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Effect of Sodium Benzoate, *Aloe vera* Gel and *Nigella sativa* Oil on the Physiological and Biochemical Activities in the Aril Browning of Pomegranate (*Punica granatum* L.) cv. 'Bhagwa'

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A B S T R A C T

Based on the results obtained from a series of experiments with edible coating treatments, the best treatment from each experiment was tested again in different combinations on the arils of pomegranate fruit variety 'Bhagwa'. The combined treatments contained Sodium benzoate, *Aloe vera* gel and *Nigella sativa* oil in different combinations to find out their individual and combined effect on the physiological and biochemical activities of pomegranate arils during low temperature storage at 4˚C. Significant differences were observed in the physiological and biochemical activities of pomegranate arils when they were treated with different edible coatings. Among the treatments, pomegranate arils coated with sodium benzoate 400 ppm in combination with *Aloe vera* gel 30% and *Nigella sativa* oil 200 ppm recorded significantly lowest physiological loss in weight and spoilage of arils, whereas, significantly highest content of TSS, total sugars, reducing and non-reducing sugars were observed apart from significant increase in the contents of ascorbic acid, total anthocyanins and finally increased antioxidant activity on all the days of observations recorded during storage.

Introduction

Pomegranate (*Punica granatum* L.) is considered as the 'fruit of paradise' and 'elixir of life' is a rich source of minerals, vitamins and nutrients. It is one of the choicest tablefruits grown in the tropical and sub-tropical regions of the world . Pomegranate fruits are large in size , round in shape and the fruit is called 'balusta' , whereas aril is the edible material. In the recent years, minimally processed ready-to-eat pomegranate arils have become very popular due to their convenience in carrying, high value, unique sensory characteristics and health benefits. Scientific evidence has linked an increase in the consumption of pomegranate arils to improve the human health as a result of presence of active phenolic compounds in the arils which have potent pharmacological activities including anti-oxidant and anti-mutagenic properties. Keeping all these facts in view the present investigation was proposed to find out the influence of individual as well as different

combinations of edible coatings with Sodium benzoate 400 ppm, *Aloe vera* gel 30% and *Nigella sativa* oil 200 ppm on the quality parameters by preventing or reducing the malady of browning of arils which is associated with the physiological and biochemical activities in pomegranate arils. Composite edible coatings have shown positive effects in reducing the browning and microbial spoilage of pomegranate arils apart from increasing the shelf life of fresh pomegranate arils.

Materials and Methods

The present investigation was conducted at Postharvest Technology Laboratory, Horticultural College and Research Institute, V. R. Gudem during the year 2015-16. The fruits of pomegranate cv. 'Bhagwa' procured from the farmer's field located at Dharmavaram village in the Ananthapuram district of Andhra Pradesh were used in the present investigation. Based on the results obtained from a series of experiments, the best treatment from each experiment was selected and combined together with other edible coating treatments either in two combination or three combination treatments along with individual treatments. Thus, the experiment comprised of eight treatments *viz.*, T_1: Pomegranate arils treated with sodium benzoate 400 ppm (SB 400), T_2: Pomegranate arils treated with *Aloe vera* gel 30% (AVG 30), T_3: Pomegranate arils treated with *Nigella sativa* oil 600 ppm (NS 600), T_4: Pomegranate arils treated with SB 400 + AVG 30, T_5: Pomegranate arils treated with SB 400 + NS 600, T_6: Pomegranate arils treated with AVG 30 + NS 600, T_7: Pomegranate arils treated with SB 400 + AVG 30 + NS 600, T_8: Control (no coating) with three replications in CRD. Well-developed good fruits with uniformity in size and free from the attack of pests and diseases were harvested from the field at right stage of maturity and brought to the laboratory with proper packing in CFB boxes. After unpacking, the fruits were kept overnight under open condition in the laboratory. On the next day morning, fruits were washed thoroughly under tap water and cleaned with dry cotton cloth. The arils were extracted manually after splitting the fruits with the help of sterilized knife. The entire process of aril extraction and packing were completed under hygienic conditions in the laboratory. The spoilage was determined based on the visual observation as shrivelling of the arils which led to fungal infection and subsequent rotting. The total soluble solids content of pomegranate arils was determined by using ERMA hand refractometer. A drop of juice obtained from arils was placed on the prism of the refractometer and observed the coincidence of shadow of sample by reading on the scale and expressed as °Brix (Ranganna, 1986). The percentage of reducing sugars content in the pomegranate aril juice was determined by Lane and Eyon method (AOAC, 1965). Ascorbic acid content in the pomegranate arils was determined as per the procedure outlined by Ranganna (1986). Total anthocyanins content in pomegranate aril juice was determined by adopting the procedure outlined by Harborne (1973). Antioxidant activity in the pomegranate arils was assessed by using the free radical DPPH method (Bond and Michel, 1997). The data were subjected to statistical analysis as per the procedure outlined by Panse and Sukhatme (1985).

Results and Discussion

Significant differences were observed in the physiological loss in weight (PLW) of pomegranate arils treated with different edible coating combination treatments and stored at a low temperature of 4˚C (Table 1). Significantly lowest PLW of pomegranate arils was observed with a combination of SB

400 + AVG 30 + NS 600 (1.022, 1.175, 1.234 and 1.336 respectively on day 8, 12 and 16) during storage. Control recorded significantly highest PLW (2.140, 3.745, 4.494 and 5.842 respectively on day 4, 8, 12 and 16) on all the days of observation recorded during storage.

The results obtained indicate that pomegranate arils coated with SB 400 + AVG 30 + NS 200 combination was found the best treatment in minimizing the physiological loss in weight compared to all other treatments on all the days of storage at a low temperature of 4˚C. Application of edible coating combined with *Aloe vera*, *Nigella sativa* oil and sodium benzoate 400 ppm showed a significant effect on the physiological loss in weight of pomegranate arils. The surface coatings used in this study showed a significant suppression of respiratory activity. From the data it was evident that application of surface coating in combination reduced the physiological loss in weight of pomegranate arils compared to the individual coating. The results obtained were found in confirmity with the earlier findings of Anany *et al.*, (2009) who reported a significant delay in weight loss of cold stored apple fruits coated with arabic gum compared to the uncoated. Sarkale *et al.*, (2003) reported significantly lowest physiological loss in weight of pomegranate fruits coated with a combination of Waxol (12%) + Calcium chloride (4%) + Carbendazim (0.1%) compared to control. Chauhan and Raju (2011) reported a significant reduction in the rate of respiration and a delay in the peak ethylene synthesis during low temperature storage of apple cut slices coated with shellac and *Aloe vera* gel in combination with citric acid (200 mg/kg), ascorbic acid (200 mg/kg) and sodium benzoate (200 mg/kg). The physiological loss in weight occurs essentially due to the process of transpiration and respiration (Krishnamurthy and Subramanyam, 1973). Cutting and peeling increases the physiological loss in weight of fresh commodities hence, the damage during the preparation should be lowered to extend the shelf-life of fresh commodities.

The changes in spoilage per cent of arils of pomegranate cv. 'Bhagwa' influenced by different edible coating combinations stored at a low temperature of 4˚C were presented in Table 1. Significant differences were observed among the treatments with respect to spoilage per cent of arils of pomegranate cv. 'Bhagwa'. Significantly lowest spoilage per cent of pomegranate arils was observed with SB 400 + AVG 30 + NS 200 (2.282, 2.625, 2.756 and 2.985 respectively on day 4, 8, 12 and 16) on all the days of observation recorded. Control recorded significantly highest spoilage per cent (4.780, 8.365, 10.038 and 13.049 respectively on day 4, 8, 12 and 16) on all the days of observation recorded. The results obtained indicate that pomegranate arils coated with SB 400 + AVG 30 + NS 200 was found the best coating treatment in minimizing the spoilage per cent compared to all other coatings on all the days of storage at 4˚C temperature. Banana fruits treated with a coating combination of chitosan1.5% + gibberellic acid 100 ppm, jojoba wax and glycerol (98%) showed lesser rate of decay percentage compared to the uncoated bananas (Neeta *et al.*, 2011). The present results were in confirmation with the above findings. Guilbert *et al.*, (1996) explained that an edible coating is a thin film prepared from edible material that act as a barrier to the external elements (factors like moisture, oil, vapour, etc.,) and thus protect the product and extend its shelf-life.

The changes in the data pertaining to TSS (˚Brix) of arils of pomegranate cultivar 'Bhagwa' influenced by different edible coating combinations and stored at a low temperature of 4˚C were presented in Table 2. Significant differences were observed among the treatments with respect to total soluble

solids content (˚Brix) in pomegranate arils. Arils treated with SB 400 + AVG 30 + NS 200 recorded significantly lowest values of total soluble solids (16.054 and 16.334 respectively on days 4 and 8) during the initial period of storage, whereas, significantly highest TSS content was recorded (16.743 and15.906 respectively on days 12 and 16) was observed during the later part of the storage period which might be due to slower rate of respiration during the entire period of storage when compared with all other treatments. Control recorded significantly highest TSS (16.298 and 16.583 respectively on days 4 and 8) content during the initial part of the storage period whereas, significantly lowest content of TSS (14.096 and 12.827 respectively on day 12 and 16) was observed during the later part of the storage period due to rapid rate of metabolic activity thereby spoilage of arils. The remaining all other treatments were found intermediate between these two treatments on all the days of observation recorded.

Total soluble solids content coated with SB 400 + AVG 30 + NS 200 steadily increased with passage of time up to day 12 and since then onwards decreased gradually. The trend was the same with other treatments, but the increase in the TSS content was only up to day 8 and then onwards a continuous decline in the TSS content was noticed till the end of storage period. The changes in TSS content were found much less with SB 400 + AVG 30 + NS 200 even with passage of time when compared with all other treatments. The results obtained indicate that pomegranate arils coated with SB 400 + AVG 30 + NS 200 was found the best coating in maintaining the TSS content without much variation in the treated arils compared to all other coatings on all days of storage at 4˚C temperature. Virgilio *et al.,* (2015) reported an extended shelf life of pear fruits with improved TSS content by coating the fruits with a combination of candelilla wax (3%), gum arabic (4%), jojoba oil (0.15%) and pomegranate polyphenols (0.015%). The present results were in confirmation with the above findings. Arils treated with SB 400 + AVG 30 + NS 200 recorded significantly lowest values of total soluble solids during the initial period of storage, whereas, significantly highest TSS content was recorded during the later part of the storage period which might be due to slower rate of respiration during the entire period of storage when compared with all other treatments. Randhawa (2009) also reported increased TSS (°Brix) content due to dehydration, but the decrease in TSS (°Brix) content at the end of the storage might be attributed to higher rate of fermentation as evidenced by the development of off- flavours.

The changes in titrable acidity of arils of pomegranate cv. 'Bhagwa' influenced by different edible coating combinations stored at a low temperature of 4˚C were presented in Table 2. The titrable acidity of pomegranate arils treated with different edible coating combinations was found decreased gradually with each successive interval of observation during storage period. Arils treated with SB 400 + AVG 30 + NS 200 coating recorded significantly lowest values of titrable acidity (0.452 and 0.459 respectively on day 4 and 8) during the initial period of storage whereas, significantly highest titrable acidity (0.469 and 0.448 respectively on day 12 and 16) was observed due to delayed metabolic changes and a slow conversion of organic acids to sugars during the entire period of storage when compared with all other treatments. Control recorded significantly highest titrable acidity (0.458 and 0.465 respectively on day 4 and 8) during the initial stage of storage period whereas, significantly lowest titrable acidity (0.403 and 0.371 respectively on day 12 and 16) during the later part of the storage period. Titrable acidity rapidly decreased in

control because of faster conversion of organic acids to sugars and spoilage of arils. Titrable acidity coated with SB 400 + AVG 30 + NS 200 steadily increased with passage of time up to day 12 and since then onwards decreased gradually. The trend was same with other treatments, but the increase in the titrable acidity was only up to day 8 and then onwards a continuous decline in the titrable acidity was noticed till the end of storage. The change in titrable acidity was found much less with SB 400 + AVG 30 + NS 200 even with the passage of time when compared with all other treatments. Results obtained indicate that pomegranate arils coated with SB 400 + AVG 30 + NS 200 was found the best coating in maintaining the titrable acidity compared to all other coatings on all the days of storage at 4˚C temperature. Garcia *et al.,* (1998) and Zhang and Quantick (1998) reported decreased titrable acidity with passage of time, but to a lesser extent than that of uncoated fruit with the application of chitosan or starch based coating in strawberries and kept under cold storage. The present results were in confirmation with the earlier findings of the above. The decrease in titrable acidity with passage of time in the packaged materials stored at a low temperature might be due to the fact that the packaging material results in capturing higher concentration of CO_2 (Vines and Obserbacher, 1961) which decreased the rate of respiration (Petracek *et al.,* 1998).

The changes in total sugars content of pomegranate arils influenced by different edible coating combinations and stored at a temperature of 4˚C were presented in Table 3. Significant differences were observed among different treatment combinations with respect to total sugars of arils of pomegranate. Arils treated with SB 400 + AVG 30 + NS 200 recorded significantly lowest values of total sugars (14.805 and 15.064 respectively on day 4 and 8) during the initial storage period whereas, significantly highest values of total sugars (15.440 and 14.668 respectively on day 12 and 16) was observed during the later part of the storage period when compared with all other treatments. Control recorded significantly highest total sugars (15.030 and 15.293 respectively on day 4 and 8) content during the initial part of the storage period whereas, significantly lowest total sugars content (12.999 and 11.829 respectively on day 12 and 16) was observed during the later part of the storage period which might be due to rapid rate of respiration and spoilage of arils.

The remaining all other treatments were found intermediate between these two treatments on all the days of observation recorded. Total sugars content coated with SB 400 + AVG 30 + NS 200 steadily increased with passage of time up to day 12 and since then onwards decreased gradually. The trend was the same with other treatments, but increase in the total sugars content was only up to day 8 and then onwards a continuous decline in the totals sugars content was noticed till the end of the experiment. The results obtained indicate that pomegranate arils treated with SB 400 + AVG 30 + NS 200 was found the best coating treatment in minimizing variation in the total sugars content compared to all other treatments on all the days of storage period.

Total sugars are considered as a good index for the determination of storage life. An increase in the content of total sugars was observed initially in both treated arils as well as untreated arils. However, throughout the storage period, arils coated with SB 400 + AVG 30 + NS 200 significantly delayed the sugars accumulation and showed lesser contents of sugars than that of other treatments as well as control.

Table.1 Effect of Sodium benzoate, *Aloe vera* gel and *Nigella sativa* oil combination of coatings on physiological loss in weight and spoilage of arils of pomegranate cv. 'Bhagwa' during storage

Treatments	PLW (%)				Spoilage (%)			
	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16
SB 400	1.926	3.371	4.045	5.258	4.302	7.529	9.034	11.744
AVG 30	1.914	3.349	4.019	5.224	4.274	7.480	8.976	11.669
NS 200	1.770	3.097	3.716	4.831	3.447	6.033	7.239	9.411
SB 400 + AVG 30	1.543	2.701	3.241	4.213	3.233	5.657	6.789	8.825
SB 400 + NS 200	1.447	2.533	3.039	3.951	2.856	4.998	5.998	7.797
AVG 30+ NS 200	1.296	1.543	1.666	1.824	2.896	3.446	3.722	4.075
SB 400 + AVG 30 + NS 200	1.022	1.175	1.234	1.336	2.282	2.625	2.756	2.985
Control	2.140	3.745	4.494	5.842	4.780	8.365	10.038	13.049
Mean	**1.590**	**2.592**	**3.058**	**3.889**	**3.396**	**5.515**	**6.819**	**8.259**
SEm ±	0.025	0.063	0.080	0.113	0.058	0.137	0.175	0.246
CD at 5%	0.078	0.193	0.248	0.350	0.178	0.421	0.539	0.758

SB - Sodium Benzoate 400 ppm; AVG - *Aloe vera* 30% gel; NS - *Nigella sativa* oil 200 ppm

Table.2 Effect of Sodium benzoate, *Aloe vera* gel and *Nigella sativa* oil combination of coatings on total soluble solids and titrable acidity of arils of pomegranate cv. 'Bhagwa' during storage

Treatments	TSS (°Brix)				Titrable acidity (%)			
	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16
SB 400	16.265	16.550	14.233	13.521	0.456	0.463	0.422	0.403
AVG 30	16.265	16.550	14.233	13.521	0.456	0.463	0.422	0.403
NS 200	16.217	16.500	14.850	14.108	0.456	0.464	0.406	0.389
SB 400 + AVG 30	16.184	16.467	15.150	14.392	0.455	0.462	0.429	0.410
SB 400 + NS 200	16.135	16.417	15.597	14.817	0.454	0.461	0.441	0.421
AVG 30+ NS 200	16.102	16.384	16.057	15.254	0.453	0.460	0.452	0.432
SB 400 + AVG 30 + NS 200	16.054	16.334	16.743	15.906	0.452	0.459	0.469	0.448
Control	16.298	16.583	14.096	12.827	0.458	0.465	0.403	0.371
Mean	**16.190**	**16.473**	**15.118**	**14.293**	**0.455**	**0.462**	**0.432**	**0.411**
SEm ±	0.006	0.006	0.015	0.012	0.001	0.001	0.005	0.006
CD at 5%	0.018	0.018	0.046	0.038	0.004	0.005	0.016	0.020

SB - Sodium Benzoate 400 ppm; AVG - *Aloe vera* 30% gel; NS - *Nigella sativa* oil 200 ppm

Table.3 Effect of Sodium benzoate, *Aloe vera* gel and *Nigella sativa* oil combination of coatings on total sugars and ascorbic acid of arils of pomegranate cv. 'Bhagwa' during storage

Treatments	Total sugars (%)				Ascorbic acid (mg/100 g)			
	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16
SB 400	15.022	15.285	13.145	12.488	9.016	9.946	8.954	7.654
AVG 30	15.000	15.262	13.126	12.469	9.013	9.959	8.963	7.887
NS 200	14.955	15.217	13.695	13.010	9.346	10.328	9.295	8.180
SB 400 + AVG 30	14.925	15.186	13.971	13.273	9.680	10.697	9.627	8.472
SB 400 + NS 200	14.880	15.140	14.383	13.664	10.014	11.065	9.959	8.764
AVG 30+ NS 200	14.850	15.110	14.807	14.067	10.348	11.900	11.662	10.345
SB 400 + AVG 30 + NS 200	14.805	15.064	15.440	14.668	11.176	12.284	12.292	10.679
Control	15.030	15.293	12.999	11.829	8.345	7.928	7.294	6.418
Mean	**14.920**	**15.182**	**14.060**	**13.283**	**9.617**	**10.513**	**9.755**	**8.549**
SEm ±	0.005	0.006	0.014	0.011	0.032	0.057	0.065	0.058
CD at 5%	0.017	0.017	0.042	0.035	0.099	0.177	0.200	0.180

SB - Sodium Benzoate 400 ppm; AVG - *Aloe vera* 30% gel; NS - *Nigella sativa* oil 200 ppm

Table.4 Effect of Sodium benzoate, *Aloe vera* gel and *Nigella sativa* oil combination of coatings on total anthocyanins and antioxidant activity of arils of pomegranate cv. 'Bhagwa' during storage

Treatments	Total anthocyanins (mg/100 g)				Antioxidant activity (%)			
	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16
SB 400	2.911	3.216	2.895	2.547	56.469	62.398	56.158	49.419
AVG 30	3.018	3.335	3.002	2.642	57.235	63.399	57.160	50.168
NS 200	3.126	3.454	3.109	2.736	56.468	62.397	56.157	49.418
SB 400 + AVG 30	3.234	3.574	3.216	2.830	58.559	64.708	58.237	51.249
SB 400 + NS 200	3.609	3.988	3.589	3.159	60.651	67.019	60.317	53.079
AVG 30+ NS 200	3.342	3.843	3.766	3.341	62.742	69.330	62.397	54.909
SB 400 + AVG 30 + NS 200	3.450	3.967	3.969	3.449	66.925	76.964	76.965	66.909
Control	2.695	2.560	2.355	2.073	52.286	60.129	58.926	46.274
Mean	**3.173**	**3.492**	**3.237**	**2.847**	**58.91**	**65.793**	**60.597**	**52.678**
SEm ±	0.010	0.019	0.021	0.019	0.216	0.338	0.353	0.317
CD at 5%	0.032	0.057	0.065	0.058	0.666	1.041	1.086	0.975

SB - Sodium Benzoate 400 ppm; AVG - *Aloe vera* 30% gel; NS - *Nigella sativa* oil 200 ppm

On day 8 of storage, accumulation of sugars was found higher in the control treated arils whereas, a decrease in the total sugars content of pomegranate arils after 12 days of treatment indicated deterioration of the quality of arils. An increase in the total sugars content of pomegranate arils during the initial period of storage in all the treatments could be attributed to conversion of starch into sugars. The delayed increase in the total sugars content in the coated pomegranate arils when compared to that of the control arils was probably due to the effects of composite coatings which exerted a physical barrier to the gaseous exchange that helped in delaying the rate of sugar metabolism. Similar kind of result was obtained by Zapata *et al.,* (2008) who found a lower rate of increase in sugar and organic acids concentration in tomatoes coated with alginate and zein at the end of the experiment than that of the control fruits, which suggested a more advanced ripening stage observed in the control fruit than coated tomatoes. Increase in total sugars content might be due to partial hydrolysis of complex carbohydrates. The increase in reducing sugars as well as total sugars content correspond to the increase in total soluble solids and ultimate decrease in the non-reducing sugars content in the storage period. The increased level of total sugars content was probably due to conversion of starch and pectin into simple sugar, which declined later on during storage, might be due to their rate of consumption for respiration and other energy sources. Such information has been reported earlier by Patel *et al.,* (2011) in custard apple. Custard apple fruits treated with a combination (*Aloe vera* 50%, Sago 10%, Calcium chloride 20%) coating showed highest sugars percentage compared to the control at the end of the storage period.

The data pertaining to ascorbic acid content of arils of pomegranate cv. 'Bhagwa' influenced by different edible coating combinations and stored at a low temperature of 4˚C were presented in Table 3. From the data, it is evident that ascorbic acid content of pomegranate arils treated with edible coating combinations decreased gradually with passage of time at each successive interval of observation recorded. Significantly highest ascorbic acid content was observed in pomegranate arils coated with SB 400 + AVG 30 + NS 200 (11.176, 12.284, 12.038 and 10.679 respectively on day 4, 8, 12 and 16) followed by AVG 30 + NS 200 (10.348, 11.900, 11.662 and 10.345 respectively on day 4, 8, 12 and 16) on all the days of observation recorded. Control recorded significantly lowest ascorbic acid content (8.345, 7.928, 7.294 and 6.418 respectively on day 4, 8, 12 and 16) on all the days of observation recorded. Ascorbic acid content coated with SB 400 + AVG 30 + NS 200 steadily increased with passage of time up to day 12 and since then onwards decreased gradually. The trend was found the same with other treatments, but the increase in the ascorbic acid content was found only up to day 8 and then onwards a continuous decline in the ascorbic acid content was noticed till the end of experimentation. The changes in ascorbic acid content were found much less even with the passage of time when compared with all other treatments. The result obtained indicate that pomegranate arils coated with SB 400 + AVG 30 + NS 200 was found the best coating in the maintenance of ascorbic acid content compared to all other coatings on all the days of storage at 4˚C temperature. The result of the present study represents the consistency of the decline in ascorbic acid content throughout the storage period. This could be related to its oxidation. The loss of vitamin C represents the conversion of di-hydro ascorbic acid to di-keto gluconic acid (Oms-Oliu *et al.,* 2008). However, the combination of SB 400 + AVG 30 + NS 200 was able to maintain the higher level of ascorbic acid in the pomegranate arils

throughout the storage. On the contrary, the control arils showed a higher reduction in the ascorbic acid content when compared to treated arils indicating a great loss of ascorbic acid content. These findings suggest that the edible coating used in the present study helped in retaining the ascorbic acid content in pomegranate arils. Banana fruits treated with a coating combination of chitosan1.5% + gibberellic acid 100 ppm, jojoba wax and glycerol (98%) delayed an increase in the ascorbic acid content and the loss at the ripening stage of the banana (Neeta *et al.*, 2011). Ayranci and Tunc (2003) stated that tightly packed network structure of film or coating exhibits limited oxygen permeability which has a positive effect on the quality of preservation as the reduced oxygen availability in the coated product could reduce the oxidation of ascorbic acid content. Similar kind of observation was observed in grape berries coated with composite coating of xanthan gum and olive oil incorporated with antioxidants (Rao *et al.*, 2016).

The changes in total anthocyanins content of arils of pomegranate cultivar 'Bhagwa' influenced by different edible coating combinations stored at a low temperature of 4˚C were presented in Table 4. Significantly highest total anthocyanins content of pomegranate arils was recorded in arils coated with SB 400 + AVG 30 + NS 200 (3.450, 3.967, 3.969 and 3.449 respectively on day 4, 8, 12 and 16) followed by AVG 30 + NS 200 (3.342, 3.843, 3.766 and 3.341 respectively on day 4, 8, 12 and 16) on all the days of observation recorded. Control recorded significantly lowest total anthocyanins content (2.695, 2.560, 2.355 and 2.073 respectively on day 4, 8, 12 and 16) on all the days of observation recorded. Total anthocyanins content coated with edible coating combination treatments was found increased steadily with passage of time up to day 12 and since then onwards decreased gradually. The trend was found the same with other treatments, but increase in the total anthocyanins content was only up to day 8 and then onwards a continuous decline in the total anthocyanins content was noticed till the end of shelf life of arils. The changes in the total anthocyanins content were found much less with SB 400 + AVG 30 + NS 200 even with passage of time when compared with all other treatments. The results obtained indicate that pomegranate arils coated with SB 400 + AVG 30 + NS 200 was found the best edible coating combination in the maintenance of total anthocyanins content compared to all other treatments on all the days of storage at 4˚C temperature. Similar kind of result was observed in grape berries coated with composite coating of xanthan gum and olive oil incorporated with antioxidants (Rao *et al.*, 2016).

The changes in antioxidant activity of arils of pomegranate cultivar 'Bhagwa' influenced by different edible coating combinations and stored at a low temperature of 4˚C were presented in Table 4. Significantly highest antioxidant activity of pomegranate arils was observed in the arils coated with SB 400 + AVG 30 + NS 200 (66.925, 76.964, 76.965 and 66.909 respectively on day 4, 8, 12 and 16) followed by AVG 30 + NS 200 (62.742, 69.330, 62.397 and 54.909 respectively on day 4, 8, 12 and 16) on all the days of observation recorded. Control recorded significantly lowest antioxidant activity (52.286, 60.129, 58.926 and 46.274 respectively on day 4, 8, 12 and 16) on all the days of observation recorded. Antioxidant activity coated with SB 400 + AVG 30 + NS 200 steadily increased with passage of time up to day 12 and since then onwards decreased gradually. The trend was found the same with other treatments, but the increase in the antioxidant activity was only up to day 8 and then onwards a continuous decline in the antioxidant activity was noticed till the

end. The change in antioxidant activity was found much less even with the passage of time when compared with all other treatments. The result obtained indicate that pomegranate arils coated with SB 400 + AVG 30 + NS 200 was found the best coating in the maintenance of antioxidant activity compared to all other coatings on all the days of storage at 4˚C temperature. The activity of oxidizing enzymes plays an important role in cut fruits and vegetables, as the oxidizing enzymes *viz.,* poly phenol oxidase (PPO) and peroxidase (POD) are activated as a response to the stress generated by the wounding process in the form of cutting. These enzymes are responsible for protection against microbial attacks by means of browning and detoxification, by causing breakdown of hydroperoxides generated during the degeneration of biological membranes. The induction of these enzymes can be attributed to rise in respiration caused by the cutting operation. Application of a coating combination of *Nigella sativa, Aloe vera* and Sodium benzoate on pomegranate arils coupled with low temperature showed significant reduction in the activities of these enzymes. *Aloe vera* coating showed a maximum influence in terms of restriction of PPO and POD activities, which could be attributed to the higher barrier property of the *Aloe vera* coating towards respiratory gases.

The total antioxidant activity was found to be enhanced in treated fruits as compared to that of untreated fruits indicating the efficacy of coating (enriched with antioxidants) in enhancing the aril quality by means of antioxidant activity. Thus, result of the present study was in accordance with the earlier result of Oms-Oliu *et al.,* (2008) who observed an enhanced antioxidant activity in the fresh-cut pears by using polysaccharide based edible coatings incorporated with antioxidants. Most postharvest treatments involve altering the natural conditions of the fruit to prolong postharvest life. It may be suggested that the activation of the antioxidant system is a response to postharvest stress which can be considered as a helpful response that improves the antioxidant status of tropical fruits. Similar kind of result was observed in grape berries coated with composite coating of xanthan gum and olive oil incorporated with antioxidants (Rao *et al.,* 2016). The present result was in confirmation with the above results. Significantly highest antioxidant activity of pomegranate arils was recorded in arils coated with SB 400 + AVG 30 + NS 200. Control recorded significantly lowest antioxidant activity on all the days of observation recorded. Antioxidant activity coated with SB 400 + AVG 30 + NS 200 steadily increased with passage of time up to day 12 and since then onwards decreased gradually. The trend was found the same with other treatments, but the increase in the antioxidant activity was only up to day 8 and then onwards a continuous decline in the antioxidant activity was noticed till the end. The change in antioxidant activity was found much less even with the passage of time when compared with all other treatments.

Based on all these observations, it could be concluded that pomegranate arils treated with SB 400 + AVG 30 + NS 200 proved the best edible coating combination in extending the shelf life and quality of pomegranate arils packed in the polypropylene boxes and stored at a low temperature of 4^{o}C thereby recorded a reduced spoilage of pomegranate arils due to browning.

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