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Influence of Edible Coatings to Enhance the Postharvest Quality of Passion Fruit (*Passiflora edulis* Sims.) under Cold Storage conditions

***Mohamed Jassim J.*[1*]*, Prem Joshua J.*[2*]*, Saraswathy S.*[3]*, Muthuramalingam S.*[4]*, Anitha T.*[5] *and Vani V.*[5]**

[1]*PG Scholar, Department of Fruit Science,*
Horticultural College and Research Institute, Periyakulam, TNAU (Tamil Nadu), India.
[2]*Professor, Horticultural Research Station (HRS), Pechiparai, Kanyakumari (Tamil Nadu), India.*
[3]*Professor and Head, Department of Fruit Science,*
Horticultural College and Research Institute, Periyakulam, TNAU (Tamil Nadu), India.
[4]*Assistant Professor, Department of Fruit Science,*
Horticultural College and Research Institute, Periyakulam, TNAU (Tamil Nadu), India.
[5]*Assistant Professor, Department of Postharvest Technology,*
Horticultural College and Research Institute, Periyakulam, TNAU (Tamil Nadu), India.

(Corresponding author: Mohamed Jassim J.)*
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ABSTRACT: The postharvest quality of passion fruit deteriorates rapidly because of intense physiological metabolism and serious water loss which leads to shrinkage in passion fruit. In this context, the experiment was carried out to evaluate the effect of edible coatings *Aloe vera* gel (50 %, 75 %), Gum arabic (10 %, 15 %), Chitosan (1 %, 2 %), Sodium alginate (1 %, 2 %) and Carboxy methyl cellulose (1 %, 1.5 %) to enhance the postharvest quality of passion fruit under cold storage (8±1 °C) conducted at Horticultural College and Research Institute, Periyakulam, Theni. Results indicated that the passion fruit coated with chitosan (2 %) recorded minimum weight loss (19.53 %) and maximum titratable acidity (3.68 %), ascorbic acid (19.81 mg 100 g^{-1}), firmness (15.21 N) and shelf life of about 26.5 days compared to control. Consequently, Chitosan (2 %) is effective for extending the shelf life and maintaining the postharvest quality of passion fruit at 8±1°C by regulating water loss and physiological metabolism.

Keywords: Passion fruit, cold storage, *Aloe vera* gel, Gum arabic, Chitosan, Sodium alginate and Carboxy methyl cellulose.

INTRODUCTION

Passion fruit (*Passiflora edulis* Sims.) is a native of Brazil in the Tropical American region and it belongs to the Passifloraceae family. It was first introduced to India in the early twentieth century in the Nilgiris, Coorg and Malabar regions of Southern India. It is generally grown in tropical and subtropical regions of the world, ranging from South America to Australia, Asia, and Africa. Recently, Passion fruit is under cultivation in an area of 12.0 thousand ha in India, with a production of 76.0 thousand MT (NHB, 2020). It is a woody, climbing, perennial vine that bears round or ovoid fruits. The rind of the fruits is stiff, smooth, and waxy, with a faint, small white flecks. The fruit has an orange pulpy liquid with a high quantity of small, firm, dark brown to black pitted seeds (Tripathi, 2018).

Fruits are almost round to oval in shape, with a strong peel that is smooth and waxy and weighs approximately 60 to 80 g in purple passion fruit and bear on woody perennial vines (Thokchom & Mandal 2017). The juice taste is delicious, has great flavour and have an excellent source of Vitamin A (1300-2500 IU 100 g^{-1} pulp), vitamin C (30–50 mg 100 g^{-1} pulp), and minerals like potassium, sodium, magnesium, sulphur, and chlorides are abundant in fruits. Passion fruit is high in natural phenolic compounds, which have been shown to protect against oxidative damage (Joy and Divya 2016).

Postharvest quality of passion fruit is mostly determined by harvest time and storage conditions. Moisture loss, peel colour darkening, microbial infection and nutritional loss are the main causes of postharvest degradation. These are the factors which contribute to the unappealing appearance of fresh fruits, which include wrinkles, unappealing colour, postharvest deterioration and nutritional deficiency. It is classified physiologically as climacteric fruit due to its respiratory properties, ethylene production, climacteric increase and specific responses. Its quality and appearance decline over time and the fruit begins to dehydrate shortly after harvest. During ripening, an increase in respiration rate is driven by a high level of ethylene production. The fruit becomes unmarketable as a result of this degradation. Appropriate storage temperature and postharvest treatment are critical aspects in maintaining the quality of diverse horticulture commodities, as well as prolonging storage life while ensuring product safety.

After harvesting, fruit losses are estimated at around 18 to 28 %. The losses will then continue to grow throughout the trading process. Applying an edible coating to the fruit can help to reduce postharvest losses (Nor and Ding 2020). Fruit coating works on the same principle as modified atmosphere packaging, in which an altered atmosphere is formed in the headspace with high CO_2 content and a low O_2 concentration (Blakistone, 1999).

There are a variety of post-harvest coatings available for important fruits such as bananas, mangoes, pineapples, and avocados that can effectively extend the shelf-life, minimise water loss, reduce chilling damage and reduce post-harvest disease. Coatings for minor fruits such as durian, rambutan, passion fruit and mangosteen are still scarce and are done from lipid and protein-based coatings. Therefore, the current study was carried out to investigate the influence of edible coatings to enhance the postharvest quality of passion fruit.

MATERIALS AND METHODS

The present investigation was carried out at the Department of Postharvest Technology, Horticultural College and Research Institute, Periyakulam, Theni, Tamil Nadu - 625 604. Purple passion fruits were collected from one-year-old vines in Cumbum valley. Matured fruits were harvested at light purple to the purple colour rind and pulp had yellowish orange colour with black colour seeds. The average weight of the fruit is 60-80 g. The fruit has a higher juice content (38-48%) and a better flavour and scent as fresh, canned, or frozen juice or pulp than the yellow one. Within an hour after harvesting, fruits were kept in a pre-cooling room at 15° to remove the field heat. Fruits were cleaned with tap water using a Batch tub bubble washer and drying of water using a Dewatering drying conveyor. After drying, fruits were divided into eleven groups and each group had 10 fruits for postharvest treatments. Treatments were divided into T_1 (*Aloe vera* gel-50 %), T_2 (*Aloe vera* gel-75 %), T_3 (Gum Arabic-10 %), T_4 (Gum Arabic 15 %), T_5 (Chitosan 1 %), T_6 (Chitosan-2 %), T_7 (Sodium alginate 1 %), T_8 (Sodium alginate 2 %), T_9 (Carboxy methyl cellulose-1 %), T_{10} (Carboxy methyl cellulose-1.5 %) and T_{11} (Control). Then the fruits were dipped in edible coatings for five minutes. In each treatment, glycerol was added to act as a plasticizer. Coated fruits were dried for 1 hour at room temperature and stored in cold storage (8±1°) condition. The experiment was carried out in a completely randomized design with three replications and the observations on physicochemical parameters were taken once in five days.

Physiological loss in weight (%). The weight loss of the fruits was measured once in five days. Using the formula, the physiological weight loss was estimated. It was given as a percentage (Aboud, 1974).

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

Firmness (N). Fruit Hardness Tester (Model: FR-5120) with plunger was used to determine the firmness of Passion fruit (diameter- 11mm). The firmness of the fruit was expressed as Newtons.

Total soluble solids (°brix). A digital Hand-held Pocket refractometer was used to quantify the passion fruit total soluble solids (TSS) (Model: PAL-3). TSS was expressed as ºBrix.

Titratable acidity (%). Titratable acidity of the passion fruit was determined by following the method given by Ranganna, (1986). It was calculated by using the below formula and represented as a percentage (%).

$$\text{Titratable acidity (\%)} = \frac{T \times N \times E \times V_1}{V_2 \times W} \times 100$$

Where,

T- Titre value, V_1= Volume made up, N= Normality of NaOH, V_2= Volume of extract taken for estimation, E= Equivalent weight of citric acid, W= Weight of a sample taken for estimation.

Ascorbic acid (mg 100 g^{-1}). The oxalic acid titration method was used to determine ascorbic acid (Sadasivam and Balasubramaniam 1987). The following formula was used to determine it, and it was given as mg 100g^{-1}.

$$\text{Ascorbic acid (mg 100 g}^{-1}\text{)} = \frac{0.5\text{ mg} \times V_2 \times 100}{V_1 \times 15\text{ ml} \times \text{wt. of the sample}} \times 100$$

Where,

V_1- Dye factor value,

V_2- Titre value.

Shelf-life (days). The shelf life of passion fruit was determined by the number of days the pulp remained palatable and free of browning. Freshness was determined by the fruit's visual appearance, such as colour, shrinkage index, pathogenic decay degree, and juiciness, among other factors. (Nanda *et al*., 2001)

Statistical analysis. The experiment was carried out in a completely randomized design (CRD) with eleven treatments and three replications. The results obtained were subjected to analysis of variance (ANOVA) at a $P< 0.05$ level of significance using AGRES software (Panse and Sukhatme 1967).

RESULT AND DISCUSSION

A. Physiological loss in weight (%)

Weight loss of passion fruit is mainly due to the consumption of nutrients and loss of water, which is caused by the strengthening of respiration and transpiration (Zhang *et al*., 2019). On Day 5, the minimum weight loss was observed at 4.90 % in T_6 (Chitosan-2 %) and the control sample reaches a maximum weight loss of 10.68 %. The weight loss of passion fruit shows an upward trend during cold storage and minimal weight loss was observed in T_6 (19.53 %) and the control group reaches a weight loss of as high as 33.63 % on Day 25 (Table 1). Similar results were found on bananas, where the highest weight loss of 22 % was observed in the control sample and the lowest weight loss of 10% was found in the sample coated with chitosan 2% (Suseno *et al*., 2014). Slower rates of weight loss in chitosan-coated fruits can be attributed to the barrier properties for gas diffusion of stomata, the organelles that regulate the transpiration process and gas exchange between the fruit and the environment (Maftoonazad and Ramaswamy 2005).

Table 1: Influence of edible coatings on Physiological loss in weight (%), Firmness (N) and Shelf life of passion fruit during cold storage.

Treatments	Physiological loss in weight (%)					Firmness (N)					Shelf life (Days)
	5 Days	10 Days	15 Days	20 Days	25 Days	5 Days	10 Days	15 Days	20 Days	25 Days	Mean
T_1	6.70	9.79	11.96	15.89	22.34	41.03	36.32	25.20	17.24	-	23.00
T_2	6.02	9.69	11.23	14.13	21.84	41.70	37.65	25.45	18.87	13.97	25.25
T_3	7.68	10.66	13.78	18.78	27.24	39.35	35.35	24.03	-	-	20.50
T_4	7.20	10.02	12.21	16.34	23.24	40.05	35.67	24.70	-	-	22.50
T_5	6.90	9.89	12.01	16.23	22.76	40.92	35.84	24.82	19.13	-	23.25
T_6	4.90	7.64	8.97	12.18	19.53	43.11	39.98	27.25	20.98	15.21	26.50
T_7	7.52	10.32	12.45	16.89	25.06	39.13	34.53	23.21	-	-	20.25
T_8	7.41	10.29	12.34	16.45	23.86	39.76	35.52	24.32	-	-	22.00
T_9	8.50	10.96	14.05	19.23	30.48	38.89	33.94	22.75	-	-	19.25
T_{10}	7.56	10.43	12.56	17.98	26.43	39.05	34.23	23.01	-	-	21.00
T_{11}	10.68	13.45	16.05	21.58	33.63	37.68	31.21	18.89	-	-	18.00
Mean	7.37	10.29	12.51	16.88	25.13	40.06	35.48	23.97	19.05	14.59	21.95
SE (d)	0.135	0.254	0.292	0.385	0.654	0.431	0.362	0.233	0.180	0.116	0.486
CD (0.05)	0.281**	0.528**	0.606**	0.799**	1.356**	0.894**	0.751**	0.483**	0.373**	0.242**	1.008**

*- significant at ($p< 0.05$); **-significant at ($p< 0.01$)

Firmness (N). Softening is one of the major factors affecting the quality of fruits during storage. It is normally due to starch hydrolysis to sugar and the degradation of cell walls which is involved in fruit ripening (Guerreiro *et al*., 2015). The firmness of passion fruit in each group continuously decreases with the extension of storage time (Table 1). The firmness of the control fruit decreases from the initial value of 40.06 N to the final value of 14.59 N, which proves that its edible value is completely lost. Whereas, the maximum fruit firmness from the initial value (43.11 N) to the 25th day (15.21) was recorded on T_6 (Chitosan-2 %) and the minimum firmness observed in T_{11} (control) initial value of 37.68 N to 18.89 N. Softening is due to the catabolic activity of polygalacturonase (PG) and pectin methylesterase (PME) enzymes during ripening, leading to degradation of middle lamella between parenchyma cells, cell wall disruption, and loss of cellular turgidity (Harker *et al*., 2010). Shah and Hashmi (2020) reported that all mango fruits were softened during storage. However, the chitosan-coated fruit softened to a lesser extent.

Titratable acidity (%). The rate of reduction in acidity increased with the increased storage period. The reduction in acidity during storage is probably due to the catabolism of citrate and malate and the pace of catabolism increases with the storage period (Sammi and Masud 2007). Fig. 1 shows that titratable acidity of passion fruit decreases with an increased storage period. On Day 5, the higher titratable acidity was found on 4.86 % in T_6 (Chitosan-2 %), compared to control with 4.05 %. On the 25th day, the titratable acidity was reduced to 3.68 % in T_6 (Chitosan-2 %). It was thought that the reason for this slower decrease in titratable acidity in the chitosan-coated fruits could be due to the reduction of organic acid use in respiration through chitosan acting as a barrier (Nabifarkhani *et al*., 2015).

Ascorbic acid (mg 100 g^{-1}). As shown in Fig. 2, the ascorbic acid content of passion fruit in each group showed a downward trend with an increased storage period, among which the control group decreases the fastest. There is a significant difference between coated and control fruit. The ascorbic acid content of passion fruit decreased from 28.30 to 19.81 mg 100 g^{-1} as in T_6 (Chitosan-2 %) (Fig. 1). Whereas, control fruit decreases faster with an increased storage period from 19.60 to 8.31 mg 100 g^{-1} (Fig. 1). According to Zhou *et al*. (2008), the decrease in ascorbic acid is influenced by the oxygen content that can degrade ascorbic acid oxidase and phenol oxidase during storage, thus decreasing the ascorbic acid content of the fruit. It is thus logical to suggest that chitosan coating reduced O_2 availability, limited oxidation of compounds and limited the generation of free radicals at the surface of passion fruit.

Shelf-life (Days). An increase in shelf life was due to better cell wall integrity because calcium infusion had thickened calcium pectate in the cell wall. The shelf life of coated passion fruits stored under cold storage conditions was shown in Table 1.

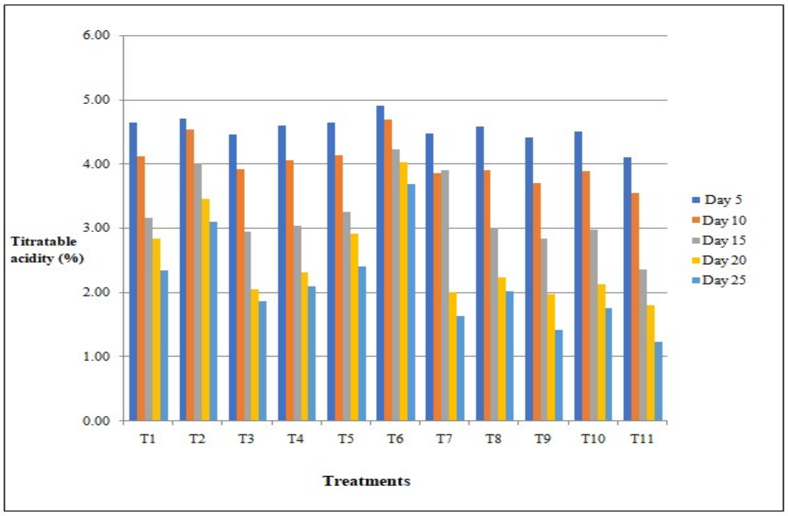

Fig. 1. Influence of edible coatings on Titratable acidity (%) of passion fruit during cold storage.

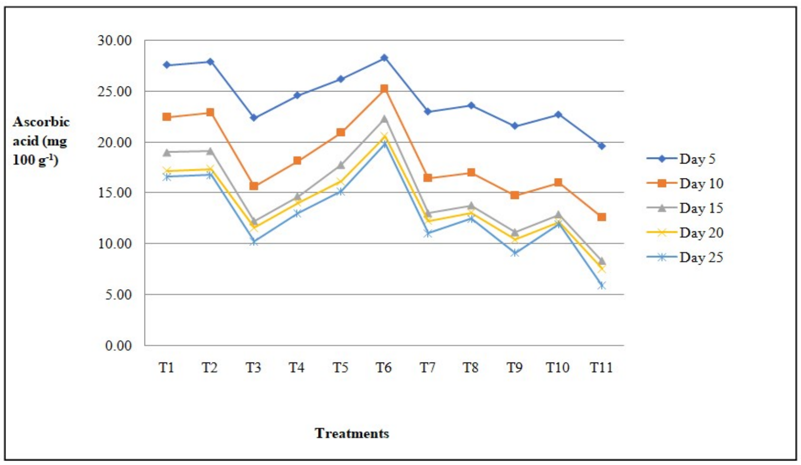

Fig. 2. Influence of edible coatings on Ascorbic acid (mg 100 g^{-1}) of passion fruit during cold storage.

Maximum shelf life of 26.5 days after storage was recorded in T_6 (Chitosan-2 %) followed by T_2 (*Aloe vera* gel-75 %) had 25.25 days whereas control samples had eighteen days. Trevino *et al*. (2015) revealed that Chitosan (1.5 %) coated strawberry fruits increased the shelf life from 6 days (control) to 15 days (coated fruits).

CONCLUSION

The synergistic effect of postharvest edible coatings and cold storage conditions significantly influenced the physiological loss in weight, firmness, titratable acidity, ascorbic acid and shelf life. Compared to all the treatments, passion fruit coated with chitosan (2 %) up to 25 days recorded minimum weight loss (19.53 %), maximum titratable acidity (3.68 %), Ascorbic acid (19.81 mg 100 g^{-1}) and firmness (15.21 N). Maximum shelf life of 26.5 days was also observed in Chitosan (2 %) treated fruits compared to control which had a minimum shelf life of about eighteen days.

FUTURE SCOPE

For future prospects, chitosan edible coating with polyethylene packaging techniques will enhance the postharvest quality of passion fruit compared to coatings alone.

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Author contributions. All authors equally contributed.
Conflict of interest. None.

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