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Gum-based Composite Edible Coatings Maintained the Postharvest Quality of Peach Cv. Early Grande Fruits under Refrigerated Storage

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ABSTRACT

Background: Peaches are highly perishable in nature and have a short life so an experiment was conducted to assess the suitability of xanthan and guar gum-based composite edible coatings on prolonging shelf life and quality of peach fruits.

Methods: Fruits were dipped in different concentrations of xanthan gum (1.0% and 1.5%) and guar gum (1.0% and 1.5%) supplemented with or without calcium gluconate @ 1.5% and ascorbic acid @ 1.0% and stored at a refrigerated temperature of 10°C for 20 days. Physiological loss in fruit weight, firmness, shrinkage, decay, total soluble solids, pH, titratable acidity, ascorbic acid, total sugars, carotenoids content, phenolic content and antioxidant capacity were determined at every 5days intervals until fruits became unmarketable.

Result: The results of the periodic physicochemical and functional quality analysis of stored peach fruits indicated that the application of xanthan gum-based coating in combination with calcium gluconate as a texture enhancer and ascorbic acid as an anti-oxidant was more effective than guar gum coatings on enhancing the shelf life. Among all coating formulations, 1.0% xanthan gum incorporated with 1.5% calcium gluconate and 1.0% ascorbic acid was found most effective in maintaining the overall quality of peach fruits for 20 days. The treatment also significantly reduced weight loss and firmness and preserved ascorbic acid, total carotenoid content, phenolic content and antioxidant capacity as compared to control uncoated peach fruits.

Key words: Edible coatings, Guar gum, Peach, Postharvest quality, Xanthan gum.

INTRODUCTION

Peach [*Prunus persica* (L.) Batsch.] is one of the most delectable stone fruits grown in temperate and sub-tropical regions of the world. It can be grown in lower elevations where most of the other temperate fruits do not succeed (Chanana, 2006). Peach is a popular fruit worldwide because of its nutritional value, pleasant flavour, aroma and acceptable sugar-to-acid ratio. Peaches contain relatively good amounts of proteins, carbohydrates, ascorbic acid, vitamins and minerals in comparison to the majority of other common stone fruits and are used for table purposes (Sharma *et al*., 2002). Peach production in India is confined to mid hills of the Himalayas at an elevation of 1500-2000 msl and in plains it performs well at an altitude ranging from 240-450 m (Rana *et al*., 2006). Peaches are highly perishable fruits and huge postharvest losses (28-30%) occur at different stages of handling, right from harvesting to sale in retail markets (Singh *et al.,* 2017) due to increase rate of respiration and ethylene production during maturity to ripening stages.

Low chill cultivars of peach have gained popularity and their cultivation is confined to subtropical areas of north India including Uttar Pradesh, Uttarakhand, Punjab and Haryana (Pathak and Pathak, 2001). Many postharvest applications have been tested over the years to extend the storage life of peach fruits due to their perishable nature. An edible coating (*Aloe vera* gel, xanthan gum, guar gum, Arabic gum, sodium alginate *etc*) provides an additional protective coating to fresh fruits and vegetables and also provides the same effect as modified atmosphere in modifying the internal gas composition. It also acts as a natural barrier to moisture and oxygen, which are the main agents of deterioration of fruits and vegetables (Hazarika *et al*., 2023).

Gums are polysaccharides and are made up of polymer chains, with excellent gas barrier properties. Xanthan gum is a major bacterial polysaccharide authorized by the U.S.

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Food and Drug Administration for application as food additives (stabilizer and emulsifier) without any restrictions (Ghashghaei *et al*., 2016) in the food industry. It is produced by a wide range of bacteria of the genus *Xanthomonas* commercially from *Xanthomonas campestris* during aerobic fermentation (Leela and Sharma, 2000; Habibi and Khosravi, 2017). Guar gum is also a polysaccharide and natural edible thickening agent extracted from the endosperm of guar bean (*Cyamopsis tetragonolobus*) (Perchyonok *et al*., 2016). Ascorbic acid is a potent reducing agent and scavenger of free radicals in biological systems (Duarte and Lunec, 2005) and involved in first line of antioxidant defense. Calcium gluconate as a texture enhancer was added to coating solution to maintain firmness during storage (Hernandez-Munoz *et al*., 2008). So, keeping all these in views, an experiment was conducted to assess the suitability of xanthan and guar gum-based composite edible coatings on prolonging shelf life and quality of peach cv. Early Grande.

MATERIALS AND METHODS

Preparation of sample

Fruits of 'Early Grande' peach (*Prunus persica* L.) were harvested at commercial maturity from an orchard located at Horticultural Research Centre, Patharchatta, Pantnagar and immediately transferred to Post harvest laboratory of Department of Horticulture at G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India. Infested and injured fruits were sorted out and healthy fruits were uniformly graded. Fruits were washed with tap water to remove any adhered dust and dirt. They were air-dried and kept for coating treatments.

Preparation of edible coating formulations

Xanthan gum solutions @ 1% and 1.5% (w/v) were prepared by dissolving 2 g and 3 g of xanthan gum in 200 ml of distilled water, respectively. Calcium gluconate @ 1.5% and ascorbic acid @ 1% (w/v) was also incorporated in the same solutions as per treatment formulations. The solution was then constantly agitated using a magnetic stirrer (Make Biogen Scientific, Model BGS-169) for 30 minutes and then sterilized in hot pan for 10 minutes.

Coating applications

Peach fruits were coated with two concentrations of xanthan gum (1 and 1.5% XG) and guar gum (1 and 1.5% GG) coating alone and in combinations with calcium gluconate (CG) @1.5% and ascorbic acid (AA) @ 1.0%, *viz*., 1.0% XG(T_1); 1.0% XG + 1.5% CG (T_2); 1.0% XG + 1.0% AA (T_3); 1.0% XG + 1.5% CG+1.0% AA (T_4); 1.5% XG (T_5); 1.5% XG + 1.5% CG (T_6); 1.5% XG + 1.0% AA (T_7); 1.5% XG + 1.5% CG+1.0% AA (T_8); 1.0% GG (T_9); 1.0% GG + 1.5% CG (T_{10}); 1.0% GG + 1.0% AA (T_{11}); 1.0% GG + 1.5% CG+1.0% AA (T_{12}); 1.5% GG (T_{13}); 1.5% GG + 1.5% CG (T_{14}); 1.5% GG + 1.0% AA (T_{15}); 1.5% GG + 1.5% CG+1.0% AA (T_{16}) and Control (T_{17}). The trial was carried out in three replicates. One set of 8 fruits per replication per treatment was taken for coating and dipped into coating solutions for 1 minute and excess gum was removed from the fruits with the help of soft brush and surface dried under fan thereafter. Treated fruits of every replication packed in corrugated fibre boxes (9×6×3 inches) of one kg capacity and stored at 10°C and 75% RH for 20 days in a cooling chamber. Fruits were analyzed for various physico-chemical and functional quality attributes at 0, 5, 10, 15 and 20 days of harvest.

Physico-chemical and functional quality observations

Physiological loss in weight (PLW) in both treated and untreated fruits was determined initially on zero days and then at specific intervals for each treatment and the results is expressed as a percentage of weight loss at every interval compared to the initial fresh weight of zero-day of harvest. On the basis of the number of fruits spoiled (unfit for human consumption) at every five-day interval, the per cent decay was worked out and the spoiled fruits were removed.

TSS was recorded by using a digital hand refractometer (Make: Macro Scientific Works, Model MSW 503) at room temperature and expressed in terms of degree brix. Titratable acidity in terms of maleic acid was determined by titrating the juice with 0.1 N NaOH using phenolphthalein as an indicator. Ascorbic acid expressed in terms of mg ascorbic acid/100 g of juice was determined as per the method described in Ranganna (1986).

The total phenolics content (mg GAE/g fresh weight) in the pulp of fruit was determined using the Folin-Ciocalteu reagent (Singleton *et al*., 1999). Total antioxidant capacity was determined following the CUPRAC (Cupric reducing antioxidant capacity) assay (Apak *et al*., 2008) and results were expressed as grams of Trolox equivalents (TEs) per kilogram of fresh weight ($gTEkg^{-1}$).

Carotenoid content was estimated by using the method of Sumanta *et al*. (2014). The homogenized sample mixture was centrifuged at 10000 rpm for 15 minutes at 4°C (Make: REMI, Model: CM-12 Plus). The supernatant was separated and 0.5 ml of it was mixed with 4.5 ml of 95% ethanol. The solution mixture was analyzed for Chlorophyll-a (Ca), Chlorophyll-b (Cb) and carotenoid content in a spectrophotometer (2206PC-Based Double Beam Uv-VIS Spectrophotometer).

Statistical analysis

The experiments were laid out in two factorial (coating treatments and storage intervals) completely randomized design having three replications and eight fruits per replications. Data was analyzed according to the procedure given by Snedecor and Cochran (1987). The overall significance of differences among the treatments was tested using critical difference (C.D.) at 5% level of significance. The data was presented through Tables and Figure.

RESULTS AND DISCUSSION

Coating effects on fruit quality

Physiological loss in weight

Physiological loss in weight (PLW) increased significantly with the advancement of storage irrespective of the treatments (Table 1). It increased slowly in the beginning but as the storage period progressed, the rate of PLW was at higher pace. Mean PLW was increased from 1.82% to 11.53% as the storage period extended from day 5 to 20 days. 1.0% Xanthan gum coating combined with 1.5% calcium gluconate and 1.0% ascorbic acid (T_4) results in the lowest mean PLW (4.11%) followed by T_7 *i.e.* 1.5% XG + 1.0% AA (4.35%) while uncoated control fruits showed highest mean PLW (7.14%) at the end of storage period. Guar gum coatings alone @ 1.0% were found more effective as compared to their composite coating formulations. Coating the peach fruit with xanthan gum-based coatings was found to be clearly effective in conferring a barrier to moisture loss as compared to non-treated ones. The results were in close conformity with Sohail *et al*. (2015) where weight loss in untreated peach fruits was significantly greater than that of coated fruits. Adetunji *et al*. (2014) also observed retention of weight in xanthan gum treated papaya fruit.

Fruit decay

Fruit decay was significantly influenced by all the treatments and was increased with an increase in storage period. Minimum fruit decay of 8.56 % was found in T_4 (1.0% xanthan gum + 1.5% calcium gluconate + 1.0% ascorbic acid) followed by 9.48% in T_7 (1.5% xanthan gum + 1.0% ascorbic acid) while it was increased to 28.05% in uncoated fruits on 20th day of storage (Table 1, Plate 1 and Plate 2). No decay was observed until the 10th day of storage in xanthan gum coating treatments of T_4, T_5, T_7 and T_8 and guar gum coatings of T_9 and T_{12} as compared to 7.42% decay in control uncoated fruit.

Among guar gum coating's formulations, guar gum coating alone @ 1.0% with 13.08% (T_9) decay was found

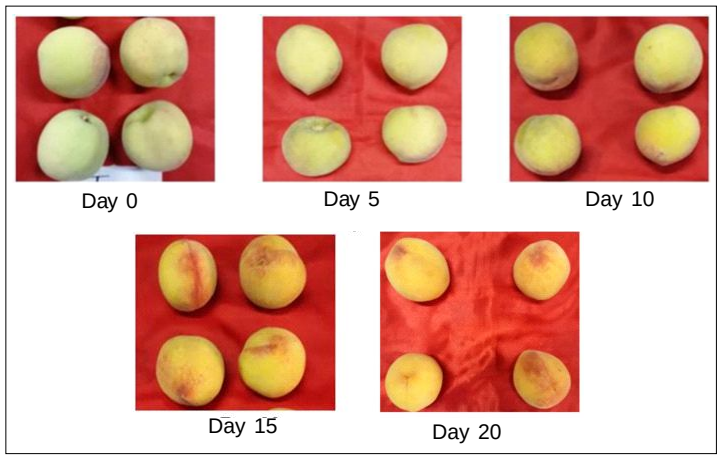

Plate 1: Peach fruits as influenced by coating with 1.0% Xanthan gum + 1.5% Calcium gluconate + 1.0% Ascorbic acid (T_4) under low temperature storage condition.

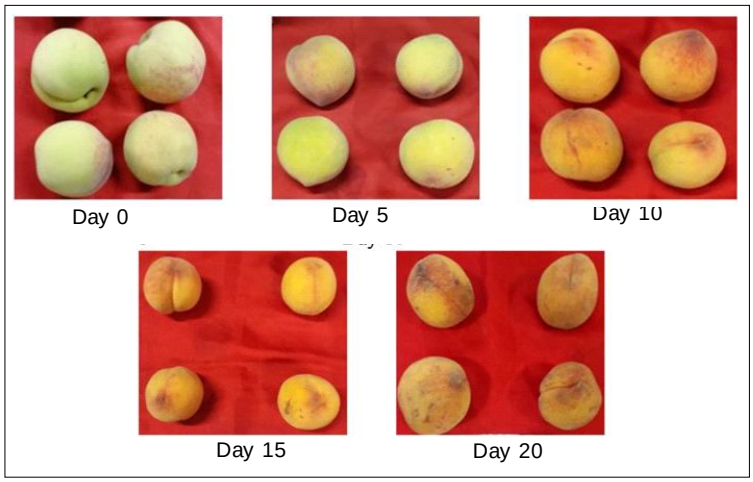

Plate 2: Uncoated peach fruits i.e. control (T_{17}) under low temperature storage condition.

Table 1: Effect of edible coatings on percent physiological loss in fruit weight and decay of peach fruits during low temperature storage.

Quality attributes	Physiological loss in fruit weight (%)						Decay (%)					
Coating treatments	Storage intervals (days)					Mean	Storage intervals (days)					Mean
	0	5	10	15	20		0	5	10	15	20	
T_1:1.0% XG	0.00	1.72	4.79	8.08	10.56	5.03	0.000	0.000	4.81	11.18	20.48	7.29
T_2:1.0% XG + 1.5% CG	0.00	1.67	4.63	7.27	9.92	4.70	0.000	0.000	3.24	9.64	18.23	6.22
T_3:1.0% XG + 1.0% AA	0.00	1.71	5.20	7.72	10.41	5.01	0.000	0.000	4.62	10.20	20.16	7.00
T_4:1.0% XG + 1.5% CG+1.0% AA	0.00	1.16	3.23	6.80	9.36	4.11	0.000	0.000	0.00	3.21	8.56	2.35
T_5:1.5% XG (T_5)	0.00	2.34	4.08	6.84	9.45	4.54	0.000	0.000	0.00	4.26	11.10	3.07
T_6:1.5% XG + 1.5% CG	0.00	1.78	4.87	8.75	10.93	5.27	0.000	0.000	4.88	11.46	22.26	7.72
T_7:1.5% XG + 1.0% AA	0.00	1.25	3.56	6.94	9.98	4.35	0.000	0.000	0.00	3.38	9.48	2.57
T_8:1.5% XG + 1.5% CG+1.0% AA	0.00	1.59	4.32	7.14	9.80	4.57	0.000	0.000	0.00	4.50	11.54	3.21
T_9:1.0% GG	0.00	1.76	4.88	8.79	11.06	5.30	0.000	0.000	0.00	5.11	13.08	3.64
T_{10}:1.0% GG + 1.5% CG	0.00	2.02	6.30	10.77	13.08	6.43	0.000	0.000	6.48	12.52	25.44	8.89
T_{11}:1.0% GG + 1.0% AA	0.00	2.23	7.27	11.83	13.86	7.04	0.000	0.000	6.86	13.65	26.62	9.43
T_{12}:1.0% GG+1.5% CG+1.0% AA	0.00	1.53	5.18	10.12	11.71	5.71	0.000	0.000	0.00	6.50	15.06	4.31
T_{13}:1.5% GG	0.00	1.91	4.75	10.50	12.47	5.93	0.000	0.000	5.48	12.12	21.58	7.84
T_{14}:1.5% GG + 1.5% CG	0.00	1.91	5.46	9.59	12.41	5.88	0.000	0.000	5.12	11.50	22.12	7.75
T_{15}:1.5% GG + 1.0% AA	0.00	1.71	6.72	11.59	13.44	6.69	0.000	0.000	5.54	12.26	24.30	8.42
T_{16}:1.5% GG+1.5% CG+1.0% AA	0.00	2.14	6.97	12.43	13.59	7.03	0.000	0.000	6.20	13.05	25.12	8.87
T_{17}: Control	0.00	2.42	7.40	11.94	13.96	7.14	0.000	0.000	7.42	14.23	28.05	9.94
Mean	0.00	1.82	5.27	9.24	11.53		0.000	0.000	3.57	9.34	19.01	
Factors		CD at 5%			SE (m)			CD at 5%			SE (m)	
Treatments (T)		0.249			0.089			0.184			0.066	
Storage intervals(S)		0.135			0.048			0.100			0.036	
Interaction (T × DS)		0.557			0.199			0.412			0.148	

Where, XG= Xanthan gum; GG= Guar gum; CG= Calcium gluconate; AA= Ascorbic acid.

Table 2: Effect of edible coatings on total soluble solids and titratable acidity of peach fruits during low temperature storage.

Quality attributes	Total soluble solids (%)						Acidity (%)					
Coating treatments	Stoage intervals (days)					Mean	Storage intervals (days)					Mean
	0	5	10	15	20		0	5	10	15	20	
T_1:1.0% XG	9.35	9.53	10.03	11.12	12.75	10.56	0.81	0.76	0.65	0.50	0.36	0.62
T_2:1.0% XG + 1.5% CG	9.35	9.53	9.91	10.95	12.64	10.48	0.81	0.80	0.68	0.51	0.36	0.63
T_3:1.0% XG + 1.0% AA	9.35	9.53	9.92	11.03	12.67	10.50	0.81	0.78	0.66	0.50	0.34	0.62
T_4:1.0% XG + 1.5% CG+1.0% AA	9.35	9.49	9.81	10.81	12.33	10.36	0.81	0.78	0.70	0.58	0.46	0.67
T_5:1.5% XG (T5)	9.35	9.51	9.88	10.87	12.47	10.41	0.81	0.76	0.67	0.53	0.44	0.64
T_6:1.5% XG + 1.5% CG	9.35	9.56	10.49	11.73	13.29	10.89	0.81	0.82	0.68	0.51	0.35	0.63
T_7:1.5% XG + 1.0% AA	9.35	9.50	9.87	10.85	12.38	10.39	0.81	0.80	0.71	0.57	0.40	0.66
T_8:1.5% XG + 1.5% CG+1.0% AA	9.35	9.53	9.89	10.92	12.59	10.47	0.81	0.75	0.65	0.50	0.38	0.62
T_9:1.0% GG	9.35	9.53	10.06	11.17	12.82	10.58	0.81	0.80	0.68	0.50	0.41	0.64
T_{10}:1.0% GG + 1.5% CG	9.35	9.55	10.35	11.63	13.20	10.81	0.81	0.78	0.64	0.44	0.36	0.61
T_{11}:1.0% GG + 1.0% AA	9.35	9.58	10.61	12.05	13.74	11.06	0.81	0.77	0.63	0.40	0.30	0.58
T_{12}:1.0% GG+1.5% CG+1.0% AA	9.35	9.53	10.17	11.21	12.84	10.62	0.81	0.81	0.68	0.49	0.36	0.63
T_{13}:1.5% GG	9.35	9.54	10.27	11.49	12.95	10.73	0.81	0.79	0.65	0.43	0.33	0.60
T_{14}:1.5% GG + 1.5% CG	9.35	9.53	10.20	11.41	12.90	10.68	0.81	0.78	0.67	0.49	0.37	0.62
T_{15}:1.5% GG + 1.0% AA	9.35	9.55	10.38	11.53	13.05	10.77	0.81	0.76	0.62	0.43	0.35	0.59
T_{16}:1.5% GG+1.5% CG+1.0% AA	9.35	9.57	10.40	11.68	13.20	10.84	0.81	0.80	0.67	0.46	0.34	0.62
T_{17}: Control	9.35	9.58	10.57	11.97	13.60	11.02	0.81	0.77	0.63	0.40	0.31	0.58
Mean	9.35	9.54	10.17	11.32	12.91		0.81	0.78	0.66	0.49	0.37	
Factors		CD at 5%			SE (m)			CD at 5%			SE (m)	
Treatments (T)		0.070			0.025			0.010			0.004	
Storage intervals (S)		0.038			0.014			0.005			0.002	
Interaction (T × DS)		0.157			0.056			0.022			0.008	

Where, XG= Xanthan gum; GG= Guar gum; CG= Calcium gluconate; AA= Ascorbic acid.

Table 3: Effect of edible coatings on ascorbic acid and total carotenoid content (µg/100g)of peach fruits during low temperature storage.

Quality attributes	Ascorbic acid (mg/100 g)						Total carotenoid content (µg/100 g)					
Coating treatments	Storage intervals (days)					Mean	Storage intervals (days)					Mean
	0	5	10	15	20		0	5	10	15	20	
T_1:1.0% XG	6.67	6.14	5.58	4.60	3.15	5.23	140.24	144.48	150.32	157.96	148.20	148.24
T_2:1.0% XG + 1.5% CG	6.67	6.19	5.71	4.86	3.58	5.40	139.86	143.94	150.72	159.58	151.44	149.11
T_3:1.0% XG + 1.0% AA	6.67	6.22	5.68	4.74	3.39	5.34	140.94	146.26	151.30	157.12	148.26	148.78
T_4:1.0% XG + 1.5% CG+1.0% AA	6.67	6.46	6.16	5.34	4.24	5.78	141.88	146.76	151.90	159.97	161.78	152.46
T_5:1.5% XG (T_5)	6.67	6.33	6.02	5.27	4.09	5.68	142.85	145.92	151.48	158.53	149.18	149.59
T_6:1.5% XG + 1.5% CG	6.67	6.08	5.46	4.40	2.94	5.11	140.28	145.12	150.15	157.27	146.06	147.78
T_7:1.5% XG + 1.0% AA	6.67	6.49	6.17	5.31	4.16	5.76	142.16	146.24	152.32	158.48	160.52	151.94
T_8:1.5% XG + 1.5% CG+1.0% AA	6.67	6.35	6.01	5.21	3.91	5.63	139.94	144.82	151.70	158.76	149.94	149.03
T_9:1.0% GG	6.67	6.15	5.56	4.36	2.86	5.12	140.67	145.42	151.30	158.18	147.04	148.52
T_{10}:1.0% GG + 1.5% CG	6.67	5.97	5.22	3.92	2.34	4.83	139.77	143.46	148.64	157.20	146.06	147.03
T_{11}:1.0% GG + 1.0% AA	6.67	6.07	5.13	3.63	2.03	4.70	139.54	142.12	148.12	156.36	138.21	144.87
T_{12}:1.0% GG+1.5% CG+1.0% AA	6.67	6.02	5.46	4.36	2.88	5.08	138.45	144.33	150.24	158.18	147.12	147.66
T_{13}:1.5% GG	6.67	5.92	5.28	4.06	2.52	4.89	140.14	145.02	150.14	157.24	145.32	147.57
T_{14}:1.5% GG + 1.5% CG	6.67	6.11	5.36	4.25	2.76	5.03	140.07	144.46	149.22	155.54	146.81	147.22
T_{15}:1.5% GG + 1.0% AA	6.67	6.09	5.39	4.14	2.59	4.97	140.22	144.45	149.58	156.42	145.24	147.18
T_{16}:1.5% GG+1.5% CG+1.0% AA	6.67	6.03	5.25	3.93	2.33	4.84	140.16	144.24	149.18	154.02	140.42	145.60
T_{17}: Control	6.67	6.08	5.18	3.78	2.06	4.75	138.30	142.02	147.54	157.18	135.09	144.03
Mean	6.67	6.16	5.57	4.48	3.05		140.32	144.65	150.23	157.53	147.45	
Factors		CD at 5%			SE (m)			CD at 5%			SE (m)	
Treatments (T)		0.102			0.037			2.789			0.998	
Storage intervals(S)		0.056			0.020			1.513			0.541	
Interaction (T × DS)		0.229			0.082			6.237			2.232	

Where, XG= Xanthan gum; GG=Guar gum; CG= Calcium gluconate; AA=Ascorbic acid.

Table 4: Effect of edible coating on total phenolic content and total antioxidant activityof peach fruits during low temperature storage.

Quality attributes	Total phenolic content (mg GAE/g)						Total antioxidant activity (g TE kg^{-1})					
Coating treatments	Storage intervals (days)					Mean	Storage intervals (days)					Mean
	0	5	10	15	20		0	5	10	15	20	
T_1:1.0% XG	0.80	0.73	0.63	0.50	0.42	0.61	1.40	1.28	0.95	0.60	0.29	0.91
T_2:1.0% XG + 1.5% CG	0.80	0.79	0.72	0.63	0.57	0.70	1.40	1.25	0.98	0.66	0.33	0.92
T_3:1.0% XG + 1.0% AA	0.80	0.74	0.66	0.55	0.47	0.64	1.40	1.25	0.97	0.63	0.31	0.91
T_4:1.0% XG + 1.5% CG+1.0% AA	0.80	0.80	0.75	0.69	0.65	0.74	1.40	1.32	1.12	0.84	0.51	1.04
T_5:1.5% XG (T_5)	0.80	0.76	0.71	0.65	0.60	0.70	1.40	1.28	1.04	0.73	0.40	0.97
T_6:1.5% XG + 1.5% CG	0.80	0.76	0.65	0.52	0.42	0.63	1.40	1.25	0.94	0.59	0.34	0.90
T_7:1.5% XG + 1.0% AA	0.80	0.78	0.74	0.68	0.64	0.73	1.40	1.31	1.10	0.80	0.48	1.02
T_8:1.5% XG + 1.5% CG+1.0% AA	0.80	0.77	0.71	0.63	0.58	0.70	1.40	1.27	1.02	0.70	0.36	0.95
T_9:1.0% GG	0.80	0.73	0.65	0.55	0.49	0.64	1.40	1.27	0.98	0.65	0.32	0.92
T_{10}:1.0% GG + 1.5% CG	0.80	0.76	0.64	0.49	0.41	0.62	1.40	1.25	0.88	0.51	0.28	0.87
T_{11}:1.0% GG + 1.0% AA	0.80	0.76	0.63	0.47	0.40	0.61	1.40	1.20	0.86	0.50	0.26	0.84
T_{12}:1.0% GG+1.5% CG+1.0% AA	0.80	0.78	0.69	0.59	0.52	0.68	1.40	1.25	0.95	0.61	0.30	0.90
T_{13}:1.5% GG	0.80	0.76	0.66	0.52	0.41	0.63	1.40	1.25	0.92	0.56	0.29	0.88
T_{14}:1.5% GG + 1.5% CG	0.80	0.78	0.67	0.54	0.43	0.65	1.40	1.24	0.93	0.58	0.29	0.88
T_{15}:1.5% GG + 1.0% AA	0.80	0.74	0.65	0.50	0.42	0.62	1.40	1.24	0.90	0.54	0.28	0.87
T_{16}:1.5% GG+1.5% CG+1.0% AA	0.80	0.76	0.64	0.48	0.40	0.62	1.40	1.27	0.87	0.50	0.27	0.86
T_{17}: Control	0.80	0.75	0.61	0.44	0.40	0.60	1.40	1.26	0.86	0.48	0.22	0.85
Mean	0.80	0.76	0.67	0.56	0.48		1.40	1.26	0.96	0.62	0.33	
Factors		CD at 5%			SE (m)			CD at 5%			SE (m)	
Treatments (T)		0.013			0.005			0.019			0.007	
Storage intervals(S)		0.007			0.003			0.011			0.004	
Interaction (T × DS)		0.030			0.011			0.044			0.016	

Where, XG= Xanthan Gum; GG=Guar gum; CG= Calcium gluconate; AA=Ascorbic acid.

more effective as compared to other guar gum-based formulations. Almost twice of fruits decayed between 15 and 20 days of storage period irrespective of treatments. Asghar *et al*. (2014), Wani *et al.* (2021), Naveed *et al*. (2024) and Gull *et al.* (2024) reported similarly that xanthan gum coated fruits showed lowest decay incidence as compared to both uncoated control fruits irrespective of the applied concentration.

Total soluble solids and acidity

TSS concentrations in all treatments increased slowly till the 10th day from 9.35% on the zero day to 9.58% on the 10th day (Table 2) but it was increased at a faster rate in most of the treatments except T_4 and T_7. An increase in TSS could be attributed to the enzymatic conversion of higher polysaccharides such as starches and pectin into simple sugars during ripening (Hussain *et al.*, 2008). Gull *et al.* (2024) also observed that the TSS content increased throughout the storage period but diminished under the influence of xanthan coatings. Kumar *et al.* (2021) observed similar response in mango fruit coated with xanthan gum, in which a reduced increase in TSS was observed.

The titratable acidity of peach fruits declined slowly in xanthan gum-coated fruits (T_4) and was greatest in the uncoated samples (Table 2). Studies revealed that acidity in all the treatments reduced slowly until the 10th day of storage and thereafter declined at a faster rate. On the 20th day of storage, edible coating of T_4 and T_7 maintained the maximum acidity level of 0.46 and 0.40, respectively as compare to 0.31% in control uncoated fruits. Gupta *et al.* (2011) and Asghar *et al.* (2014) also observed maintenance of higher titratable acidity in coated peach fruits while it reduced to minimum in control fruits.

Ascorbic acid

The data displayed on Table 3 showed that coated treatments significantly reduced the deterioration rate of ascorbic acid content throughout the storage as compared to uncoated control fruits. The ascorbic acid content of peach decreased from 6.67 to 2.06 in uncoated fruits while it was merely reduced to 4.24 in the best-performing coating treatment of T_4 (1.0% xanthan gum + 1.5% calcium gluconate + 1.0% ascorbic acid). Gull *et al.* (2024) and Bajaj *et al.* (2024) also reported similar performance where XG-coated fruits showed the minimum ascorbic acid loss in guava and kinnow fruits, respectively whereas the non-coated fruits showed the maximum loss in ascorbic acid content. Higher ascorbic acid content in the xanthan gum composite-coated fruits could be attributed to the modification of the atmosphere around the fruit's surface which may have regulated the oxygen flow and suppressed the conversion of ascorbic acid into dehydroascorbic acid (Gol *et al.,* 2016).

Total carotenoid content (µg/100 g)

Coating treatments had a significant effect on the total carotenoid content of fruits and were significantly influenced by all the treatments as well as by storage days. Data in Table3 revealed that mean carotenoid content progressively increased from 140.32 µg/100 g on the initial day to 157.53 µg/100 g on the 15th day of storage; thereafter it tended to decrease in most of the treatments. Xanthan gum-based coating treatments T_4 and T_7 exhibited an increasing pattern of carotenoid content upto the 20th day while the carotenoid content increased only upto the 15th day in other treatments and thereafter declined. This may be attributed to the increased activity of various enzymess like polyphenol oxidase and polyglacturonase with the advancement in storage that might be responsible for the breakdown of carotenoids. These results were in agreement to the earlier findings of Navjot and Gurcharan (2006) that carotenoid content was higher in xanthan and guar gum-coated fruits as compared to uncoated fruits.

Total phenolic content (mg GAE/g) and total antioxidant activity (g TE kg^{-1})

The data revealed that retention of both phenolic content and antioxidant activity of peach fruits decreased progressively irrespective of the treatments with the advancement of storage period (Table 4). Xanthan gum coating treatment T_4 had higher retention of phenolic content *i.e.* 0.80 mg GAE/g on an initial day to 0.65 mg GAE/g on 20th day of storage which was *at par* with 0.64 mg GAE/g in T_7 treatment while in control uncoated fruits phenolic content reduced to 0.40 mg GAE/g. These results were with following the earlier findings of Ghasemnezhad *et al*. (2010) and Kumar *et al.* (2023) that the total phenolic content in all coated fruits was significantly higher and reduced the degradation of phenolic content of fruit synergistically as compared to control.

The data mentioned in Table 4 revealed that the antioxidant activity of peaches was significantly influenced by all the treatments as well as storage days. All xanthan gum coating formulations showed better retention of antioxidant activity as compared to gum coating and control uncoated fruits. Xanthan gum coating treatment T_4 retained maximum antioxidant activity (0.51 g TEkg^{-1}) followed by T_7 (0.48 g TE kg^{-1}) as compared to only 0.22 g TE kg^{-1} in control (T_{17}) at the 20th day of storage. The decline in antioxidant activity of fruit samples might have been due to decay and senescence at the end of storage period. These findings were in full agreement with the earlier findings of Sogvar *et al*. (2016) who had studied the effect of Aloe vera and ascorbic acid coatings and reported increased antioxidant capacity of coated fruits than control fruits. Similar findings were reported by Wani *et al*. (2021) and Totad *et al.* (2019) that xanthan gum coatings retained higher antioxidants in coated strawberries and blueberries, respectively during their postharvest storage.

CONCLUSION

From the overall physico-chemical and functional attributes of fruits, it was observed that xanthan gum and guar gum

coatings exerted a positive effect on the shelf life of peach fruits. Uncoated control peach fruits showed a shelf life of only 10 days at low temperatures while shelf life extended to double for 20 days in the case of xanthan gum and 15 days for guar gum coated fruits. Based on findings of the investigation, it is concluded that surface coating of peach fruits with 1.0% xanthan gum incorporated with calcium gluconate @ 1.5% as texture enhancer and ascorbic acid @ 1.0% as an antioxidant was found most promising in controlling the weight loss, persevering physico-chemical and functional quality attributes and also diminishing decay to a greater extent throughout the storage period up to 20 days and thereby maintained the quality and doubled the shelf life.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish or preparation of the manuscript.

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