23 in (Table 9).

Gradual decreased was observed in fruit colour throughout the storage duration due to respiration resulting water loss from the fruit and affected the fruit quality [31, 41] investigated that the quality of fruit was seriously affected by the respiration rate during storage. Aloe Vera gel and calcium chloride slowdown the ripening process due to minimum biological process and respiration rate from the surface of fruit [12]. Similar results were also found by [14] for fig coated with Aloe Vera gel which retained the fruit colour, softness and ripening during storage.

**Flavor**

A significant (p<0.05) decrease was observed during storage of all samples. Highest test score was showed by T₄ 7.10 and T₃ 6.80. Minimum test score was showed by T₀ 5.78 and T₃ 6.08 in (Table 10).

Aloevera gel and CaCl₂ coating are the best coating for delaying the ripening process which helped in maintaining the fruit flavor. Aloevera gel and CaCl₂ coating maintain the Flavor of Apple. [14] For fig coated with Aloe Vera gel which retained the fruit flavor during storage as compared to uncoated fruits. [42] also studied the response of Aloe Vera gel coated by the papaya fruit and suggested that coating material retained the flavor of papaya due the development of barrier for the ripening agents. Flavor of fruit depends on the external environment where exchange of gases occurred during storage.

**Texture**

A significant (p<0.05) decrease was observed during storage of all samples. Highest mean value was found in T₄ 7.03 followed by T₃ 6.85. The lowest mean value was found in T₀ 5.83 followed by T₃ 6.20 in (Table 11).

Aloevera gel and CaCl₂ retained the fruit stability for maximum time due to strengthening of structural membrane which retained the fruit attributes for longer duration. [43]. Alterations in the fruit physiological activities seriously affected the fruit texture in postharvest studies of the commodities. Coating material retained the texture of fruit due the slowdown biochemical and ripening agent’s activities [42]. Similar observations were also taken by [6, 14, 17] in sweet cherry, peach and in plum and suggested that coating material of Aloe Vera gel had antimicrobial properties which reduced decay loss and microbial attack and retained the fruit texture.

**Overall acceptability**

A significant (p<0.05) decrease was observed during storage of all samples. Highest mean value was found in T₄ 7.06 followed by T₃ 6.80. The lowest mean value was found in T₀ 5.75 followed by T₃ 6.13 in (Table 12).

The overall acceptability of apple fruit was significantly affected during storage based on color, flavor and texture. Both of coating material of Aloe Vera gel and calcium chloride maintained the quality aspects significantly during the storage of apple fruit. The degradation process of fruit during storage increased with the passage of time which effected the fruit quality [24, 42, 44] demonstrated that calcium had synergistic effect with ripening process due to which delaying the catabolic and anabolic activities in fruit. Additionally, they suggested that overall acceptability of fruit during storage fully depended on fruit...
firmness and appearance of fruit [31, 43]. So, it is concluded from the study that overall acceptability of apple fruit significantly affected by both the coating materials of Aloe Vera gel and calcium and found more stable and highly acceptable during the postharvest storability.

Table 1. Effect of aloevera gel and calcium chloride coating and storage intervals on the total soluble solids of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
| Initial    | 15 | 30 | 45 | 60 | 75 |       |
| T₀         | 12.45 | 12.85 | 13.75 | 14.45 | 14.85 | 15.15 | 13.91 a |
| T₁         | 12.40 | 12.62 | 12.95 | 13.15 | 13.35 | 13.85 | 13.05 c |
| T₂         | 12.20 | 12.72 | 13.00 | 13.15 | 13.45 | 13.95 | 13.07 c |
| T₃         | 12.30 | 12.40 | 12.50 | 12.61 | 13.25 | 13.45 | 12.75 d |
| T₄         | 12.25 | 12.30 | 12.35 | 12.65 | 12.95 | 13.25 | 12.62 e |
| T₅         | 12.25 | 12.65 | 13.35 | 13.75 | 13.75 | 14.75 | 13.40 b |
| Means      | 12.31 f | 12.59 e | 12.98 d | 13.29 c | 13.58 b | 14.07 a |       |

Figures with different letters are significantly different (p<0.05) from each other

Table 2. Effect of aloevera gel and calcium chloride coating and storage intervals on the acidity (%) of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
| Initial    | 15 | 30 | 45 | 60 | 75 |       |
| T₀         | 0.66 | 0.63 | 0.53 | 0.47 | 0.43 | 0.41 | 0.52 d |
| T₁         | 0.64 | 0.63 | 0.61 | 0.54 | 0.51 | 0.44 | 0.56abc |
| T₂         | 0.65 | 0.59 | 0.57 | 0.54 | 0.48 | 0.44 | 0.54bcd |
| T₃         | 0.65 | 0.64 | 0.61 | 0.57 | 0.52 | 0.47 | 0.57ab |
| T₄         | 0.67 | 0.65 | 0.64 | 0.59 | 0.53 | 0.48 | 0.59 a |
| T₅         | 0.64 | 0.59 | 0.55 | 0.52 | 0.47 | 0.42 | 0.53 cd |
| Means      | 0.65 a | 0.62 a | 0.59 b | 0.54 c | 0.49 d | 0.44 e |       |

Figures with different letters are significantly different (p<0.05) from each other

Table 3. Effect of aloevera gel and calcium chloride coating and storage intervals on the sugar acid ratio of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
| Initial    | 15 | 30 | 45 | 60 | 75 |       |
| T₀         | 18.91 | 20.44 | 25.99 | 30.79 | 34.58 | 37.00 | 27.95 a |
| T₁         | 19.42 | 20.08 | 21.27 | 24.40 | 26.22 | 31.52 | 23.81 d |
| T₂         | 18.81 | 21.60 | 22.85 | 24.40 | 28.07 | 31.75 | 24.58 c |
| T₃         | 18.97 | 19.42 | 20.54 | 22.17 | 25.53 | 28.66 | 22.55 e |
| T₄         | 18.33 | 18.97 | 19.34 | 21.49 | 24.48 | 27.65 | 21.71 f |
| T₅         | 19.19 | 21.49 | 24.32 | 26.49 | 29.30 | 35.16 | 25.99 b |
| Means      | 18.94 f | 20.33 e | 22.39 d | 24.96 c | 28.08b | 31.96 a |       |

Figures with different letters are significantly different (p<0.05) from each other
### Table 4. Effect of aloevera gel and calcium chloride coating and storage intervals on the pH of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
|            | Initial | 15 | 30 | 45 | 60 | 75 | Mean |
| T₀         | 4.35    | 4.57 | 4.79 | 4.97 | 5.27 | 5.66 | 4.93a |
| T₁         | 4.31    | 4.35 | 4.41 | 4.57 | 4.67 | 4.95 | 4.54d |
| T₂         | 4.38    | 4.48 | 4.57 | 4.67 | 4.81 | 5.18 | 4.68c |
| T₃         | 4.23    | 4.17 | 4.27 | 4.53 | 4.63 | 4.79 | 4.44e |
| T₄         | 4.15    | 4.20 | 4.23 | 4.27 | 4.52 | 4.67 | 4.34f |
| T₅         | 4.34    | 4.65 | 4.69 | 4.83 | 5.17 | 5.47 | 4.85b |
| Means      | 4.29    | 4.40 | 4.49 | 4.64 | 4.84 | 5.12 | 4.93a |

Figures with different letters are significantly different (p<0.05) from each other.

### Table 5. Effect of aloevera gel and calcium chloride coating and storage intervals on the ascorbic acid (mg/100g) of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
|            | Initial | 15 | 30 | 45 | 60 | 75 | Mean |
| T₀         | 8.30    | 7.80 | 7.50 | 6.90 | 5.80 | 4.60 | 6.82f |
| T₁         | 8.60    | 8.20 | 7.90 | 7.10 | 6.80 | 5.60 | 7.37c |
| T₂         | 8.50    | 8.30 | 7.80 | 6.60 | 6.10 | 5.40 | 7.12d |
| T₃         | 8.60    | 8.40 | 8.20 | 7.80 | 6.60 | 5.80 | 7.56b |
| T₄         | 8.70    | 8.50 | 8.30 | 8.10 | 7.80 | 6.20 | 7.93a |
| T₅         | 8.40    | 7.70 | 7.40 | 6.80 | 6.70 | 5.10 | 7.01e |
| Means      | 8.51    | 8.15 | 7.85 | 7.22 | 6.63 | 5.45 | 6.82f |

Figures with different letters are significantly different (p<0.05) from each other.
Table 6. Effect of aloevera gel and calcium chloride coating and storage intervals on the weight loss (%) of Apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
|            | Initial | 15 | 30 | 45 | 60 | 75 |       |
| T₀         | 0       | 6.75 | 8.19 | 11.25 | 15.85 | 18.40 | 10.08 a |
| T₁         | 0       | 3.25 | 5.15 | 7.85 | 9.25 | 13.15 | 6.45 d |
| T₂         | 0       | 3.86 | 6.47 | 9.23 | 11.45 | 15.63 | 7.78 c |
| T₃         | 0       | 2.68 | 4.50 | 6.65 | 8.85 | 11.95 | 5.78 e |
| T₄         | 0       | 2.55 | 4.37 | 6.39 | 8.25 | 10.85 | 5.41 f |
| T₅         | 0       | 5.14 | 7.47 | 10.52 | 13.45 | 16.18 | 8.80 b |
| Means      | 0.00 f | 4.04 e | 6.03 d | 8.65 c | 11.18 b | 14.36 a |       |

Figures with different letters are significantly different (p<0.05) from each other.

Table 7. Effect of aloevera gel and calcium chloride coating and storage intervals on the firmness (kg/cm²) of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
|            | Initial | 15 | 30 | 45 | 60 | 75 |       |
| T₀         | 6.45 | 6.25 | 6.15 | 5.85 | 5.35 | 5.05 | 5.85e |
| T₁         | 6.25 | 6.25 | 6.25 | 5.85 | 5.75 | 5.25 | 5.93 c |
| T₂         | 6.25 | 6.15 | 6.15 | 5.85 | 5.75 | 5.35 | 5.91 c |
| T₃         | 6.55 | 6.45 | 6.35 | 6.25 | 6.05 | 5.75 | 6.23 b |
| T₄         | 6.85 | 6.75 | 6.65 | 6.45 | 6.25 | 6.15 | 6.51 a |
| T₅         | 6.15 | 6.15 | 6.05 | 6.05 | 5.85 | 5.05 | 5.88 d |
| Means      | 6.41 a | 6.33 b | 6.27 c | 6.05 d | 5.83 e | 5.43 f |       |

Figures with different letters are significantly different (p<0.05) from each other.
Table 8. Effect of aloevera gel and calcium chloride coating and storage intervals on the decay index (%) of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|--------|
|            | Initial | 15  | 30  | 45  | 60  | 75  |
| T₀         | 0       | 4.05| 8.73| 13.82| 18.95| 23.86| 11.57 a |
| T₁         | 0       | 2.32| 3.64| 5.17 | 8.24 | 12.77| 5.36d  |
| T₂         | 0       | 2.30| 4.97| 6.95 | 10.37| 14.03| 6.44c  |
| T₃         | 0       | 2.26| 4.35| 5.15 | 6.33 | 8.42 | 4.41 e |
| T₄         | 0       | 2.24| 2.83| 4.24 | 6.15 | 7.34 | 3.80f  |
| T₅         | 0       | 2.58| 5.76| 8.65 | 12.56| 16.00| 7.60b  |
| Means      | 0.00 f  | 2.62 e| 5.04 d| 7.33 c| 10.43 b| 13.75 a|

Figures with different letters are significantly different (p<0.05) from each other.

Table 9. Effect of aloevera gel and calcium chloride coating and storage intervals on the colour score rate of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|--------|
|            | Initial | 15  | 30  | 45  | 60  | 75  |
| T₀         | 8.50   | 7.20 | 6.30| 5.30 | 4.20 | 3.10 | 5.76 f |
| T₁         | 8.70   | 7.30 | 6.90| 6.30 | 5.50 | 4.30 | 6.50 c |
| T₂         | 8.70   | 7.10 | 6.60| 5.90 | 5.30 | 4.30 | 6.31 d |
| T₃         | 8.80   | 8.10 | 7.30| 6.80 | 5.70 | 4.50 | 6.86 b |
| T₄         | 8.90   | 8.20 | 7.70| 6.90 | 5.90 | 4.90 | 7.08 a |
| T₅         | 8.60   | 7.30 | 6.40| 5.90 | 5.10 | 4.10 | 6.23 e |
| Means      | 8.70 a | 7.53 b| 6.86 c| 6.18 d | 5.28 e| 4.20 f|

Figures with different letters are significantly different (p<0.05) from each other.
Table 10. Effect of aloe vera gel and calcium chloride coating and storage intervals on the flavor score rate of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
|            | Initial | 15  | 30  | 45  | 60  | 75  |
| T<sub>0</sub> | 8.40   | 7.10 | 6.30 | 5.40 | 4.40 | 3.10 | 5.78 f |
| T<sub>1</sub> | 8.60   | 7.20 | 6.50 | 5.80 | 5.40 | 4.80 | 6.38 c |
| T<sub>2</sub> | 8.60   | 7.30 | 6.40 | 5.70 | 5.10 | 4.10 | 6.20 d |
| T<sub>3</sub> | 8.80   | 8.20 | 7.40 | 6.10 | 5.80 | 4.50 | 6.80 b |
| T<sub>4</sub> | 8.80   | 8.30 | 7.60 | 6.90 | 5.90 | 5.10 | 7.10 a |
| T<sub>5</sub> | 8.60   | 7.30 | 6.50 | 5.90 | 5.10 | 3.10 | 6.08 e |
| Means      | 8.63   | 7.56 | 6.78 | 5.96 | 5.28 | 4.11 | 4.11 f |

Figures with different letters are significantly different (p<0.05) from each other

Table 11. Effect of aloe vera gel and calcium chloride coating and storage intervals on the texture score rate of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
|            | Initial | 15  | 30  | 45  | 60  | 75  |
| T<sub>0</sub> | 8.50   | 7.20 | 6.40 | 5.40 | 4.30 | 3.20 | 5.83 f |
| T<sub>1</sub> | 8.70   | 7.30 | 6.80 | 5.70 | 5.50 | 4.70 | 6.45 c |
| T<sub>2</sub> | 8.60   | 7.30 | 6.70 | 5.60 | 5.30 | 4.30 | 6.30 d |
| T<sub>3</sub> | 8.80   | 8.20 | 7.50 | 6.20 | 5.70 | 4.70 | 6.85 b |
| T<sub>4</sub> | 8.80   | 8.40 | 7.80 | 6.30 | 5.80 | 5.10 | 7.03 a |
| T<sub>5</sub> | 8.60   | 7.10 | 6.50 | 5.80 | 5.10 | 4.10 | 6.20 e |
| Means      | 8.66   | 7.58 | 6.95 | 5.83 | 5.28 | 4.35 | 4.35 f |

Figures with different letters are significantly different (p<0.05) from each other
Table 12. Effect of aloevera gel and calcium chloride coating and storage intervals on the overall acceptability of apple fruits

| Treatments | Storage Intervals (days) | Means |
|------------|--------------------------|-------|
|            | Initial  | 15    | 30 | 45 | 60 | 75 |
| T₀         | 8.40     | 7.10  | 6.30 | 5.30 | 4.30 | 3.10 | 5.75 f |
| T₁         | 8.60     | 7.20  | 6.70 | 5.90 | 5.40 | 4.60 | 6.40 c |
| T₂         | 8.60     | 7.20  | 6.50 | 5.70 | 5.20 | 4.20 | 6.23 d |
| T₃         | 8.80     | 8.10  | 7.40 | 6.30 | 5.70 | 5.10 | 6.80 b |
| T₄         | 8.80     | 8.30  | 7.70 | 6.70 | 5.80 | 5.10 | 7.06 a |
| T₅         | 8.60     | 7.20  | 6.40 | 5.80 | 5.10 | 3.70 | 6.13 e |
| Means      | 8.63 a   | 7.51 b | 6.83 c | 5.95 d | 5.25 e | 4.20 f |

Figures with different letters are significantly different (p<0.05) from each other.

Conclusion
Apples fruit treated in aloevera gel and calcium chloride have longer shelf life as compared to untreated fruit, so calcium chloride and aloevera gel have the potential to minimize the post-harvest losses of apple fruit. Based on overall quality (physicochemical and sensory analysis) sample T₄ with 10% aloevera gel and 2% CaCl₂ followed by T₃ with 2% CaCl₂ was considered as the best sample because it retained the quality attributes to a greater extend as compared to other treatments.

Authors’ contributions
Conceived and designed the experiments: N Khan & A Riaz, Performed the experiments: N Khan & Z Rahman, Analyzed the data: JU Mawa, Contributed materials/ analysis/ tools: H Begum & A Riaz, Wrote the paper: N Khan & Z Rahman.

References
1. Chaudhry MI, Malik MN (1994). Fruit crops in Horticulture) 1stEdn. National Book Foundation, Islamabad 471-473.
2. Agric Stat of Pakistan (2011-2012). Govt. of Pakistan. Agriculture, Forestry and Fisheries, (Economic Wing) Islamabad Pakistan, pp 1-89.
3. Vieths S, Schoning B & Jankiewicz A (1993). Occurrence of IgE binding allergens during ripening of apple fruits food. Agric Immunol 5: 93-105.
4. Hussain T (2001). Food Composition table for Pakistan, Govt. of Pakistan ministry of P & D Islamabad.
5. Boyer JI and Ruilin RH 2004. Apple phytochemicals and their health benefits.Dept. Food Sci and Inst Comp and Envirtoxal USA NJ 3(5):1-15.
6. Martinez RD, Alburquerque NJM, Valverde AF, Guillen AS, Castillo AD, Valero AM & Serrano M (2006). Postharvest sweet cheery quality and safety maintainance by Aloe Vera treatment a new edible coating. J of Postharv Bio and Tech 39: 93-100.
7. Dang KT, Singh HZ & Swinny EE (2008). Edible coatings influence fruit ripening, quality, and aroma biosynthesis in mango fruit. J of Agri Food Chem 56: 1361–1370.
8. Chardonnet CO, Charron CS, Sams CE & Conway WS (2003). Chemical changes in the cortical tissue and cell walls of calcium infiltrated ‘Golden Delicious’ apples during storage. J of Postharvest Bio and Tech 28: 97–111.
9. Martin D & Belen A (2007) .Calcium for extending the shelf life of fresh whole and minimally processed fruits and vegetables: A review. Trends in Food Sci & Technol 18: 210-218.
10. Akhtar A, Abbasi NA & Hussain A (2010). Effect of Calcium chloride...
treatment on quality characteristics of loquat fruit during storage. Pak J Bio 42: 181-188.

11. Jilani MS, Bibi F, Waseem K & Khan AM (2010). Evaluation of physico-chemical characteristics of mango (Mangifera indica L.) cultivars grown in D.I. Khan. J of Agri Res 48: 201-207.

12. Romero MDN, Alburquerque JM, Valverde F, Guillem S, Castillo D & Valero M (2006). Postharvest sweet cherry quality and safety maintenance by Aloe vera treatments a new edible coating. J of Postharv Bio and Tec 39: 93-100.

13. Valverde JM, Valero D, Romero MD, Guillem F, Castillo S & Serrano M. (2005). Novel edible coating based on Aloe vera gel to maintain table grape quality and safety. J of Agri Food Chem 53: 7807-7813.

14. Marpudi SK, Ramchandaran P & Srividya N (2011). Aloe vera gel coating for post-harvest quality maintenance of fresh fig fruits. Res J Pharma Biolo Chem Sci 4(1): 43-41.

15. Adetunji CO, Fawole AB, Oloke JK, Adetunji JB & Makanjoula. (2012). Effect of edible coating from Aloe Vera gel on Citrus sinenesis during ambient storage. J of Agric Res & Develop 11(1): 23-26.

16. Asghari M, Ahadi L & Riaie S (2013). Effect of salicylic acid and edible coating based aloe vera gel treatment on storage life and postharvest quality of grape (Vitus vinifera L. cv. Gizel Uzum). Inter J of Agric Crop Sci 5(23): 2890-2898.

17. Ahmad MJ, Singh Z & Khan AS (2009). Postharvest Aloe vera gel coating modulates fruit ripening and quality of ‘Arctic Snow’ nectarine kept in ambient and cold storage. Inter J of Food Sci and Tech 44(7): 1024-1033.

18. Mohebbi M, Ansarifar E, Hasanpour N & Reza M (2012). Suitability of AloeVera and gum tragacanth as edible coating for extending the shelf life of button mushroom. J of Food Bioprocess Tech 5: 3193-3202.

19. AOAC (2012). Official methods of analysis Association of Official and Analytical Chemists 17th Edi. Washington, DC.

20. Larmond E (1977). Laboratory methods of survey evaluation of food publication in Canada. Deptt Agri Ottawa 30: 78-88.

21. Steel RG & Torrie JH (1997). Principles and procedures of statistics. A biometrical approach, 2nd ed. New York, McGraw-Hill, pp 633.

22. Cheour F, Willemot C, Arul Y, Desjardins J, Makhlouf P & Gosselin A (1990). Effects of foliar application of CaCl2 on postharvest strawberry ripening. J of the Amer Soc for Horticult Sci 115(5): 789-792.

23. Brishtia FH, Misira J & Sarker A (2013). Effect of Bio preservatives on storage life of papaya (Carica papaya L.). Inter J of Food Sta 2: 126-136.

24. Hussain PR, Dar MA, Meen R, Shafi F & Wani AM (2008). Changes in quality of apple (Malus domestica) cultivars due to gamma irradiation and storage condition. J of Food Sci & Tech 45: 444-449.

25. Cordenunsi, BR, Nascimento JRO & Lajola FM (2003). Physico-chemical changes related to quality of five strawberry fruit cultivars during cool storage. J of Food Chem 83: 167-173.

26. Serrano M, Romero DM, Castillo S, Guillem F & Valero D (2004). Effect of preharvest sprays containing calcium, magnesium and titanium on the quality of peaches and nectarines at harvest and during postharvest storage. J of Agric & Food Sci 84(11): 1270-1276.

27. Arowora KA, Williams JO, Adetunji CO, Fawole OB, Afolayan SS, Olaleye OO, Adetunji JB & Ogundele BA (2013). Effects of Aloe vera coatings on quality characteristics of oranges stored under cold storage. J of Agr Sci 3(1): 39-47.
28. Wani AM, Hussain PR, Meena RS & Dar MA (2008). Effect of gamma irradiation and refrigerated storage on the improvement of quality and shelf life extension of pear (Pyrus communis L, Cv. Bartlett/ William). *Rad Phy Chem* 77: 983-989.

29. Lowings PH & Cutts DF (1982). The preservation of fresh fruits and vegetables. *Inter Food Sci Tech Annual Symposium, Nottingham, UK*.

30. Salunkhe DK, Boun HR & Reddy NR (1991). Storage processing and nutritional quality of fruits and vegetables. Volume 1. *Fresh Fruits & Vegetables*. CRC Press, Boston MA, USA.

31. Hayat I, Masud T & Rathore HA (2003). Effect of coating and wrapping materials on the shelf life of apple (Malus domestica cv. Borkh). *Inter J of Food Safety* (5): 24-34.

32. Manganaris GA, Vasilakakis M, Diamantidis G, Mignani I (2007). The effect of postharvest calcium application on tissue calcium concentration, quality attributes incidence of flesh browning and cell wall physicochemical aspects of peach fruits. *J of Food Chem* 100: 1385-1392.

33. Southy M, Reich M, Breuils L, Jacquemin Y & Audergon JM (1995). Effect of postharvest calcium treatments on shelf-life and quality of apricot fruit. *J of Act Horticult* 384: 619-623.

34. Munoz PH, Almenar E, Ocio MJ & Gavara R (2006). Effect of calcium dips and chitosan coating on post-harvest life of strawberries (Fragaria x ananassa). *Postharv Biol and Technol* 39(3): 247-253.

35. Bayindirli L (2002). Density and viscosity of grape juice as a function of concentration & temperature. *J of Food Preserv* 17: 147–151.

36. Lee SK, Shin IS & Park YM (1993). Factors involved in skin browning of fruits and vegetables. *Inter J of Food Sci & Tech Annual Symposium, Nottingham, UK*.

37. Dong X, Wrolstad RE & Sugar D (2000). Extending shelf life of freshcut pears. *J of Food Sci 65*: 181–186.

38. Kohle H, Blick J, Poten W, Blaschek F & Kauss W (1985). Chitosan-elicited callose synthesis in soy bean cells as a Ca2+ dependent process. *J of Plant Physiol* 77: 544-551.

39. Benitez S, Achaerandio I, Sepulcre F & Pujola M (2013). Aloevera based edible coating improves the quality of minimally processed ‘Hayward’ Kiwifruit *J of Postharv Bio & Tech* 81: 29-36.

40. Romerao MDN, Castilho S, Guillena F, Mulaa HMD, Zapata PJ, Valeroa D & Serrano M (2013). Aloe vera gel coating maintains quality and safety of ready to eat pomegranate arils. *J of Postharv Bio & Tech* 86: 107-112.

41. Bhartiya SP, Sharma RM, Kapoor AP & Ahmad M (1998). Effect of postharvest chemical treatments on shelf life of apple (Malus domestica Borkh) fruits. *Inter J of Horticult* 11(1): 9-16.

42. Chuhan OP, Ashoq C, Ravi N, Roopa N & Raju N (2013). Shellac and Aloevera gel based surface coating for shelf life extension of tomatoes. *Inter J of Food Sci & Tech*, pp 1-6.

43. Prakash A, Manley J, Decosta S, Caporaso F & Foley DM (2002). The effect of gamma irradiation on the microbiological, physical and sensory qualities of diced tomatoes. *Radiat Phys Chem* 63: 387–390.