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Influence of postharvest application of antioxidants on the physiological and quality parameters of pomegranate arils cv. 'Bhagwa'

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Abstract
The present investigation consisting of different antioxidants *viz.,* sodium benzoate, ascorbic acid and citric acid with different concentrations was carried out at the Postharvest Technology Laboratory, Horticultural College & Research Institute, Venkataramannagudem, West Godavari District, Andhra Pradesh during the year 2015-16. The experiment was laid out in a completely randomized design with three replications. The main objective of the study was to reduce browning of arils with improved antioxidant activity. Significant differences were observed among the edible antioxidant coating treatments with regard to many of the physiological and biochemical activities in the pomegranate arils. The arils of pomegranate treated with sodium benzoate 400 ppm recorded significantly lowest values for total sugars during the early phase of storage whereas at the later phase of storage recorded significantly highest value of total sugars (14.40 and 13.68% respectively on day 12 and 16) in comparison with all other treatments. Similarly, the lowest value of titrable acidity on day 4 and 8 were recorded against to day 12 and 16, whereas, significantly highest value of titrable acidity was recorded by sodium benzoate 400 ppm. Arils treated with sodium benzoate 400 ppm recorded significantly highest ascorbic acid, anthocyanins content and antioxidant activity throughout the storage period.

Keywords: Pomegranate arils, sodium benzoate, TSS, ascorbic acid, antioxidant activity

Introduction
Pomegranate (*Punica granatum* L.) popularly known as Anar belongs to the family Punicaceae. It is an important fruit of tropical and sub-tropical regions of the world and is considered one of the hardiest fruit crops grown and thrives well under arid and semi-arid climatic conditions due to its wider adaptability, resistance to drought and salinity conditions with higher yield. Aril is the economical part of the fruit which possess many medicinal properties and is sweet and acidic in taste. In the recent times, minimally processed ready-to-eat pomegranate arils have become most popular in the market. However, browning of arils is the major problem associated with quick spoilage of arils. Keeping all these things in view the present investigation was designed coating the arils with edible antioxidants which act as barriers during processing, handling and storage. Further, these do not solely retard the deterioration of arils but also reported to enhance the shelf life and quality of arils. Coating with antioxidants is reported to reduce the rate of respiration besides preventing the water loss due to transpiration thereby act as hydrophobic barriers. Different compounds *viz.*, wax, milk protein, cellulose, lipid, starch, zein and alginate have been in vogue mainly as edible coatings to prevent the rate of transpiration in the commodity. Keeping all these findings in view, the present investigation was proposed to find out the influence of different antioxidants *viz.*, sodium benzoate, citric acid and ascorbic acid at different concentrations to reduce spoilage due to browning as well as improving the quality of arils.

Materials and Methods
The present investigation was conducted at Horticultural College and Research Institute, Venkataramannagudem, West Godavari district, Andhra Pradesh during the year 2015-16 to elucidate information on the influence of certain edible antioxidants in reducing the spoilage due to browning and improving the quality of pomegranate arils. The experiment comprised of seven treatments *viz.*, Sodium benzoate at the rate of 200 and 400 ppm, Citric acid at the rate of 0.5 and 1.0%, Ascorbic acid at the rate of 0.5 and 1.0% and control (without any coating) with three replications. The fruits of pomegranate cv. 'Bhagwa' procured from a farmer's field

located at Dharmavaram village in Ananthapuram district of Andhra Pradesh were used in the current experimentation. Well developed, good looking fruits with uniformity in size and free from pest and disease attack were harvested at right stage of maturity and brought to the laboratory with proper packing in polypropylene modular 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 total 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) [25]. The percentage of reducing sugars content in the pomegranate aril juice was determined by Lane and Eyon method (AOAC, 1965) [5]. Ascorbic acid content in pomegranate arils was determined as per the procedure outlined by Ranganna (1986) [25]. Total anthocyanins content in pomegranate aril juice was determined by adopting the procedure outlined by Harborne (1973) [14]. Antioxidant activity in pomegranate arils was assessed by using the free radical DPPH method (Bond and Michel, 1997) [8]. The data were subjected to statistical analysis as per the procedure outlined by Panse and Sukhatme (1985) [20].

Results and discussion

Significant differences were observed in the spoilage percent of arils of pomegranate cultivar 'Bhagwa' treated with different antioxidant treatments (Table 1). Significantly lowest spoilage percent of pomegranate arils was observed with sodium benzoate 400 ppm (2.282, 2.625, 2.756 and 2.985% respectively on day 4, 8, 12 and 16) followed by citric acid 1.0% (2.896, 3.446, 3.722 and 4.075% respectively on day 4, 8, 12 and 16). Among all the treatments, significantly highest spoilage percent was recorded in control (4.780, 8.365, 10.038 and 13.049% respectively on day 4, 8, 12 and 16) on all the days of storage at a low temperature of 4˚C. Guilbert *et al.* (1996) [13] explained that an edible coating is a thin film formed from the material that acts as a barrier to the external elements such as moisture, oil, vapour, etc., and thus protect the product thereby extending the shelf-life and quality of the product. The spoilage percent of pomegranate arils might be due to oxidation of phenolic compounds during storage. Stabilization of anthocyanin pigments is essential in order to prevent the oxidation of phenolic compounds and to achieve good quality of arils (Gil *et al.*, 1996a and Ayhan and Esturk, 2009) [11, 6]. Decay is primarily caused by weight-loss, not only through direct quantitative loss but also through the deterioration of appearance mainly textural quality (softness, loss of turgidity and juiciness) and nutritional quality (Moncayo *et al.*, 2013) [18].

Significant differences were observed in the data pertaining to TSS content of arils of pomegranate cultivar 'Bhagwa' treated with different antioxidant treatments and stored at a low temperature of 4 ˚C (Table 1). Significant decrease in the TSS content of pomegranate arils was observed with passage of time in almost all the antioxidant coated pomegranate arils during storage at a low temperature of 4 ºC. Arils treated with sodium benzoate 400 ppm recorded significantly lowest value of total soluble solids (16.054 and 16.334ºBrix respectively on days 4 and 8), whereas, control recorded significantly highest TSS (16.298 and 16.583ºBrix respectively on day 4 and 8). With passage of time significantly highest TSS (16.743 and 15.906 ºBrix respectively on day 12 and 16) was recorded by sodium benzoate 400 ppm due to slower rate of respiration when compared with all other treatments, whereas, control recorded significantly lowest TSS (14.096 and 12.827 ºBrix respectively on day 12 and 16). The result evidenced a rapid decrease in the TSS content in control treated arils during the latter part of the storage period which might be due to rapid increase in the rate of respiration thereby exhaustion of sugars taken place. The remaining all other treatments were found intermediate between these two treatments on all the days of observation recorded. The total soluble solids content of pomegranate arils coated with sodium benzoate 400 ppm steadily increased with passage of time up to day 12 and then onwards decreased gradually. However, in the remaining all other treatments the TSS content increased up to day 8 and then onwards a gradual decrease was observed in all other treatments except control where a rapid decrease was observed in the TSS content till the end of experiment. The changes in the TSS content were found much less when pomegranate arils were treated with sodium benzoate 400 ppm even with passage of time when compared with all other treatments. The result obtained indicate that pomegranate arils treated with sodium benzoate 400 ppm has recorded significantly highest TSS content with little changes during the storage period compared to all other antioxidant treatments. The total soluble solids include sugars, proteins and mineral elements etc. Food materials containing higher total soluble solids are generally considered nutritionally rich when compared to foods containing less total soluble solids. Based on the result obtained in the present study, it could be noticed that TSS content was found to increase initially but later onwards a decrease was observed as the storage period progressed. Increase in TSS content during the early period of storage might be attributed to the conversion of starch and other polysaccharides to sugars or due to increased respiration and transpiration rate as recorded by Bhuller *et al.* (1981) [7]. This increase in TSS content was found more pronounced in control treatment whereas, a significantly delayed change was observed in the antioxidant coated pomegranate arils. Such a progressive increase in TSS content was explained as a consequence of water evaporation from aril surface. Arils coated with sodium benzoate 400 ppm recorded significantly highest TSS content at the end of the storage period. The present result was in confirmation with the earlier findings reported by Rao *et al*. (2016) [26] in grapes coated with *Aloe vera* gel and El-Sharony *et al*. (2015) [9] in date palm coated with arabic gum. Randhawa (2009) [24] also reported an increase in TSS content due to dehydration, but the decrease in TSS content at the end of the storage period might be attributed to the higher rate of fermentation as evidenced by the development of off-flavours. The decrease in TSS content due to increased rate of respiration in advanced stage of storage was reported by Mukherjee and Dutta (1967) [17]. Further, lower storage temperature reduced the activity of degradative enzymes which are found responsible for buildup of TSS content, whereas, lower rate of respiration at low temperature under cold storage conditions resulted in the retention of TSS content.

Significant changes were observed in the titrable acidity of pomegranate arils cultivar 'Bhagwa' treated with different

antioxidants (Table 1). Titrable acidity of pomegranate arils was found gradually decreased at each successive interval of observation during storage with many of the antioxidant treatments. Arils treated with sodium benzoate 400 ppm recorded significantly lowest value of titrable acidity (0.452 and 0.459% respectively on day 4 and 8) during the early stages of storage and highest titrable acidity (0.469 and 0.448% respectively on day 12 and 16) due to delayed metabolic changes and reduction in respiration rate was observed during the later phase of storage when compared with all other treatments. Control recorded significantly highest value of titrable acidity (0.458 and 0.465% respectively on day 4 and 8), whereas, a rapid decrease in titrable acidity was observed in the control treatment (0.403 and 0.371% respectively on day 12 and 16) during the later phase of storage period due to rapid rate of respiration and spoilage. Based on the results obtained it may be concluded that pomegranate arils coated with sodium benzoate 400 ppm was found the best coating in maintaining the titrable acidity with minimal changes during the entire storage period compared to all other coatings. At harvest, pomegranate fruits had the highest titratable acidity but its content was found gradually decreased with passage of time. The declining trend of TSS and TA resulted in to a decrease in the TSS to TA ratio. The decrease in acidity demonstrates maturity development and the same trend observed in pomegranate arils coated with antioxidants. However, a delayed decrease in acidity was observed in all the antioxidant coated treatments. These results were in accordance with Gaouth *et al*. (1991) [10] in chitosan coated tomatoes. Similar kind of observation was recorded in strawberries by treating with wheat gluten films under refrigerated conditions (Patricia *et al*., 2005) [21]. Similar kind of result was reported in strawberry fruits by coating with thymol oil (Amal *et al*. 2003) [4]. 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 packaging material's ability in capturing higher concentration of CO_2 (Vines and Obserbacher, 1961) [33] which decrease the rate of respiration (Petracek *et al*. 1998) [22]. However, the titrable acidity behavior under low temperature storage conditions would differ depending on the cultivar, growing region and storage environment (Gil *et al*., 1996b and Romero *et al*., 2013) [12, 28]. The present results were in confirmation with the earlier findings reported by Nanda *et al*. (2001) [19] and Hussain *et al*. (2004) [15].

Significant differences were observed in the reducing sugars content treated by different edible antioxidant coatings and stored at a low temperature of 4 ˚C (Table 2). Arils treated with sodium benzoate 400 ppm recorded significantly lowest value of reducing sugars (12.035 and 12.245% respectively on day 4 and 8) content during the early phase of storage whereas, during the later phase of storage recorded significantly highest value of reducing sugars (12.551 and 11.924% respectively on day 12 and 16) content due to delayed metabolic changes and reduced rate of respiration when compared with all other treatments. Control recorded significantly highest reducing sugars (12.218 and 12.432% respectively on day 4 and 8) content during the early phase of storage period, whereas, at a later phase of storage period recorded a rapid decrease (10.567 and 9.616% respectively on day 12 and 16) in the reducing sugars content which might be due to increased rate of respiration and spoilage occurred in the arils. The reducing sugars content steadily increased up to day 12 and then onwards slightly decreased with respect to arils treated with sodium benzoate 400 ppm, whereas, in the remaining all other treatments, increase in the reducing sugars content was observed up to day 8 and then onwards there was a rapid decline in the reducing sugars content. The reducing sugars content decreased as the storage period has progressed. The reason might be due to utilization of sugars in the respiration process as suggested by Pool *et al.* (1972) [23]. The higher level of sugars content observed during the initial storage period would have stimulated the carbon flow through glycolysis thereby increasing the cytoplasm pyruvate and other TCA intermediates leading to an increase in NAD(P)H in the matrix and ultimately stimulating oxidase activity, an enzyme responsible for the alternative pathway of respiration (Nanda *et al.*, 2001) [19]. Amal *et al*. (2003) [4] have reported similar kind of result in strawberry fruits by coating with thymol oil.

The data pertaining to non-reducing sugars content of pomegranate arils treated with different antioxidant treatments has recorded significant differences during storage period (Table 2). Arils treated with sodium benzoate 400 ppm recorded significantly lowest value of non-reducing sugars (1.775 and 1.806% respectively on day 4 and 8) during the early phase of storage period whereas, at a later phase of storage it has recorded significantly highest value of reducing sugars (1.851 and 1.759% respectively on day 12 and 16) content due to delayed metabolic changes and reduced rate of respiration when compared with all other treatments. Control recorded significantly highest non-reducing sugars (1.802 and 1.834% respectively on day 4 and 8) content initially, but at a later stage a rapid decrease was observed in the non-reducing sugars content (1.559 and 1.418% respectively on day 12 and 16) due to rapid rate of respiration and spoilage. The results obtained indicate that pomegranate arils coated with sodium benzoate 400 ppm was found the best in maintaining the non-reducing sugars content compared to all other coatings on all the days of storage at 4 ˚C temperature. Amal *et al*. (2003) [4] have reported similar kind of result in strawberry fruits by coating with thymol oil.

Significant differences were observed in the total sugars content of pomegranate arils treated with different edible antioxidant coating treatments (Table 2). Arils treated with sodium benzoate 400 ppm recorded significantly lowest values of total sugars (13.810 and 14.051% respectively on day 4 and 8) during the early phase of storage, whereas, at a later phase of storage period significantly highest value of total sugars (14.403 and 13.683% respectively on days 12 and 16) content was recorded under low temperature storage when compared with all other treatments. Control recorded significantly highest total sugars (14.020 and 14.265% respectively on day 4 and 8) content during the initial storage period, whereas, at a later stage of storage period it was observed that total sugars (12.126 and 11.034% respectively on day 12 and 16) content significantly decreased mainly because of 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 sodium benzoate 400 ppm steadily increased with passage of time up to day 12 and then onwards a gradual decrease was observed. The trend was found similar with other antioxidant treatments, but the increase in the total sugars content was observed only up to day 8 and then onwards a continuous decrease was observed in the totals sugars content till the end of the storage period. Increase in the total sugars content of arils during the initial storage period in all the treatments could be attributed to conversion of starch into sugars. The declining trend in the

total sugars content at the later phase of storage period was possibly due to utilization of sugars as a substrate in the metabolic processes like respiration (Rocha *et al*., 2003) [29]. The present results were found in confirmation with the earlier findings reported by Rao *et al*. (2016) [26]. Similar kind of result was observed in strawberries treated with wheat gluten films under refrigerated conditions (Patricia *et al*., 2005) [21]. The slow and steady increase in total sugars content of arils packed in polypropylene packaging boxes might be due to slower rate of physiological changes and metabolic activity hence, slower rate of conversion of starch to sugars observed (Nanda *et al*. 2001) [19].

Significant differences were observed in the ascorbic acid content of arils of pomegranate cultivar 'Bhagwa' treated with different antioxidants and stored at a low temperature of 4˚C (Table 3). Significant decrease in the ascorbic acid content of pomegranate arils was observed with passage of time during storage. Among all the treatments, sodium benzoate 400 ppm recorded significantly highest ascorbic acid content (12.045, 11.443, 10.527 and 9.264 mg $100g^{-1}$ respectively on day 4, 8, 12 and 16) followed by citric acid 1.0% (11.563, 10.985, 10.106 and 8.893 mg $100g^{-1}$ respectively on day 4, 8, 12 and 16), whereas, control recorded significantly lowest ascorbic acid content (8.030, 7.629, 7.018 and 6.176 mg $100g^{-1}$ respectively on day 4, 8, 12 and 16). The result obtained indicate that pomegranate arils coated with sodium benzoate 400 ppm was found the best coating in maintaining the ascorbic acid content compared to all other coatings on all the days of storage at 4˚C temperature. Ascorbic acid content steadily decreased as the storage period progressed. The reason may be attributed to degradation of ascorbic acid by oxidative enzymes. Similar kind of observation was reported earlier in different fruits by Singh (1981) [31] and Reddy (1999) [27]. The present results were in accordance with the earlier findings of Ahmad *et al*. (1994) [2] who reported that kinnow mandarins coated with a combination of corn starch, stearic acid, jojoba oil showed highest ascorbic acid content compared to control at the end of the storage period. Albanese *et al*. (2007) [3] reported higher content of ascorbic acid by dipping treatment of fresh cut apple slices compared to control after 6 days of storage.

Significant differences were observed in the anthocyanins content of pomegranate arils treated with different antioxidant treatments (Table 3). From the data, it is evident that anthocyanins content of pomegranate arils significantly decreased with passage of time. Significantly highest anthocyanins content was observed in pomegranate arils coated with sodium benzoate 400 ppm (2.623, 2.607, 2.560 and 2.463 mg $100g^{-1}$ respectively on day 4, 8, 12 and 16). Citric acid 1.0% and sodium benzoate 200 ppm were found at par with sodium benzoate 400 ppm with respect to anthocyanins content. Control recorded significantly lowest anthocyanins content (1.797, 1.687, 1.627 and 1.557 mg $100g^{-1}$ respectively on day 4, 8, 12 and 16) during the entire period of storage at a low temperature of 4 ˚C. The oxidative activity of poly-phenol oxidase enzyme might have contributed to a reduction in the anthocyanins content during the storage period which led to changes in the colour of pomegranate arils (Vigyazo, 1981) [32]. Anthocyanins are generally water soluble pigments which are observed in the vacuoles of the cell and confer a range of colours from orange to purple. Jaiswal *et al*. (2009) [16] reported a general trend of a decrease in the total anthocyanins content with progress of storage period. Gil *et al*. (1996a) [11] observed a slight decrease in the total anthocyanins content resembling to a small pigmentation, indicating like leakage of juice from arils, which might have thought to be damaged by the peeling procedure. An increase in the anthocyanins content could be attributed to the accumulation of pigments due to loss of moisture from vacuole. Concomitant to the loss in moisture content from vacuole an initial raise in TSS content was noticed. This might be due to hydrolysis of protective 3-glucoside linkages to give unstable anthocyanin pigments. Similar kind of result was reported in strawberry fruits by coating with thymol oil (Amal *et al*. 2003) [4].

Significant differences were observed in the antioxidant activity of pomegranate arils treated with different antioxidant coating treatments (Table 3). From the data, it is evident that a significant decrease was observed in the antioxidant activity of pomegranate arils with passage of time. Arils treated with sodium benzoate 400 ppm recorded significantly highest antioxidant activity (75.425, 71.653, 65.921 and 58.010% respectively on day 4, 8, 12 and 16) followed by citric acid 1.0%. Control recorded significantly lowest antioxidant activity (50.283, 47.763, 43.947 and 38.674 respectively on day 4, 8, 12 and 16) throughout the storage period. The result obtained indicate that pomegranate arils coated with sodium benzoate 400 ppm was found the best coating in maintaining the antioxidant activity throughout the storage period compared to all other antioxidant coatings on all the days of storage at 4 ˚C temperature. Loss of antioxidant activity during storage period varies by the type of fruit, storage temperature and environment. Ascorbic acid and citric acid were found the most reactive of all the antioxidants in most studies of antioxidant activity losses. During the advanced stage of tissue senescence, concentration of antioxidant substances increases to repair the effects of damage. Regeneration of ascorbic acid helps to offset the growing production of reactive oxygen species and other free radicals which lead to cellular injury or death. Ascorbic acid has the ability to donate electrons in a wide range of enzymatic and non-enzymatic reactions which makes it the main reactive oxygen species (Shewfelt, 1990) [30]. Abbasi *et al*. (2013) [1] reported a significant reduction in the browning index of loquat fruit by coating with citric acid at the rate of 250 mg/l and ascorbic acid at the rate of 500 mg/l to maintain the fruit quality.

Table 1: Effect of antioxidants on spoilage, TSS and titrable acidity during storage of pomegranate arils cv. 'Bhagwa'

Treatments	Spoilage (%)				TSS (°Brix)				Titrable acidity (%)			
	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16
Ascorbic Acid 0.5%	4.27	7.48	8.98	11.67	16.27	16.55	14.23	13.52	0.456	0.464	0.406	0.389
Ascorbic Acid 1.0%	3.45	6.03	7.24	9.41	16.18	16.47	15.15	14.39	0.455	0.462	0.429	0.410
Sodium Benzoate 200 ppm	3.23	5.66	6.79	8.83	16.14	16.42	15.60	14.82	0.454	0.461	0.441	0.421
Sodium Benzoate 400 ppm	2.28	2.63	2.76	2.99	16.05	16.33	16.74	15.91	0.452	0.459	0.469	0.448
Citric Acid 0.5%	3.95	6.92	8.30	10.79	16.22	16.50	14.85	14.11	0.456	0.463	0.422	0.403
Citric Acid 1.0%	2.90	3.45	3.72	4.08	16.10	16.38	16.06	15.25	0.453	0.460	0.452	0.432
Control	4.78	8.37	10.04	13.05	16.30	16.58	14.01	12.83	0.458	0.465	0.403	0.371

Mean	3.55	5.79	6.83	8.69	16.18	16.46	15.25	14.40	0.455	0.462	0.431	0.411
SEm ±	0.057	0.140	0.179	0.253	0.006	0.006	0.015	0.012	0.001	0.001	0.005	0.006
CD at 5%	0.175	0.430	0.553	0.781	0.018	0.018	0.046	0.038	0.004	0.005	0.016	0.020

Table 2: Effect of antioxidants on reducing sugars, non-reducing sugars and total sugars during storage of pomegranate arils cv. 'Bhagwa'

Treatments	Reducing sugars (%)				Non-reducing sugars (%)				Total sugars (%)			
	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16
Ascorbic Acid 0.5%	12.194	12.407	10.670	10.136	1.798	1.830	1.574	1.495	13.992	14.237	12.244	11.631
Ascorbic Acid 1.0%	12.132	12.345	11.357	10.789	1.789	1.821	1.675	1.591	13.922	14.165	13.032	12.381
Sodium Benzoate 200 ppm	12.096	12.307	11.692	11.108	1.784	1.815	1.724	1.638	13.880	14.123	13.417	12.746
Sodium Benzoate 400 ppm	12.035	12.245	12.551	11.924	1.775	1.806	1.851	1.759	13.810	14.051	14.403	13.683
Citric Acid 0.5%	12.157	12.370	11.133	10.576	1.793	1.824	1.642	1.560	13.950	14.194	12.775	12.136
Citric Acid 1.0%	12.071	12.283	12.037	11.435	1.780	1.812	1.775	1.687	13.852	14.094	13.812	13.122
Control	12.218	12.432	10.567	9.616	1.802	1.834	1.559	1.418	14.020	14.265	12.126	11.034
Mean	12.129	12.341	11.430	10.798	1.789	1.820	1.686	1.593	13.918	14.161	13.115	12.390
SEm ±	0.004	0.004	0.011	0.009	0.001	0.001	0.002	0.001	0.005	0.005	0.013	0.011
CD at 5%	0.014	0.014	0.034	0.028	0.004	0.002	0.005	0.004	0.016	0.016	0.039	0.032

Table 3: Effect of antioxidants on ascorbic acid, anthocyanins and antioxidant activity during storage of pomegranate arils cv. 'Bhagwa'

Treatments	Ascorbic acid content (mg/100g)				Anthocyanins content (mg/100g)				Antioxidant activity (%)			
	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16	Day 4	Day 8	Day 12	Day 16
Ascorbic Acid 0.5%	9.315	8.849	8.141	7.164	2.085	1.980	1.822	1.603	58.328	55.412	50.979	44.861
Ascorbic Acid 1.0%	10.439	9.917	9.124	8.029	2.336	2.219	2.042	1.797	65.368	62.100	57.132	50.276
Sodium Benzoate 200 ppm	11.242	10.680	9.826	8.646	2.516	2.390	2.199	1.935	70.396	66.876	61.526	54.143
Sodium Benzoate 400 ppm	12.045	11.443	10.527	9.264	2.696	2.561	2.356	2.073	75.425	71.653	65.921	58.010
Citric Acid 0.5%	10.038	9.536	8.773	7.720	2.246	2.134	1.963	1.728	62.854	59.711	54.934	48.342
Citric Acid 1.0%	11.563	10.985	10.106	8.893	2.588	2.458	2.262	1.990	72.408	68.787	63.284	55.690
Control	8.030	7.629	7.018	6.176	1.797	1.707	1.571	1.382	50.283	47.769	43.947	38.674
Mean	10.382	9.862	9.073	7.984	2.323	2.207	2.030	1.786	65.009	61.758	56.817	49.999
SEm ±	0.093	0.063	0.063	0.072	0.064	0.063	0.063	0.072	0.583	0.063	0.063	0.072
CD at 5%	0.287	0.194	0.194	0.222	0.021	0.194	0.194	0.222	1.796	0.194	0.194	0.222

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