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IMPROVEMENT OF POSTHARVEST QUALITY AND SHELF LIFE OF CAPE GOOSEBERRY (*PHYSALIS PERUVIANA* L.) FRUIT WITH BIOACTIVE COMPOSITE COATINGS DURING LOW TEMPERATURE STORAGE

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ABSTRACT

The functionality of xanthan gum and guar gum was evaluated individually and in combination with olive oil on the qualitative properties of cape gooseberry fruit stored at the lower temperature (10±1 ˚C) at a regular interval of 5 days. On the 10th day of the storage period, the maximum hardness (8 N) was seen in the cape gooseberry fruit treated with xanthan gum 0.5% (T1), whereas minimum (4.7 N) hardness occurred in untreated (C) cape gooseberry fruit. The lower activity of softening enzymes was noticed in cape gooseberry treated with xanthan gum followed by xanthan gum enriched with olive oil. The shelf life of uncoated fruits was up to 17 days, whereas fruits coated with xanthan gum had extended shelf life up to 9 days more. This study showed that 0.5% xanthan gum alone and its combination with olive oil delayed the ripening of cape gooseberries as compared to that of the control and other coated fruits.

Key words: Composite edible coating, Guar gum, Physalis peruviana L., Shelf life, Xanthan gum

INTRODUCTION

Cape gooseberries or golden berries (*Physalis peruviana*) are popular fruits known for their organoleptic properties such as flavor, odor, and color, nutritional value (vitamins A and C, potassium, phosphorous, and calcium), and health benefits [1].The fruit is named as cape gooseberry because it is first cultivated in the Cape of Good Hope in South Africa and in India it is commonly known as “Rasbhari” [1]. Cape gooseberries as reported to have more antioxidants than goji berries, broccoli, apples and pomegranates. Cape gooseberries contain twice the vitamin C of lemons hence they have magnificent antioxidants that help to fend off cardiovascular disease, strokes and cancer. The fruit is enclosed in a papery husk or calyx, and is around 2 cm wide, 4–5 g in weight, with a smooth, orange–yellow skin and juicy pulp containing abundant small yellowish seeds. During ripening the fruit color turns from green to orange due to the breakdown of chlorophyll and accumulation of carotenoid (mainly carotene for this berry), and progressive softening occurs [2]. When fully ripe, the fruit is sweet with a pleasant grape-like tang [3]. The fruit is eaten fresh, in cocktails or in salads, or cooked. The fruit is very high in pectin and makes excellent pies and jellies [4]. It has been introduced as a specialized culture in warm regions worldwide, particularly in some American countries as well as in specific areas of Oceania (Australia and New Zealand), Asia (India) and Central and South Africa [5].
Use of edible coatings is a technology which helps to extend the shelf life and to retain the nutritional properties of fruit. Thus, the application of edible composite coatings would be an effective measure for the postharvest shelf life improvement and avoid high product loss of cape gooseberry fruit.

Gums in edible forming preparation are used for their texturizing capabilities. All gums are polysaccharides composed of sugars other than glucose [6]. Guar gum is a polysaccharide composed of the sugars, galactose and mannose. Guar gum is more soluble and it is a better stabilizer. It is nonionic and hydro colloidal. Guar gum has been reported to extend the postharvest shelf life of apple, cucumber and tomato [7]. Xanthan gum, synthesized as an exo-polysaccharide by *Xanthomonas campestris* under unfavorable conditions, is a Generally

Recognized as Safe (GRAS) compound (FDA, 21CFR172.695, 2013) for its use as a stabilizer, thickener or emulsifier. It forms an extremely viscous solution in hot or cold water at low concentration with outstanding stability over a wide range of pH and temperature and it is also resistant to enzymatic degradation. Moreover, it facilitates the suspension of particulates, even in complex formulations for a long time [8]. It is widely used in foods because of its good solubility in either hot or cold solutions, high viscosity even at very low concentrations, and excellent thermal stability. Xanthan gum forms very viscous solutions and at sufficiently high polymer concentration, it exhibits frail gel-like properties [9]. For that reason, lipid component can be incorporated to enhance the film forming property of the xanthan gum to be used as a coating material. Olive oil is such lipid component which is composed of 56.3–86.5% monounsaturated fatty acids (MUFA) and extensively consumed due to its nutritional value and its organoleptic characteristics.

In view of the above reports, the current study has been undertaken to evaluate the potential of postharvest treatments of guar gum and xanthan gum and also their combinations with olive oil as a composite coating on the shelf life and physicochemical characteristics of cape gooseberry fruit during its substantial postharvest loss.

METHODOLOGY

Fruit Source

Cape gooseberry fruits used in the present study were purchased from the fruit market of Anand, Gujarat, India and they were graded for their uniformity in size, shape and color and the fruits free from any mechanical injury were selected.

Chemicals

Xanthan gum ($C_{35}H_{49}O_{29}$, monomer) and guar gum of Himedia brand, Mumbai (India) were procured through local chemical vendors; whereas the food-grade refined olive oil (92 % purity) was purchased from the local market of Anand town, Gujarat (India).

Methodology of Film-Forming Dispersions

Xanthan gum (0.5%, w/v) was initially dispersed in hot water and stirred at 80 °C for 2 hr. and this coating solution was labeled as T1. Guar gum was prepared by dissolving 0.5 g of powder in 100 ml of distilled water and stirred for 1 hr. at room temperature. Glycerol (0.75%) was added as a plasticizer and the solution was stirred for 10 min under the same conditions and labeled as a T2. To make the composite coating, xanthan gum (0.25%) and guar gum (0.25%) powder were added in distilled water and stirred for 2 hr. and labeled as T3. Olive oil 0.2% (v/v) was added separately to the solutions of xanthan gum (0.5%) and guar gum (0.5%) and stirred using a magnetic stirrer (2 MLH, Remi equipments, India), at 80 °C, for 30 min. and labeled as T4 and T5 respectively. To the composite coating of xanthan gum (0.25%) + guar gum (0.25%) olive oil was added and labeled as T6 (Table 1).

Application of Edible Coatings

Cape gooseberry fruits were surface disinfected by immersing them in 2% sodium hypochlorite solution for 2 min, washed, and air-dried for 30 min. at room temperature. The fruit were randomly categorized into seven groups, having 200 g in each, and each group was in two replicates. Six groups were assigned to coating treatments (T) as follows: Xanthan gum 0.5% (T1), Guar gum 0.5% (T2), Xanthan gum 0.25% + Guar gum 0.25% (T3), Xanthan gum 0.5% + Olive oil 0.2% (T4), Guar gum 0.5% + Olive oil 0.2% (T5), Xanthan gum 0.25% + Guar gum 0.25% + Olive oil 0.2% (T6) and fruit dipped in distilled water, designed as control (C) samples. The treatments include dipping of fruits for 3 min. in coating solutions. Residual solutions of fruit were allowed to drain off and the fruit were dried at 26±2 ˚C for 30min., and then these samples were placed in clamshells and were stored at 10±1 ˚ C and 40–45%

relative humidity (R.H.). The fruits of treatments as well as control were evaluated for the following quality attributes at the beginning of the experiment (i.e., 0 day) and after 5, 10, 15, and 20 days of their storage period. For control fruit, the data were recorded only up to 15 days of storage period, as subsequently, they began to decompose.

Determination of Physicochemical Attributes

Total Soluble Solids (TSS)

Total soluble solids (TSS) content of fruit was determined by using refractrometer (Atago Co., Tokyo, Japan). Homogenous sample was prepared by blending the cape gooseberry fruit. The sample was thoroughly mixed and a few drops of juicy fruit pulp were taken on prism of refractrometer and direct reading was taken by reading the scale in meter as described in AOAC [10].

Determination of Biochemical Attributes

Total sugars were estimated by following the phenol-sulphuric acid method cited by Thimmaiah [11]. Estimation of total phenolics content (TPC) was carried out according to the method described by Mc Donald *et al.* [12]. The quantitative analysis of ascorbic acid was carried by using dinitro-phenyl hydrazine (DNPH) method described by Roe and Kuether [13].

Determination of Firmness

Firmness was measured as the maximum penetration force (N) reached during tissue breakage, using a Texture Analyzer (Lloyd instruments ltd, type TG 34) with a 36 mm diameter flat probe. The penetration depth was 5 mm and the cross-head speed was 40 mm/min. Two replicates were used for each determination. The firmness was reported as peak force and expressed in Newton per gram (N/g) of the cape gooseberry sample [14].

Physiological weight loss (PLW)

The weight loss was calculated with the following formula:

$$Weight\ loss = \frac{[m0-m1]}{m0} \times 100 \qquad (1)$$

Where $m0$ is the initial weight and $m1$ is the weight measured during storage.

Enzyme Extraction and Assay of Polygalacturonase (PG) (EC 3.2.1.15) and Pectate lyase (PL) (EC 4.2.2.2)

Extraction of cell wall softening enzymes and assay was carried out by following the method cited by Lohani *et al.*, [15].

Postharvest Marketable (Shelf Life) Period

The shelf life of cape gooseberry fruit was calculated by counting the days required for them to attain the last stage of ripening, but up to the stage when they remained acceptable for marketability [16].

Statistical Analyses

The data presented in this paper was statistically analyzed by SPSS 17 software and the mean and standard deviation (SD) were calculated. The statistical significance of the data was assessed by one way analysis of variance and LSD test. Mean comparisons were performed using HSD of Tukey's test to examine if differences between treatments and storage time were significant at $P < 0.05$. The overall least significance difference (LSD; $p \leq 0.05$) was calculated and used to detect significant differences among all the treatments and control set [17].

RESULTS AND DISCUSSION

Effect of Edible Coatings on PLW

Cape gooseberries are extremely inclined to rapid water loss which results in shrinkage of fruit and weakening of the tissue due to their very thin skin, because weight loss

is associated with respiration and the transpiration processes of fruit. The effect of edible coating treatments on PLW of cape gooseberries stored at lower temperature was found to be significant ($p<0.05$) as shown in Figure 1a. The results of the current study suggest that during the storage period, the least PLW occurs on the 10th day in the fruits treated with T1 (15.6 %), while the higher level of it was observed in the control set of fruit on the 10th day (24.4 %) and on the 15th day (40%). In this regard, Rojas-Argudo [18] explained that the effectiveness of polysaccharide coatings as a water barrier can be enhanced by the incorporation of lipids. In the present study, addition of a lipid component such as olive oil and glycerol significantly enhanced the effectiveness of xanthan gum, indicating their regulation of the hydrophilic-hydrophobic balance, which would in turn; restrict the water loss from the fruit. Kittur *et al*. [19] reported the reduced weight loss in banana fruit coated with polysaccharide-based composite coatings as compared to that of uncoated. Thomas *et al.* [20] also noticed that the composite oil coating preserves the quality of fruit retarding ethylene emission and hence reduce PLW in pineapple fruits.

Effect of Coatings on TSS content and Total Sugars

The level of total soluble solids (ºBrix) of control and coated cape gooseberry fruits showed significant ($p<0.05$) difference (Table 2). Overall, a gradual increase in TSS was observed during the entire storage period. The TSS content in fresh cape gooseberry fruit (i.e. at day 0) was 0.73˚ brix and the amount of TSS had increased with the increase of storage period up to 25 days. The accumulation of TSS was found to be higher in the fruit of the control set during their 5th and 10th days of storage. This increase of TSS in control fruits might be due to hydrolysis of acids and deposition of polysaccharides during storage as reported by Trivedi *et al.,* [15]. The highest value of TSS (i.e.1.9 brix) was observed in the untreated (control) fruit after 10 days of the storage period, whereas fruits treated with T1 (i.e. 1.2 ˚brix) and T5 (1.3 ˚brix) showed lower accumulation of TSS content. In this regard, Debeaufort *et al.* [21] explained that the edible coatings are selective barriers to O_2 and CO_2 modifying internal atmospheres and slowing down the respiration rate of fruit. Vyas *et al.* [22] also reported that the polysaccharide-based coating of carboxymethyl cellulose slows down the accumulation of TSS in papaya fruit.

Total sugars are considered good index for the determination of storage life. The effect of edible coatings on the total sugar content of cape gooseberries was significant ($p<0.05$) as compared to control (Table 2). An increase in the content of total sugars was observed initially in both treated as well as untreated fruits. The total sugar content of cape gooseberry fruit at 0 days of storage period was 64.61 mg g^{-1}. The increasing trend of total sugars of fruits was observed up to 5 days of storage and then decreased under all treatments. This might be due to rapid conservation of polysaccharides into sugars in the earlier stage and later for utilization of sugars in respiration. However, the delayed increase was noticed in cape gooseberries coated with 0.5 % xanthan gum (70.58 mg g^{-1}) as compared to that of the control fruit (108.5 mg g^{-1}). The reason for higher total sugar content in the uncoated sample may be due to decreased rate of respiration in coated samples where the utilization of sugar as a respiratory substrate also decreases. In this regard, Rohani *et al.* [23] also reported that the slower respiration also slows down the synthesis and use of metabolites resulting in lower sugars in coated fruits.

Effect of Coatings on Cell Wall Softening Enzymes and its Relation with Firmness of Cape gooseberry Fruit

Softening is one of the main factors determining fruit quality, and it can induce the onset of infections and physical injuries. The effect of edible coating treatments on the

firmness of cape gooseberries stored at lower temperature was found to be significant ($p<0.05$), as shown in Figure 1b. Firmness of cape gooseberry fruit i.e. at 5 days of storage period, was observed lesser in untreated fruits (5.45 N/g), whereas higher firmness was noticed in cape gooseberry fruit treated with T1 (9.21N/g) Apparently, at end of the storage the higher firmness was retained in cape gooseberry fruit treated with T1 and T5 as compared to that of other treatments as well as control set of fruit. This is in agreement with Zapata *et al.* [24] who explained that the firmness retention in coated fruit could be due to a reduction in pectinesterase and polygalacturonase enzymatic activities, which are responsible for depolymerization or shortening of chain length of pectin substances at the cell wall and thus degradation of insoluble proto-pectins to the more soluble pectins and pectic acid. Low oxygen and high carbon dioxide concentrations reduce the activities of these enzymes and allow retention of the firmness during storage [25]. Hence, results of present study aptly support the findings by Pandey *et al.* [26] who reported that the composite edible coatings preserve the quality of fruits, retard ethylene emission and enhance texture. Rao *et al.* [27] also reported that the polysaccharide-based sodium alginate composite coating delays the decline of firmness of ber fruit compared to that of the control.

Enzymes involved in pectin degradation, are closely related to changes in pectins, which play an important role in the softening changes in fruit and vegetable tissues [28]. The dramatic changes associated with the pectin contents can be accredited to the reality that pectin is most subject to enzymatic changes and shows the highest water solubility among the polysaccharides during ripening and storage [29].

There was a significant ($p<0.05$) change in activity of PG of coated cape gooseberries as shown in Figure 2a. In the present study, the activity of PG enzyme of freshly harvested cape gooseberries was 0.0045 U/mg protein. On the 10^{th} day of the storage period the significant results were noticed in treated fruits. The activity of untreated cape gooseberry fruit was 0.08 U/mg protein, whereas the activity was lower in fruits treated with T1 and T3 (i.e. 0.04 U/mg protein and 0.043 U/mg protein). The interpretation is given by Yaman and Bayoindirli [30] supports the results of the present study. According to these authors, the low oxygen and high carbon dioxide concentrations reduces the activity of enzymes and allows retention of the firmness of fruits during storage. In this study, the relatively lower activities of PG and PL in the xanthan gum coated fruits contributed to the enhanced retention of firmness during storage.

Data presented in Figure 2b shows the activity of PL form 0 day to the end of the storage period. The activity of PL enzyme on 0 days (freshly harvested cape gooseberries) of storage period was 0.0041 U/mg protein. On the 5^{th} day of the storage period, the activity of the enzyme was noticed higher in untreated fruits (0.020 U/mg protein), whereas the lower activity was noticed in fruits treated with T1 and T2 (i.e. 0.017 U/mg protein and 0.018 U/mg protein respectively). As explained by Conforti and Zinck [31], the increases in senescence most likely speeds up the metabolic process which in turn may increase the activity level of the endogenous pectin-degrading enzymes.

Effect of Coatings on Bioactive Compounds of Cape gooseberry Fruit during its Storage at Low Temperature

Carotenoids

Carotenoids are one type of plant pigments responsible for the yellow color of the fruit. They contribute to the major nutritional value of cape gooseberry fruit. As the color index and maturity increase with storage and ripening, the amount of carotenoid accumulation also increase [32]. The statistical analysis showed that edible coating had a significant ($p<0.05$) effect on carotenoids of cape gooseberries during the storage period

(Table 3). In the present study, the level of carotene in cape gooseberry fruit was noticed to increase up to some extent and then started to decline towards the end of the storage period as presented in Table 3. Nevertheless, more amount of carotene was retained in the treated cape gooseberry fruit as compared to that of the untreated fruit of cape gooseberry. The amount of carotene in freshly harvested cape gooseberry fruit was 0.07 µg/g. The higher amount was observed in fruits treated with xanthan gum (0.5%) was 0.072 µg/g, whereas its amount in control fruits was 0.058 µg/g only. Guar gum and xanthan gum were effective in maintaining the quality of carotene in cape gooseberry fruit at low temperature storage. Similarly Saha *et al.* [7] also reported that persimmon fruit coated with 1% guar gum exhibit more retention of carotene as compared to that of the uncoated persimmon fruit.

TPC

There was a significant change in TPC content of coated cape gooseberries ($p<0.05$), as shown in Table 3. Phenolic compounds are beneficial compounds mainly found in fruits and vegetables. They have been implicated in the reduction of degenerative diseases in human beings, primarily because of their antioxidant potential. Phenols have been reported to exhibit antioxidant activity [33], and it is well known that total phenolic compounds contribute to fruit quality and nutritional value by modifying color, taste, aroma, and flavor and also by providing beneficial health effects. In the present study as shown in Table 3, the content of phenols in the treated as well as untreated fruits, were found to get increased during the early storage days and then decreased subsequently. Treated fruits showed a higher amount of phenols as compared to that of the untreated fruits indicating the positive effects of xanthan gum and guar gum. Among all the treatments, the fruits coated with T3 showed higher level of phenols, i.e., 0.959 mg/g on 5^{th} days of storage period. As predictable, throughout the storage period, the least amount of phenolics was noticed in the control fruits. In addition, as guar gum contains a higher amount of phenols, it helped in enhancing the level of phenols in cape gooseberry fruits and therefore, extended their shelf life. The decreasing of phenolic compounds at the end of storage might be due to the breakdown of cell structure so as to senescence phenomena during storage [34]. Similarly, Carvalho *et al.* [35] noticed that the edible coating of sodium alginate preserves the total phenolic and carotenoid content during cold storage of cape gooseberries.

Ascorbic Acid

Ascorbic acid one of the most important nutritional quality factors is present in plant tissues undergoing active growth and development. It is easily oxidized, especially in aqueous solutions, and greatly favored by the presence of oxygen and the losses are enhanced by extended storage, higher temperature, low relative humidity, physical damage and chilling injury [36]. As the results of the present study revealed that the retention of the ascorbic acid content was extremely affected by the treatment with edible coating solutions and storage time. Although the ascorbic acid content of both coated as well as control samples decreased throughout their storage, the use of xanthan gum and guar gum coatings have significantly ($P < 0.05$) reduced the loss of the ascorbic acid content in cape gooseberry fruit (Table 3). The higher amount of ascorbic acid was noticed in fruits treated with T1 and T5 (i.e. 201.25 mg $100g^{-1}$ and 322.91 mg $100g^{-1}$) on 15^{th} days of storage period, whereas 125.62 mg $100g^{-1}$ amount was noticed in uncoated fruits. Similar ascorbic acid levels were previously indicated for cape gooseberry fruit [2]. These results revealed that at the end of the storage, amongst all of the coatings, the xanthan gum (0.5%) coating was showing potential of retaining of ascorbic acid at a higher level.

Effect of Coatings on Postharvest Shelf Life

During the course of the present study, the protective role of the composite coatings along with the olive oil could be observed in reducing the decay incidence and extending the shelf life of cape gooseberry fruit. Among all the treatments, the treatment T1 (Xanthan gum) was the best in maintaining the quality, whereas the T2, T3 and T4 showed the significant effect of decay control. Coating of xanthan gum (T1) extended the shelf life up to 9 days as compared to that of the uncoated fruit which had shelf life up to 17 days only. In this regard, Guilbert *et al.* [37] explained that an edible coating act as a barrier to the external elements (factors such as moisture, oil and vapor) and thus protect the product and extend the shelf-life. Maftoonazad and Ramaswamy [38] also stated that the coating slows down the respiration rate, reduces the color changes of skin and flesh and increases the shelf life of fruits. Baraiya *et al.* [39] also reported the advantage of xanthan gum coating enriched with olive oil in prolongation of the postharvest life of the grapes stored at low temperature.

CONCLUSION

During the course of the present study, the coating of xanthan gum and guar gum incorporated with olive oil had prolonged the shelf life with better quality than that of the control fruit. Delayed increase in TSS and total sugars suggest that the xanthan gum (T1), as a preservative material, could delay the ripening process by slowing down the respiration and metabolic rate in cape gooseberry fruit. Moreover, the use of guar gum was effective on TPC of cape gooseberries. Furthermore, xanthan gum alone and with olive oil not only extended the storage life of cape gooseberry fruit but also retained their firmness along with the activity of cell wall softening enzymes during their storage and delayed the ripening process. The best effect on quality maintenance was achieved with the xanthan gum alone with a carrier of olive oil. Therefore, the composite coating of xanthan gum enriched with olive oil is promising as a composite edible coating to be used to enhance the shelf life and quality of cape gooseberry fruit.

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Table-1: Formulations of edible coatings for cape gooseberry fruit

Coating treatments	Xanthan Gum (%)	Guar Gum (%)	Olive Oil (%)
T1	0.5	----	-----
T2	----	0.5	----
T3	0.25	0.25	----
T4	0.5	----	0.2
T5	----	0.5	0.2
T6	0.25	0.25	0.2
C	----	----	----

Table-2: Effect of edible coatings on TSS and Total sugars of cape gooseberry fruit stored at low temperature (10 ± 1˚C)

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
Treatments			**Total soluble solids (°Brix)**			
T1	0.733±0.058^{d}	1.467±0.058^{ab}	1.200±0.000^{d}	0.900±0.000^{d}	1.50±0.00^{b}	2.00±0.00^{a}
T2	0.733±0.058^{d}	1.500±0.100^{a}	1.600±0.000^{bc}	1.533±0.058^{bc}	1.50±0.17^{b}	0.000±0.000
T3	0.733±0.058^{d}	1.333±0.115^{abc}	1.700±0.000^{b}	1.500±0.265^{bc}	1.90±0.00^{a}	1.83±0.38^{ab}
T4	0.733±0.058^{d}	1.300±0.000^{bc}	1.533±0.058^{c}	1.433±0.058^{c}	1.20±0.00^{c}	1.60±0.00^{ab}
T5	0.733±0.058^{d}	1.200±0.000^{c}	1.067±0.058^{d}	1.700±0.000^{abc}	1.13±0.12^{c}	1.53±0.06^{b}
T6	0.733±0.058^{d}	1.500±0.000^{a}	1.300±0.100^{b}	1.800±0.100^{ab}	0.000±0.000	0.000±0.000
C	0.733±0.058^{d}	1.500±0.000^{a}	1.900±0.000^{a}	1.900±0.000^{a}	0.000±0.000	0.000±0.000
Treatments			**Total Sugars (mg g^{-1})**			
T1	64.61±0.092	70.58±5.010^{g}	60.26±4.76^{g}	46.83±12.93^{g}	28.02±2.17	9.23±0.24^{b}
T2	64.61±0.092	93.32±12.33^{d}	73.23±5.11^{b}	67.48±9.88^{d}	35.71±0.94	0.000±0.000
T3	64.61±0.092	73.33±4.945^{f}	78.91±26.63^{f}	72.01±25.05^{e}	29.43±0.94	12.42±0.88^{a}
T4	64.61±0.092	76.63±10.31^{e}	72.92±2.82^{c}	89.31±28.40^{a}	35.61±1.87	11.52±1.71^{ab}
T5	64.61±0.092	99.05±37.42^{c}	77.32±15.44^{d}	84.14±4.82^{b}	12.13±2.02	12.79±1.09^{a}
T6	64.61±0.092	106.9±3.789^{b}	77.24±17.01^{e}	75.99±4.53^{c}	0.000±0.000	0.000±0.000
C	64.61±0.092	108.6±41.92^{a}	77.82±2.27^{a}	64.98±5.05^{f}	0.000±0.000	0.000±0.000

Values are mean ± standard deviation, n = 3. Values within treatments with different letters (a–d) in a column differ significantly ($P \leq 0.05$) with values from higher to lower.

Table-3: Effect of edible coatings on Carotenoid, TPC and Ascorbic acid of cape gooseberry fruit stored at low temperature (10 ± 1˚C)

	Day 0	Day 5	Day 10	Day 15	Day 20	Day 25
Treatments			**Carotenoids (μ g^{-1} FW)**			
T1	0.07±0.00	0.072±0.0008^{a}	0.055±0.003^{ab}	0.03±0.00^{b}	0.035±0.0005^{b}	0.031±0.002^{a}
T2	0.07±0.00	0.044±0.003^{d}	0.041±0.000^{e}	0.03±0.00^{b}	0.040±0.0001^{a}	0.000±0.000
T3	0.07±0.00	0.063±0.004^{bc}	0.047±0.000^{d}	0.04±0.00^{b}	0.042±0.0015^{a}	0.037±0.005^{ab}
T4	0.07±0.00	0.050±0.002^{d}	0.052±0.001^{bc}	0.05±0.00^{a}	0.032±0.0006^{b}	0.028±0.003^{b}
T5	0.07±0.00	0.067±0.001^{ab}	0.058±0.001^{a}	0.03±0.00^{b}	0.040±0.0017^{a}	0.024±0.006^{b}
T6	0.07±0.00	0.065±0.0009^{b}	0.052±0.000^{c}	0.03±0.00^{b}	0.000±0.000	0.000±0.000
C	0.07±0.00	0.058±0.0007^{c}	0.044±0.002^{de}	0.03±0.01^{b}	0.000±0.000	0.000±0.000
Treatments			**TPC (mg g^{-1})**			
T1	0.60±0.02^{d}	0.80±0.02^{b}	0.906±0.213^{ab}	0.749±0.059^{b}	0.882±0.066^{a}	0.982±0.078^{a}
T2	0.60±0.02^{d}	0.75±0.05^{b}	0.785±0.061^{abc}	0.551±0.027^{c}	0.842±0.123^{a}	0.000±0.000
T3	0.60±0.02^{d}	0.96±0.08^{a}	0.662±0.050^{bcd}	0.548±0.035^{d}	0.622±0.010^{b}	0.872±0.017^{a}
T4	0.60±0.02^{d}	0.86±0.03^{ab}	0.712±0.017^{bc}	0.789±0.177^{b}	0.652±0.030^{b}	0.805±0.120^{a}
T5	0.60±0.02^{d}	0.81±0.02^{b}	0.471±0.030^{d}	0.759±0.084^{b}	0.662±0.036^{b}	0.394±0.095^{b}
T6	0.60±0.02^{d}	0.72±0.09^{b}	0.585±0.049^{d}	0.996±0.391^{a}	0.000±0.000	0.000±0.000
C	0.60±0.02^{d}	0.76±0.02^{b}	1.023±0.175^{a}	0.591±0.053^{c}	0.000±0.000	0.000±0.000
Treatments			**Ascorbic acid (mg100g g^{-1})**			
T1	567.3±4.16^{a}	454.4±77.0^{ab}	325.0±5.3^{b}	201.3±3.8^{c}	210.4±14.5^{b}	236.9±13.5^{a}
T2	567.3±4.16^{a}	503.8±6.0^{a}	381.7±6.6^{a}	256.5±6.0^{b}	164.4±8.1^{c}	0.000±0.000
T3	567.3±4.16^{a}	304.2±70.2^{c}	256.3±10.3^{c}	131.5±5.6^{de}	109.0±10.5^{d}	95.8±31.8^{c}
T4	567.3±4.16^{a}	295.8±3.1^{c}	198.1±3.3^{d}	191.0±4.5^{c}	157.7±10.5^{c}	78.8±1.7^{c}
T5	567.3±4.16^{a}	121.7±80.1^{d}	387.7±5.6^{a}	322.9±2.5^{a}	267.5±6.0^{a}	188.3±1.0^{b}
T6	567.3±4.16^{a}	423.8±45.9^{abc}	189.6±3.1^{d}	136.7±0.4^{d}	0.000±0.000	0.000±0.000
C	567.3±4.16^{a}	323.3±3.0^{bc}	198.1±3.3^{d}	125.6±0.6^{e}	0.000±0.000	0.000±0.000

Values are mean ± standard deviation, n = 3. Values within treatments with different letters (a–d) in a column differ significantly ($P \leq 0.05$) with values from higher to lower.

Figure-1: Effect of edible coatings on (a) Physiological loss of weight (PLW) and (b) firmness of cape gooseberry fruit stored at low temperature (10 ± 1 ℃). Values are mean ± standard deviation, n = 3. Values within treatments with different letters (a–d) in a column differ significantly ($P \leq 0.05$) with values from higher to lower.

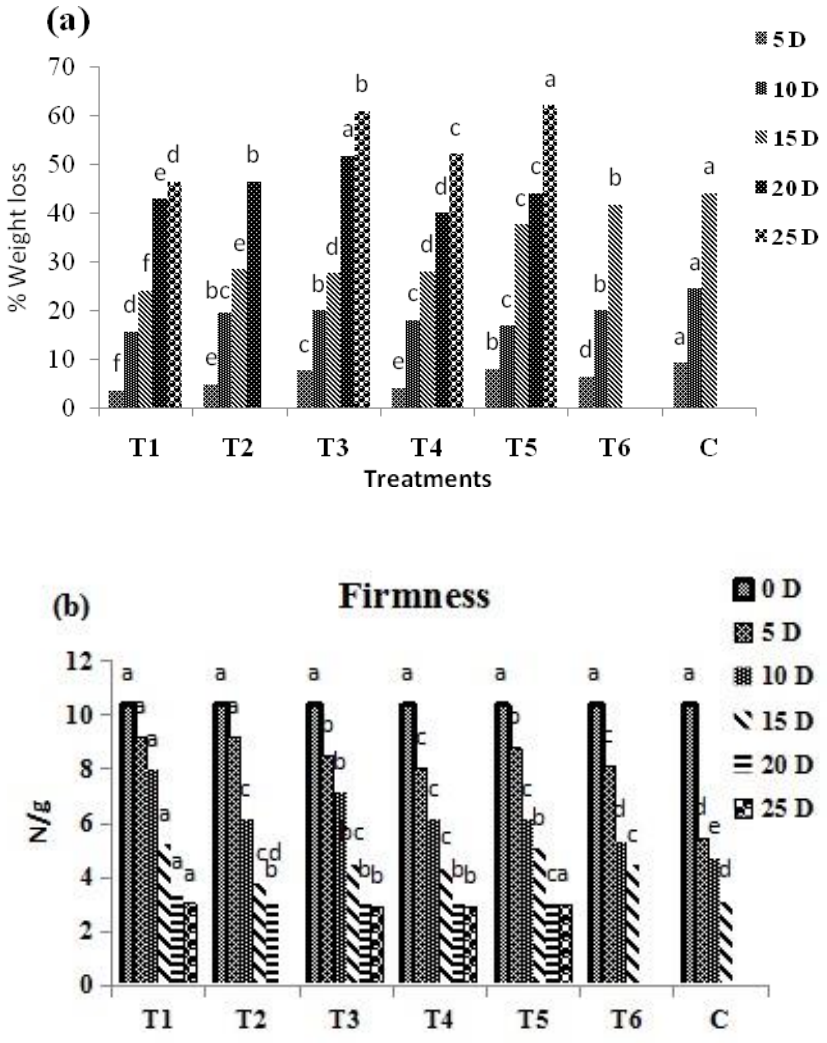

Figure-2: Effect of edible coatings on activity of (a) PG and (b) PL of cape gooseberry fruit stored at low temperature (10 ± 1 ℃). Values are mean ± standard deviation, n = 3. Values within treatments with different letters (a–d) in a column differ significantly ($P \leq 0.05$) with values from higher to lower.