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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 T_0 was used as a control (untreated), T_1 with 10 percent aloevera gel coating, T_2 with 20 percent aloevera gel coating, T_3 with 2 percent calcium chloride, T_4 with 10 percent aloevera gel and 2 percent calcium chloride coating and T_5 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 T_0 (13.91) while the lowest mean value was found in T_4 (12.62). Highest mean value for acidity was found in T_4 (0.59) while lowest mean value was found in T_0 (0.52). Highest mean value for sugar/acid ratio was found in T_0 (27.95) while lowest mean value was found in T_4 (21.72). Maximum pH value was showed by T_0 (4.93) while minimum pH value was showed by T_4 (4.34). Maximum Ascorbic Acid content was found in T_4 (7.93) while minimum Ascorbic acid was found in T_0 (6.82). Highest weight loss was found in T_0 (10.08) while lowest mean value was found in T_4 (5.41). Highest mean value for firmness was found in T_4 (6.51) while minimum firmness was showed by T_0 (5.85). Highest decay index was found in T_0 (11.57) while lowest mean value was found in T_4 (3.80). Maximum score for color was showed by T_4 (7.08) while minimum score was observed in T_0 (5.76). For flavor, maximum score was found in T_4 (7.10) while minimum score was showed by T_0 (5.78). Maximum score for texture was found in T_4 (7.03) while minimum score was observed in T_0 (5.83). Highest mean value for overall acceptability was found in T_4 (7.06) while minimum value was recorded in T_0 (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/cm^2. 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 T_4 with 10% aloe vera gel and 2% $CaCl_2$ followed by T_3 with 2% $CaCl_2$ 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. In Pakistan, the overall production was 351.9 thousand tons which incorporates 0.1 in Sindh, 3.6 in Punjab, 220.2 in Baluchistan and 12.7 thousand tons in Khyber Pakhtunkhwa [2]. In 2011-2012 the production was 827 thousand tons and almost 493 thousand tons apples were exported. 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 Aloevera 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]. Aloevera has been reported for its antimicrobial and therapeutic activities and medicinal properties [13]. Aloevera 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 Aloevera 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

T_0: Control
T_1: Aloe Vera gel 10%
T_2: Aloe Vera gel 20%
T_3: Calcium Chloride 2%
T_4: Aloe Vera gel 10% + 2% $CaCl_2$
T_5: Aloe Vera gel 20% + 2% $CaCl_2$

Storage duration

S_0: Control
S_1: 15
S_2: 30
S_3: 45
S_4: 60
S_5: 75

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 70Oc 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 (T_0, T_1 T_2, T_3, T_4 and T_5) were made. T_0 was left untreated serving as a control for checking the result of application of Aloe Vera gel and $CaCl_2$ on Apple fruits. 10% edible coating of Aloe Vera Gel was applied on T_1 while application of 20% Aloe Vera Gel coating was done on T_2, T_3 were treated with 2% Calcium chloride ($CaCl_2$). T_4 were treated with 10% Aloe Vera Gel and 2% Calcium chloride ($CaCl_2$) and T_5 were treated with 20% Aloevera gel and 2% Calcium chloride ($CaCl_2$) 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 aloevera gel amd 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 T_4 0.59 and T_3 0.57. Minimum acidity percentage was found in T_0 0.52 and T_5 0.53 in (Table 2). The application of Aloevera 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 T_0 27.95 and T_5 25.99. Minimum sugar acid ratio was found in T_4 21.71 and T_3 22.55 in (Table 3). The increased in sugar acid ratio is 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 T_0 4.93 followed by T_5 4.85. The lowest mean value was found in T_4 4.34 followed by T_3 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 T_4 7.93 followed by T_3 7.56. The lowest mean value was found in T_0 6.82 followed by T_5 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 T_0 10.08 followed by T_5 8.80. The lowest fruit weight loss was showed by T_4 5.41 and T_3 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/cm^2)

A significant ($p<0.05$) decrease was observed during storage of all samples. Highest mean value was found in T_4 6.51 followed by T_3 6.23. Minimum fruit firmness was showed by T_0 5.85 followed by T_5 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 $CaCl_2$ 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 T_0 11.57 followed by T_5 7.60. The lowest mean value was found in T_4 3.80 followed by T_3 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 anti-microbial 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 T_4 7.08 followed by T_3 6.86. The lowest mean value was showed by T_0 5.76 and T_5 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 T_4 7.10 and T_3 6.80. Minimum test score was showed by T_0 5.78 and T_5 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 T_4 7.03 followed by T_3 6.85. The lowest mean value was found in T_0 5.83 followed by T_5 6.20 in (Table 11).

Aloevera gel and $Cacl_2$ 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 T_4 7.06 followed by T_3 6.80. The lowest mean value was found in T_0 5.75 followed by T_5 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	
T_0	12.45	12.85	13.75	14.45	14.85	15.15	13.91 a
T_1	12.40	12.62	12.95	13.15	13.35	13.85	13.05 c
T_2	12.20	12.72	13.00	13.15	13.45	13.95	13.07 c
T_3	12.30	12.40	12.50	12.61	13.25	13.45	12.75 d
T_4	12.25	12.30	12.35	12.65	12.95	13.25	12.62 e
T_5	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	
T_0	0.66	0.63	0.53	0.47	0.43	0.41	0.52 d
T_1	0.64	0.63	0.61	0.54	0.51	0.44	0.56abc
T_2	0.65	0.59	0.57	0.54	0.48	0.44	0.54bcd
T_3	0.65	0.64	0.61	0.57	0.52	0.47	0.57ab
T_4	0.67	0.65	0.64	0.59	0.53	0.48	0.59 a
T_5	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	
T_0	18.91	20.44	25.99	30.79	34.58	37.00	27.95 a
T_1	19.42	20.08	21.27	24.40	26.22	31.52	23.81 d
T_2	18.81	21.60	22.85	24.40	28.07	31.75	24.58 c
T_3	18.97	19.42	20.54	22.17	25.53	28.66	22.55 e
T_4	18.33	18.97	19.34	21.49	24.48	27.65	21.71 f
T_5	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	
T_0	4.35	4.57	4.79	4.97	5.27	5.66	4.93a
T_1	4.31	4.35	4.41	4.57	4.67	4.95	4.54 d
T_2	4.38	4.48	4.57	4.67	4.81	5.18	4.68 c
T_3	4.23	4.17	4.27	4.53	4.63	4.79	4.44 e
T_4	4.15	4.20	4.23	4.27	4.52	4.67	4.34 f
T_5	4.34	4.65	4.69	4.83	5.17	5.47	4.85 b
Means	4.29 f	4.40e	4.49d	4.64c	4.84 b	5.12 a	

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	
T_0	8.30	7.80	7.50	6.90	5.80	4.60	6.82f
T_1	8.60	8.20	7.90	7.10	6.80	5.60	7.37 c
T_2	8.50	8.30	7.80	6.60	6.10	5.40	7.12 d
T_3	8.60	8.40	8.20	7.80	6.60	5.80	7.56 b
T_4	8.70	8.50	8.30	8.10	7.80	6.20	7.93 a
T_5	8.40	7.70	7.40	6.80	6.70	5.10	7.01 e
Means	8.51 a	8.15 b	7.85 c	7.22 d	6.63 e	5.45f	

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	
T_0	0	6.75	8.19	11.25	15.85	18.40	10.08 a
T_1	0	3.25	5.15	7.85	9.25	13.15	6.45 d
T_2	0	3.86	6.47	9.23	11.45	15.63	7.78 c
T_3	0	2.68	4.50	6.65	8.85	11.95	5.78 e
T_4	0	2.55	4.37	6.39	8.25	10.85	5.41 f
T_5	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/cm^2) of apple fruits

Treatments	Storage Intervals (days)						Means
	Initial	15	30	45	60	75	
T_0	6.45	6.25	6.15	5.85	5.35	5.05	5.85e
T_1	6.25	6.25	6.25	5.85	5.75	5.25	5.93 c
T_2	6.25	6.15	6.15	5.85	5.75	5.35	5.91 c
T_3	6.55	6.45	6.35	6.25	6.05	5.75	6.23 b
T_4	6.85	6.75	6.65	6.45	6.25	6.15	6.51 a
T_5	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	
T_0	0	4.05	8.73	13.82	18.95	23.86	11.57 a
T_1	0	2.32	3.64	5.17	8.24	12.77	5.36d
T_2	0	2.30	4.97	6.95	10.37	14.03	6.44c
T_3	0	2.26	4.35	5.15	6.33	8.42	4.41 e
T_4	0	2.24	2.83	4.24	6.15	7.34	3.80f
T_5	0	2.58	5.76	8.65	12.56	16.00	7.60b
Means	0.00 f	2.62 e	5.04 d	7.33c	10.43b	13.75a	

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	
T_0	8.50	7.20	6.30	5.30	4.20	3.10	5.76 f
T_1	8.70	7.30	6.90	6.30	5.50	4.30	6.50 c
T_2	8.70	7.10	6.60	5.90	5.30	4.30	6.31 d
T_3	8.80	8.10	7.30	6.80	5.70	4.50	6.86 b
T_4	8.90	8.20	7.70	6.90	5.90	4.90	7.08 a
T_5	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 aloevera 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_0	8.40	7.10	6.30	5.40	4.40	3.10	5.78 f
T_1	8.60	7.20	6.50	5.80	5.40	4.80	6.38 c
T_2	8.60	7.30	6.40	5.70	5.10	4.10	6.20 d
T_3	8.80	8.20	7.40	6.10	5.80	4.50	6.80 b
T_4	8.80	8.30	7.60	6.90	5.90	5.10	7.10 a
T_5	8.60	7.30	6.50	5.90	5.10	3.10	6.08 e
Means	8.63 a	7.56 b	6.78 c	5.96 d	5.28 e	4.11 f	

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

Table 11. Effect of aloevera 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_0	8.50	7.20	6.40	5.40	4.30	3.20	5.83 f
T_1	8.70	7.30	6.80	5.70	5.50	4.70	6.45 c
T_2	8.60	7.30	6.70	5.60	5.30	4.30	6.30 d
T_3	8.80	8.20	7.50	6.20	5.70	4.70	6.85 b
T_4	8.80	8.40	7.80	6.30	5.80	5.10	7.03 a
T_5	8.60	7.10	6.50	5.80	5.10	4.10	6.20 e
Means	8.66 a	7.58 b	6.95 c	5.83 d	5.28 e	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	
T_0	8.40	7.10	6.30	5.30	4.30	3.10	5.75 f
T_1	8.60	7.20	6.70	5.90	5.40	4.60	6.40 c
T_2	8.60	7.20	6.50	5.70	5.20	4.20	6.23 d
T_3	8.80	8.10	7.40	6.30	5.70	4.50	6.80 b
T_4	8.80	8.30	7.70	6.70	5.80	5.10	7.06 a
T_5	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

Apple fruit treated with aloevera gel and calcium chloride has 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 T_4 with 10% aloevera gel and 2% $CaCl_2$ followed by T_3 with 2% $CaCl_2$ 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.

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