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The Potential of Aloevera Gel and Cinnamon Oil Coating for Improving the Shelf Life of Pomegranate Arils

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Abstract: ***Ongoing global drive for a healthier diet has led to a rise in demand for convenient and fresh food produce, with high nutritional value and free of additives. Shelf life of pomegranate is lessened beneath 4°C or above 10°C temperatures because of increased parching and rate of rot resulting changes in physiochemical attributes and physiological disorders. Use of edible coating involving aloevera gel and an essential oil in the arils of Pomegranate reduces the respiration rate and exposure to microbial growth due to their ant oxidative and antimicrobial activities. In present study, the coated 0.25% cinnamon oil and 20% aloevera gel pomegranate arils were being packed in different Polymers under cold storage temperature (5°C) and assessed for physiochemical attributes such as physiological loss in weight (PLW), pH, acidity, TSS, hue angle and chroma, enzymatic activity which include L - phenylalanine ammonia lyase assay (PLA), Polyphenol Oxidase (PPO), Superoxide Dismutase (SOD), microbial load and organoleptic attributes to assess the effect of coating in enhancing its shelf life. This study also shows the best combination of edible gel-oil coating and packaging material that would be more suitable for prolonging the shelf life of pomegranate arils. Among the three packaging materials used, LDPE 50, HDPE 30 and HDPE 50, the coated pomegranate when stored in HDPE 30 has shown to be the most desirable results.***

Keywords : Pomegranate, Aloevera gel, Cinnamon oil, Packaging material, Physicochemical properties, Shelf-life study.

I. INTRODUCTION

Pomegranate fruit comprises of a hard weathered external skin (rind), an albedo, septa, membranes and numerous arils, which additionally include the inward system of membranes. The arils hold up around 55–60% of the fruit weight and contain 80% juice and 20% seeds [1[. Pomegranate fruit is a rich source of vitamin C, unsaturated fats, basic micro-and macronutrients and organic acids [2].

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[3] reported that pomegranate fruit and its juice are extraordinary resource of antioxidants and today it is being contrasted with red wine and a green tea infusion demonstrating that the commercial pomegranate juices had three times higher antioxidants activity than those of red wine and green tea.

The utilization of pomegranates is not extremely broad primarily because of the trouble of extricating the arils. Thus, commercialization of minimally processed and "ready- to-eat" fresh arils with in place tactile and nourishing properties is the good substitute to later demands of newly evolving heath conscious consumer class which also expect convenience. But, minimally processed fruit and vegetables are susceptible to microbial expansion because of the loss of their normal resistance and their high nutrient and water content [4]. Minimally processed arils easily degraded in weight loss, color, texture, and reduced shelf life so that keeping all nutritional components and microbial quality is a crucial challenge.

To enhance storability of pomegranate fruit low temperature is required [2]. The storage temperature prescribed for pomegranates shifts from 5 to 7°C, with shelf life of usability running from 4 to 8 m contingent upon cultivar [5]. Minimally processed fruit and vegetables are susceptible to microbial multiplication. In various experiments the shelf life of arils was reported different according to their respective treatments but also found up to 19 d shelf life of arils which were coated with *Aloevera* gel (AVG) [6]. In recent years, AVG has been used as an edible coating in pomegranate arils, plums, table grape, apple slices, papaya, pineapple, peach and plum. Apart from enhancing the shelf life, *Aloevera* gel also is colorless, tasteless and almost odorless and is considered biologically safe and ecofriendly, which makes it more desirable for coating and it could also enhance the appearance of the product by giving it glossy texture due to its transparency gelly nature.

Aloevera gel has considerable potential to reduce the growth of food borne pathogenic microorganisms such as *Bacillus cereus, Salmonella typhimurium, Escherichia coli, Klebsialla pneumonia* etc [7] and antifungal activity against several pathogenic fungi including *Botrytis cinerea* [8]. *Aloevera* gel is found to be an innovative edible coating to prevent loss of moisture and firmness, maturation, ethylene production, color change and microbial growth.

Similarly, essential oils are important for their antimicrobial and antioxidant properties [9]. EOs are extracted from plants through several different methods, including steam, hydro- distillation or supercritical carbon dioxide.

The highly volatile and antimicrobial nature of natural plant EOs or their components make them attractive candidates for antimicrobial active packaging [10]. Microbial growth was significantly reduced in whole cantaloupes when treated with antimicrobial coatings containing chitosan, lauric arginate (LAE), cinnamon oil (CO) and ethylenediaminetetraacetic acid (EDTA) and stored at 21°C for 14 d [11].

Several combinations of coating has been used along with *Aloevera* gel. [12] evaluated the ability of *Aloevera* coating to reduce the postharvest losses in papaya and to evaluate the effects with a natural polysaccharide-chitosan. Fruit were treated with *Aloe* gel (50%), papaya leaf extract (PLE) incorporated *Aloe* gel (1:1) and 2.5% chitosan and stored at 30± 3°C, 42-55% RH for 15 d. Physiological loss in weight (PLW) was significant in untreated fruit as compared to treated ones at the end of 10 d storage. PLW was obtained to be 27%, 26%, 26%, 32% for chitosan, PLE incorporated *Aloe* gel (PLEAG), *Aloe* gel and control fruit, respectively. The mean pH values of fruit enhance to 7.2 ± 0.03 from 5.7 after 10 d of storage in untreated fruit. But in PLEAG, *Aloe* gel and chitosan coated fruit there was negligible alteration in pH. The bright green color of papaya peel converted to yellow during storage in both uncoated and coated fruit apart from in PLEAG coated fruit. [13] studied weight loss and firmness in two nectarine cultivars 'Flavela' and 'Flanoba' coated with AVG alone or in combination with thymol, and then inoculated with *Botrytis cinerea*, *Rhizopus stolonifer* and *Penicillium digitatum.* The authors observed that weight loss was higher in 'Flanoba' than 'Flavela' after 6 d of storage. Firmness was decreased in control fruit. Both treatments prompted beneficial outcomes on lessening the softening of tissue. Since toward the end of experiment treated fruit had a 10% greater firmness than untreated ones. Further, the inoculation procedure or the extension of thymol did not effect to the firmness retention.

With increasing demand for fresh and natural products without addition of harmful chemicals, packaging film seems to be an ideal tool for preservation of minimally processed fruit, being cheap and easy to apply. Selection of packaging material is very important as combination of horticultural produce and permeability of film results in the passive evolution of an appropriate atmosphere within sealed packages [14] In the present study, Pomegranate arils are treated with the *Aloevera* gel and cinnamon oil and were placed in a sterilized polypropelene trays and packed in different types of Polyethylene pouches. LDPE 50, HDPE 50, HDPE 30 were being used. Different Polymer films play a unique role in controlling the enzymatic actions of the arils and affecting their shelf life. The present study aims to analyze the effect of edible coating mixture in reducing the undesirable enzymatic and microbial load over a period of time under low temperature. To assess the physico-chemical and sensory acceptance of the product stored using different polymers.

II. MATERIALS AND METHODS

A. Materials

Fresh pomegranates (*Punica granatum* L. *cv.*'Bhagwa) were purchased from Azadpur fruit market, New Delhi. Fruit were instantly transported to the cold room and stored at 5°C for experimentation. Food grade *Aloevera* gel (*Aloe barbadensis*) and essential oil (EO) (Cinnamon) were bought from Moksha lifestyle products company, New Delhi. Food grade Black polypropylene (PP) trays with measurements of 14.5 × 19.0 × 4 cm^3 were bought from Zui Trade links (Mayapuri, New Delhi) and polyethylene film (HDPE 30, HDPE 50 and LDPE 50) were bought from Grover Polypax (Moti Nagar, New Delhi). Tween-80 was added as emulsifier to structure a uniform solution of EO and *Aloevera*.

B. Chemicals and Reagents

All chemicals and reagents like Agar (Plate Count Agar, Potato Dextrose Agar, Violet Red Bile Agar), Buffer solution of pH 4, Catechol solution, Dipotassium Phosphate, Disodium Phosphate, DTT, EDTA, L-phenylalanine, Mercaptoethanol, Monosodium Phosphate, Monopotassium Phosphate, Sodium Borate, Sodium Chloride, Trichloro Acetic acid were bought from Sigma-Aldrich, New Delhi.

C. Preparation of samples and eatable coating formulations.

The whole fruit, plastic containers, knives and all other utensils that would be in a contact with the pomegranate arils were sanitized with sodium hypochlorite. Then after washing, fruit rind was carefully cut at equatorial zone with sharp knives and arils were manually taken out. Arils collected in pre-sterilized plastic crates and washed in chlorinated water holding 100 g^{-1}chlorine for 5 min and rinsed with tap water, all processing were done at 20±3°C.The *Aloevera* gel was applied with concentrations of 20%. Coatings were prepared by diluting 800g (20%) of *Aloevera* gel in 4L distilled water and then essential oil cinnamon (0. 25%) was added to it. For appropriate mixture of cinnamon oil (EO) with *Aloevera* in order to make a uniform solution, an emulsifier (Tween 80, 0.2 g EOs) was used in *Aloe* gel. The solution was blended and homogenized at 12,000g in homogenizer (IKAR, T18 d, Germany) for 120 s to form a uniform grid for *Aloe* gel and EO. The arils were dipped in prepared mixture for ten minutes. From the preliminary trial studies conducted in lab, with different concentrations of *Aloevera* gel and Cinnamon oil, a mixture of 20% *Aloevera* gel + 0. 25% cinnamon oil was found to be optimal in terms of its effects with the organoleptic properties and were packed in three different packaging materials: T_0 [*Control Arils (distilled water) LDPE 50], T_1 [*Control Arils (distilled water) HDPE 30], T_2 [*Control Arils (distilled water) HDPE 50], T_3 [Coated Arils LDPE 50], T_4 [Coated Arils HDPE 30], T_5 [Coated Arils HDPE 50] *Control Arils were treated with distilled water in place of gel-oil coating.

D. Coating treatment and storage of arils

Pomegranate arils were dipped in the solution of *Aloevera* gel and cinnamon oil for 10 min [15], then drained using steel colander, and arils were spread on blotting paper and left to dry. Arils were air-dried for 1h at room temperature. After drying, 250 g of arils were weighed in sterilized polypropylene trays.

Trays are then packed in different packaging i.e. in LDPE 50, HDPE 30 and HDPE 50 and sealed by using a paddle-sealing machine. Packed samples were stored at 5±1°C (Caleb et al., 2013b), 95 ± 2% RH for 15 d. For each treatment 12 boxes were utilized. Quality parameters (weight loss%, pH, acidity, TSS, color, microbiological assessment, enzymatic activity) were carried out on 0, 5, 10 and 15 dof storage. Three packs were analyzed for every provided condition on inspecting days.

E. Physiology changes

Weight loss (%)

eight loss for pomegranate arils was estimated according on different storage days. Initial and final weights of the packed pomegranate arils were measured using an electronic weighing balance (CTG -131, Citizen, India).

WL = Wi - Wf / Wi ×100

Where, WL is the weight loss (%),

Wi is the initial weight (g) and Wf is the final weight (g)

pH, TSS and Acidity

Pomegranate arils of every pack were juiced separately using a hand juice extractor and pH was determined. A buffer solution of pH 4 was used to standardize the pH meter (Testo India Pvt. Ltd. Pune). Total soluble solids (TSS) was determined using a digital Refractometer (Pesco. Delhi) at 20°C and expressed as % (°Brix). Titratable acidity (TA) was estimated by titrating with 0.1 N NaOH up to pH 8.2, using 0.005 L of pomegranate juice diluted in 0.035 L distilled water, and results were expressed as % citric acid. TSS to TA ratio was calculated by dividing TSS to TA percent.

Analysis of sugars

Total Sugar content was estimated by using Lane-eyon method from 0.005L of juice and expressed as gkg^{-1}

Enzyme Assay

Sample Preparation

Frozen arils (5 g) was crushed with a pestle and mortar, placed on dry ice, homogenized with chilled 80% acetone (1:10 w/v) and placed in a freezer for 15 m. Homogenate was separated and the pellet dried under vacuum (acetone powder).Then after 1 h, the homogenate was centrifuged at 27000 g for 1800 s at 4°C using Spectrophotometer (Lab India, Maharastra). The supernatant was used for assay.

L-phenylalanine ammonia lyase (PAL) enzyme assay

The reaction mixtures contained 0.0005 L of 30 µM L-phenylalanine, 30 µM sodium borate buffer of pH 8.8, and 1 mL crude extract in a total volume of 3 mL. Then the substrate was added, then after 600 s of pre-incubation the reaction was ceased with0.1 mL 6 N HCL. PAL activity was confirmed by the generation of cinnamate for 60m at 30°C with constant shaking, measured by the absorbance change at 290 nm [19]. Specific enzyme activity was expressed as nmol cinnamic acid $h^{-1}mg^{-1}$ of protein.

Superoxide Dismutase (SOD) enzyme assay (E.C.1.15.1.1).

Sample (4g) was grinded in a cold mortar and pestle with 4ml Potassium phosphate buffer (0.1 $molL^{-1}$, pH 7.4) having 1 $mmolL^{-1}$ Ethylenediaminetetraacetic acid (EDTA)and 2 $mmol^{-1}$Dithiothreitol (DTT). The homogenate was separated through four layers about muslin cloth and centrifuged (Remi, New Delhi) at 12,000g for 10min at 4°C. The supernatant obtained was used for assaying the superoxide dismutase enzyme activity. Total SOD enzyme activity was assayed in spectrophotometer at 420 nm. Superoxide dismutase activity was measured in unit 106 kg^{-1}. It was calculated by the given formula

Residual activity of enzyme in % = (S1/S0) × 100.

Where, S1 is slope of absorbance Vs time for treated sample. S0 is slope of absorbance Vs time for control sample.

Polyphenoloxidase enzyme assay (E.C.1.14.18.1)

Solvents and enzymes extraction

The enzyme extraction solution have 0.1 m sodium phosphate buffer of pH 7containing sample and 5% triton X-100, grinded and blended properly then centrifuged at 4800g for 5 min at 25°C. Then supernatant was separated through Whatman paper No. 1 (as Whatman no. 1 is inactive to the extraction for Polyphenoloxidase enzyme and is non sensitive to the segments throughout extraction) and stored at -20˚C until used.

Enzyme assays

0.6 ml of 0.1 ml Catechol solution was blended with 0.3ml of freshly prepared 0.2 M sodium phosphate buffer of pH 5.5, while 0.1ml enzyme extract was added freshly during the time of assay. Meanwhile the blank was prepared by addition of 0.6ml catechol solution with 0.4ml of sodium phosphate buffer. The readings were taken at 30 s interval for3 min, exactly after 1 min interval for every15 min. Polyphenoloxidase activity was measured in % activity. It was calculated using the given formula

Residual activity of enzyme % = (S1/S0) × 100.

Where, S1 is slope of absorbance Vs time for treated sample. S0 is slope of absorbance Vs time for control sample.

Microbial quality

Microbiological stability of samples was estimated by total plate count; for aerobic mesophilic bacteria count, plate number agar (PCA) was used. Yeast and molds were screened by IS 5403:1999 method using Potato Dextrose Agar (Himedia, Laboratories Maharashtra, India). Samples of 10 g from each group were acquired under sterile conditions (Laminar fume cupboard and gloves), which were homogenized in 90 ml of sterile peptone water (physiological solution, PS) using a stomacher (iMixR, Interlab France). Further twofold dilutions were prepared using 1.0 ml of diluents under 9.0 ml of PS. In order to identify microbial load, 1.0 ml of each dilution was pour plated in duplicate onto suitable media, PCA for aerobic mesophilic bacteria. Plates for aerobic mesophilic bacteria were incubated at 37°C for 2 d and at 25°C for 3–5 d for yeast and molds. The results were presented as Log $CFUg^{-1}$.

Change in Color

Color of aril was measured using a colorimeter. Before each measurement, the colorimeter was calibrated against a white color tile background (Illuminants C: Y = 93.6, x = 0.3133,y = 0.3195). Approximately 20 g of arils were placed in a petri dish, estimations were taken from five different point of the dish. CIE LAB parameters L* (lightness), a*(redness and greenness) and b* (yellowness and blueness) were measured.

Color was expressed in terms of H° = (arctangent b*/ a*) = Hue angle (0° = Redpurple,90°= yellow, 180° = pale blue green, 270° = Blue) (mean ± SD).The hue angle is calculated as, $H°= \tan^{-1}$ (b*/a*) and Chroma is calculated as, $C*= \sqrt{}$ a*2 +b*2.

Table1. Changes in physicochemical properties of pomegranate arils at 5^{0}C

Treatments	days	Total Sugar	pH	Acidity	TSS
T0	0	120.36±2.01^{ax}	4.08±0.01^{ax}	1.81±0.00^{ax}	17.03±0.02^{ax}
	5	116.41±1.02^{ax}	4.03±0.05^{ax}	1.59±0.01^{ay}	17.02±0.03^{ax}
	10	112.36±1.23^{az}	3.92±0.01^{ay}	1.36±0.00^{az}	16.26±0.02^{ay}
	15	114.41±1.42^{ay}	3.69±0.02^{az}	1.22±0.00^{az}	15.7±0.01^{az}
T1	0	120.43±2.21^{ax}	4.12±0.01^{bx}	1.90±0.00^{bx}	17.41±0.04^{bx}
	5	114.31±2.41^{by}	4.1±0.02^{bx}	1.81±0.00^{by}	17.3±0.02^{bx}
	10	113.21±1.31^{ay}	3.98±0.03^{ay}	1.36±0.00^{az}	17.9±0.01^{by}
	15	115.22±1.21^{az}	3.68±0.02^{az}	1.20±0.00^{az}	17.4±0.04^{bx}
T2	0	120.31±1.45^{ax}	4.13±0.03^{bx}	1.92±0.01^{bx}	17.4±0.02^{bx}
	5	114.51±2.11^{by}	4.1±0.02^{bx}	1.80±0.00^{by}	17.57±0.03^{bx}
	10	111.63±1.31^{az}	3.96±0.05^{ay}	1.34±0.00^{az}	17.6±0.01^{by}
	15	118.93±1.45^{bx}	3.59±0.02^{bz}	1.17±0.01^{bz}	17.7±0.04^{by}
T3	0	121.06±1.43^{ax}	4.1±0.01^{bx}	1.89±0.00^{cx}	17.4±0.05^{bx}
	5	119.13±1.56^{cy}	4.07±0.02^{ax}	1.58±0.01^{ay}	17.25±0.02^{by}
	10	116.41±1.03^{bz}	4±0.02^{bx}	1.4±0.00^{ay}	17.48±0.04^{cz}
	15	117.82±1.34^{bz}	3.59±0.03^{by}	1.17±0.00^{bz}	17.51±0.02^{bz}
T4	0	120.81±1.98^{ax}	4.15±0.02^{cx}	1.98±0.00^{cx}	17.6±0.01^{cx}
	5	114.43±1.35^{by}	4.11±0.02^{bx}	1.82±0.00^{cx}	17.7±0.00^{cy}
	10	110.5±1.51^{az}	3.99±0.05^{ay}	1.46±0.01^{ay}	17.75±0.05^{cy}
	15	113.69±1.67^{ax}	3.76±0.02^{cz}	1.29±0.00^{az}	17.82±0.02^{bz}
T5	0	120.93±1.86^{ax}	4.16±0.04^{cx}	2.01±0.00^{cx}	17.63±0.02^{cx}
	5	116.21±1.73^{ay}	4.09±0.02^{ax}	1.83±0.00^{cy}	17.75±0.01^{cx}
	10	110.43±1.41^{az}	3.99±0.01^{by}	1.38±0.00^{bz}	17.92±0.01^{cy}
	15	113.21±1.34^{az}	3.69±0.05^{bz}	1.21±0.01^{bz}	18.02±0.01^{cz}

Values expressed are mean ± standard deviation

Means in the same column with different letters were significantly different at p <0.05 (a, b, c for different treatments and x, y, z for time)

III. RESULT AND DISCUSSION

A. Weight loss (%)

The result in Graph 1. indicted that the weight loss (%)was influenced by coating and different packaging material. Weight loss mostly happens because of water loss by transpiration. The rate during which water may be lost relies on the water weight gradient of the fruit tissue and the encompassing environment. *Aloe* gel based eatable covering go about as barrier, thereby confining water exchange. Weight loss differed throughout cold storage of pomegranate arils, anyhow it was observed that weight loss is more in uncoated pomegranate arils packed in LDPE 50 than in the treated pomegranate arils packed in HDPE 30and HDPE 50. After 15 d of storage in 5 ±1°C control arils lost 1.15 ±0. 2 weight whereas it was observed that coated pomegranate arils packed in HDPE 50 and HDPE30 had the lowest (1. 00±0. 2) weight loss. The outcome from this study is confirmed or supported by [16]. .It has been observed that throughout the storage, the weight loss in uncoated fruit was significantly greater than the *Aloevera* gel coated fruit.

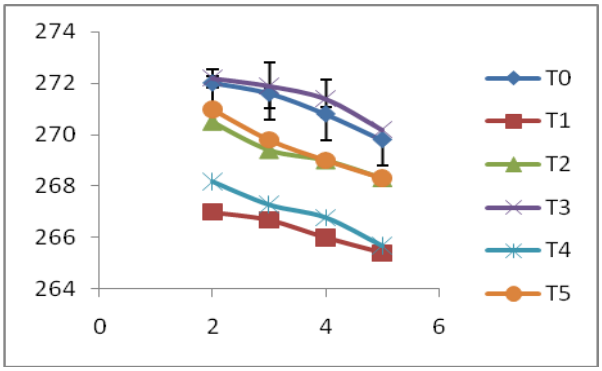

Fig 1. Weight loss in Pomegranate arils during storage at 5^0C

B. pH, TSS and Acidity

Table 1. demonstrates slight reduction in pH in coated pomegranate arils packed in different packaging material. Control tests showed diminishing pH starting with 4.08 to 3.69 at the end of storage time. In T3, reduction in pH was accounted from 4.10 to 3.59 which was higher reduction in pH among all samples, while T4 packed samples had lowest decline in pH value during storage time of 15 d at 5±1°C. These outcomes were comparable to those reported by [17] in which pomegranate samples stored in punctured polypropylene during5°C had lower pH values. Authors provide profitable data on effect of different packaging materials on minimally processed pomegranate arils on shelf life and quality parameters when stored at both room temperature and cold storage conditions. Arils packed in high density polyethylene 30 without puncturing recorded most noteworthy storability and additionally accomplished greatest TSS, brix, acid proportion and sugars at both low temperature and room temperature conditions. Further titrable acidity was also less in the arils packed in high density polyethylene 30 without puncturing. HDPE film packaging were found to be best among all packaging materials utilized and it also showed that Pomegranate packed in HDPE packaging material can be preserved for 9 months under refrigerated condition and 6 months under ambient condition without any major loss in quality [18].

B. L - phenylalanine ammonia lyase (PAL) enzyme activity

The data on PAL enzyme activity influenced by different packaging material are presented in Table 2. The activity of PAL increased in coated pomegranate arils when compared to the control samples. Then after 15 d of storage, arils from T4 was observed to have highest activities whereas T3 arils was found to have lower activity compared to the control. PAL act as key catalyst in the phenyl propanoid pathway, catalyzes transformation of phenylalanine to transcinnamic acid. Because of this conversion, in this study *Aloevera* in combination with cinnamon oil (AV+CEO) treated samples were observed to have the highest PAL activity. Furthermore, microbial counts in AV+ CEO treated arils accounted low as they are highly

C. L - phenylalanine ammonia lyase (PAL) enzyme activity

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D. Superoxide Dismutase (SOD) enzyme activity

The data on SOD enzyme activity influenced by different packaging material are presented in Table 2. Control samples have the lowest enzyme activity at initial level, and goes on decreasing as the storage time increases, and samples T3, T4 and T5 were observed to have approximate same enzyme activity on each storage days. [21] showed that for cold-stored zucchini, high Oxygen concentrations elevated the antioxidative defense mechanism and hydroxide may reduce SOD activity of fresh-cut pomegranate arils. Uncoated arils shows drastic decrease in the enzyme activity whereas coated arils do not show a huge variance and it may be because the Aloevera gel is controlling the SOD activity to some extent which could be desirable in maintaining a stable shelf life.

E. Polyphenoloxidase (PPO) enzyme activity.

The data on PPO enzyme activity influenced by different packaging material are presented in Table 3. PPO activity was observed more or less steady in all samples with slight variations as the storage time increased. At fifteenth day of storage slight decrease in values were observed in every coated samples. T4 and T5 were observed to have the lowest activity at initial level. Postharvest browning of fruit will be probably due to the fast debasement of anthocyanins caused by PPO and POD, producing tan by-products [22]. Since enzymatic browning typically brings about a negative impact on food quality, preventing or hindering enzymatic browning has become a very important factor for improving food quality during processing of fruits. The best result was obtained for treatment T4.

Table 2. Changes in enzymatic actions during the storage of pomegranate arils at 5^{0}C

Treatments	Days	PAL	SOD	PPO
	0	6.14±0.02	23.61±0.91	180.31±0.25
	5	73.1±2.02	23.32±7.01	183.63±5.02
	10	80.5±0.01	23.01±0.62	181.84±0.34
T0	15	88.6±4.15	22.85±0.93	179.63±0.53
	0	64.1±0.02	21.43±0.87	181.45±1.11
	5	75.1±3.01	21.19±0.91	183.21±5.21
	10	78.3±0.02	20.98±0.53	181.03±6.21
T1	15	81.3±1.01	20.72±0.61	178.63±0.66
	0	63.1±0.01	24.61±0.77	176.46±2.91
	5	73.4±2.25	24.43±2.91	180.33±0.19
	10	77.9±0.01	24.43±3.81	177.83±0.54
T2	15	79.8±1.01	23.97±9.23	175.34±8.99
	0	65.3±0.01	12.32±8.10	65.32±8.24
	5	69.4±0.03	12.11±0.73	70.15±7.65
	10	75.1±0.02	11.98±0.01	67.41±0.98
T3	15	81.3±0.01	11.77±0.91	64.81±2.91
	0	67.2±3.01	11.62±2.51	67.95±8.72
	5	73.8±0.02	11.43±0.66	71.65±1.61
	10	83.6±0.02	11.28±0.21	69.43±0.21
T4	15	92.1±4.01	11.05±2.51	66.82±3.45
	0	67.9±3.65	11.78±3.88	69.33±2.52
	5	74.1±4.21	11.53±0.21	73.15±2.89
	10	82.7±5.52	11.11±0.09	71.51±1.62
T5	15	91.3±0.61	11.03±0.21	68.48±6.91

F. Microbial Quality

The result for microbial analysis has been presented in Table 3.The initial population of total aerobic mesophilic bacteria on day 5thof storage was 5.2 Log CFUg^{-1} in the control arils and increased during storage time. The aerobic bacterial count increased in uncoated arils but remained lower in coated arils. At the end of 15 d of storage, the population of bacteria in control arils increased to 6.5 Log CFUg^{-1},whereasin coated arils packed in HDPE 30 and HDPE 50 (T4 andT5) were 6.2 and 6.4 Log CFUg^{-1}, respectively. This difference could be because of aloin and anthraquinones [23] compounds found in *Aloevera* and antimicrobial action of *Cinnamomum zeylanicum*(cinnamon essential oil), which is attributed to their major compounds such as cinnamaldehyde, which could cause aggravation in the cytoplasmic film function, proton intention force, electron flow, and active transport, and additionally coagulation of a microbial cell. The growth of yeast and molds were increased slowly during its storage period of 15 d at 5±1°C. Initially yeast and mold count wasobserved2.2 log CFU/g in control arils (T0) which increased to 4.2 log CFUg^{-1}during storage period where as yeast and mold count was 0 Log CFU/g in coated arils packed in LDPE 50, HDPE 30 and HDPE 50(T3, T4 and T5)which increased to 3.0, 2.0 and 3.3 log CFUg^{-1} respectively on the 10th day of storage. These outcomes are in agreement with results reported by [24] that Aloevera coatings successfully hindered alternately regulated microbial population in strawberry, apples and oranges. Yeast and mold observed to be less in numbers in the fruit treated with *Aloevera* gel with combination of 5% AA (3.47 log CFUg^{-1}) while in control fruit the population was higher (4.28 log CFUg^{-1}). Bioactive particles are reported to be present in *Aloe* species, for example, aloe-emodin and aleoninwhich have antifungal action against *Aspergillus*, *Cladosporium* and *Fusarium* [25]. Present study shows T4 sample to be more desirable in terms of both bacterial and fungal growth resistance compared to other coated pomegranate samples

G. Change in Color

It was observed that the color parameters were altogether changed with different treatments. An alternate parameter identified with pomegranate quality is shade of the aril. Color readings were measured for 15 d of storage period. On control samples, hue angle experienced a rise where as in coated arils hue angle slightly decreased.

Aloe gel and cinnamon treated arils packed in HDPE 30 (T4) accounted least reduction in hue angle initially from 34.37 to 32.91 during 15 d of storage. Chroma (C*) values increased for all samples, whereas in control arils, value increased after 5 d. On the other hand higher chroma value was accounted in T3 treatment at 15 d of storage time. These outcomes are in agreement with outcomes accounted by [26] in which chroma list brought about sharp rise in the beginning worth (9.39 ±0.54) in cold storage in control grapes, indicating a nonstop build until the limit of the storage period, arriving at levels about 18.40±0.38 difference over scores for almost all samples.

Table 3. Microbiological quality of pomegranate arils during storage at 5^{0}C

Treatments	Days	TPC	Yeast/Mold
	0	5.2±0.93	0
	5	5.4±2.23	1.3±0.06
	10	7.1±3.41	3.4±0.09
T0	15	6.3±1.92	4.1±0.01
	0	4.4±8.01	2.2±0.32
	5	5.2±2.31	2.1±0.07
	10	7.2±3.93	3.9±2.90
T1	15	6.5±9.21	4.2±1.09
	0	3.9±8.41	1.3±0.03
	5	4±0.21	3.7±0.01
	10	6.6±4.40	3.6±1.01
T2	15	6.7±5.02	4.1±2.01
	0	1.6±7.23	0
	5	3.8±1.32	1±0.03
	10	4.9±51	3±0.21
T3	15	6.3±42	3.7±0.21
	0	0	0
	5	1.5±2.50	1.4±3.50
	10	4.1±4.12	2±2.21
T4	15	6.2±5.21	3.1±0.12
	0	2.4±3.22	0
	5	2.5±1.32	1.6±0.01
	10	4.4±1.90	3.3±0.23
T5	15	6.4±8.89	3.7±0.01

D. Sensory evaluation

Sensory assessment parameters for example, flavor, texture, color, and fragrance were assessed using a 5-point scoring system. A flavor assessment of control samples of pomegranates arils were maintained up to 11 d because following 11th day a visual fungal growth was observed in control samples. Similarly, in coated pomegranate arils, flavor assessment were maintained upto 14th day for the aforesaid reason. In contrast, coated pomegranate arils packed in HDPE 30 was assessed for their flavor over 15 d of storage. However panelists found a slight taste of cinnamon oil in sample, which gave a slight negative impact on the coated sample. This taste is reported to persist for few seconds and no unusual after taste sensed. The panel members gave the most noteworthy appraisals to the samples packed in HDPE 30(T4). Among all 50 Weight Loss treatments, T4 got the noteworthy score in texture parameter, the coated arils retain their texture during storage period of 15 d at 5±1˚C. The panelists did not recognize any major distinction in the color levels of coated pomegranate arils packed in different packaging materials. Panelists offered greater color score to T4 and T5 coated arils during storage period. Panelists did not find any unusual odor in coated pomegranate arils throughout the storage time of 15 d at 5±1˚C. Thus, there was not much and T5 coated arils got significantly higher flavor scores on 15th day of storage.

Table 4. Change in color values during storage at 5^{0}C

Treatments	Days	Hue	Chroma
	0	32.8±0.21	15.07±1.11
	5	33.4±1.56	17.04±2.39
	10	34.68±1.44	16.09±1.54
T0	15	37.02±2.91	18.33±5.91
	0	31.97±2.22	16.76±0.12
	5	32.33±8.31	13.65±0.21
	10	35.02±2.43	22.43±2.01
T1	15	38.07±1.43	19.81±1.41
	0	35.14±9.51	15.55±2.39
	5	36.75±2.06	16.66±1.06
	10	38.25±1.57	18.88±0.04
T2	15	39.26±1.41	16.27±2.91
	0	33.97±1.21	13.4±1.62
	5	29.09±0.82	14.97±2.91
	10	27.64±1.72	16.01±1.22
T3	15	26.53±2.31	17.87±2.31
	0	34.3±2.32	12.59±1.41
	5	28.93±1.33	13.88±2.23
	10	27.45±3.45	12.98±2.21
T4	15	25.63±1.56	13.87±1.12
	0	32.22±2.09	14.21±1.45
	5	30.33±2.67	12.91±1.65
	10	28.48±2.99	16.44±1.82
T5	15	26.02±1.71	14.95±6.72

CONCLUSION

Aloevera gel in combination with essential oils is an innovative method to prolong the postharvest life of pomegranate arils by reduction in reduce weight loss (%), maintaining pH, color and enzyme activity, and reduce decay by suppression of total aerobic mesophilic bacteria, yeast and mold growth. It was found that, *Aloevera* gel and cinnamon oil treated arils when packed in three different packaging materials HDPE 30, HDPE 50 and LDPE 50 among which HDPE 30 seems to be best for packing gel-oil coated pomegranate arils. It also showed to have lowest weight loss, decreased pH and less variation in color compared to other samples. The coated arils retain the distinctiveness sensory attributes - color, flavor and aroma. The microbial populations were significantly low in treated arils packed in HDPE 30 comparison to HDPE 50 and LDPE 50. *Aloevera* coating containing cinnamon essential oil at higher concentrations act as natural preservative and has tremendous potential to extend the shelf life and maintain quality of pomegranate arils. This study also showed that, pomegranate arils with *Aloevera* gel and cinnamon oil can be effective coating for the inhibition of PAL, PPO and SOD enzyme activities. Although PAL increased during storage but was lower than the control samples. Reduction in the SOD and PPO activities were significant during storage, and samples packaged in HDPE 30 showed best results among others. These results suggest that *Aloevera* gel treatments may be a useful non-chemical treatment to maintain the pomegranate arils quality and extend its shelf life. Further research is needed to elucidate the underlying relationship between *Aloevera* and essential oils and antioxidant enzyme activities in pomegranate arils to extend the shelf life for more days. Hence edible coated arils with *Aloevera* gel and cinnamon oil packed in HDPE 30 can be an effective method for extension of the shelf life of pomegranate arils at low temperature.

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