Plant Archives Vol. 17 No. 2, 2017 pp. 977-984 *ISSN 0972-5210*

INFLUENCE OF WASHING, PACKAGING AND STORAGE TEMPERATURES ON SUGARS, ASCORBIC ACID AND ANTIOXIDANTS CONTENT OF 'BHAGWA' POMEGRANATE (*PUNICA GRANATUM L.*) ARILS

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Abstract

Pomegranate *cv*. Bhagwa arils were washed with antioxidants *viz*., chlorinated water plus ascorbic acid and chlorinated water plus citric acid, then packed in 80, 150 guage of Polypropylene bags and stored at low temperatures (5^0C &, 15^0C). Various quality parameters like Total Soluble Solids, sugars (reducing & total sugars), Ascorbic acid and Anthocyanin content were recorded in regular intervals. Regularly showed that the arils treated with water plus ascorbic acid and then packing in Polypropylene bags with 80 guage then stored at 5^0C recorded superior than other treatments in terms other studied parameter.

Key words: arils, washing, packaging and storage.

Inroduction

In recent years minimally processed fruits and vegetables have received tremendous attention by the consumers. Such 'ready to use' crops consist of washed, peeled, sliced or shredded raw vegetables and usually they are packed in plastic bags and stored at low temperatures to prolong the shelf life. Minimally processed fruit and vegetables are perishable than fresh produce as a consequence of tissue damage resulting from processing operations, wounding in fact, leads to increases in respiration and ethylene production rates, alters metabolic activity, increases the rate of nutritional and sensory attributes breakdown and notably reduces shelf-life. In addition, mechanical damages may enhance susceptibility to decay and pathogenic infections that are toxic to consumers (Brecht, 1995). The success of minimally processed products is favoured by social and demographic trends in the world, is linked to the consumer's present demand for convenient products coupled with a perception of freshness and natural taste.

In Pomegranate (*Punica granatum* L.) arils are the edible part of the fruit, Which constitutes 52 per cent of total fruit weight (w/w), comprising 78 per cent juice and 22 per cent arils (Kulkarni and Aradhya, 2005). Pomegranate arils are rich in vitamin C, vitamin K, antioxidants and polyphenols such as tannins, quercetin and anthocyanins which are good for heart and have anti-cancer properties (Seeram *et al*., 2006; Adams *et al*., 2006) and arils are recognised for their typical characteristics of reddish pigment due to the presence of anthocyanins, which are known to have important therapeutic properties to human health (Surh, 2003).

Pomegranate consumption is limited due to difficulty in peeling to obtain the arils. Presenting pomegranate arils in 'ready-to-eat' form would be a convenient and desirable alternative to encourage the consumption of fresh fruits and may also help to the demand for increase pomegranate cultivation. Minimally processed pomegranate arils have less post-harvest life and arils washed with antioxidants *viz*., citric acid, ascorbic acid helps to prevent microbial development (Sepulveda *et al*., 2001). Lack of appropriate information regarding minimally processed pomegranate arils for quality exports led to the development of appropriate technologies to

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orient for export of arils from the state of Telangana. However, little work has been done so far on washing of pomegranate arils, packaging and studies on storage temperatures. Therefore a collaberative study has been undertaken to find out the combined effect of washing treatments and packaging and storage temperatures on quality of minimally processed pomegranate aril *cv*. Bhagwa.

Materials and Methods

The present experiment was carried out at college of Horticulture in collaboration with Post Harvest Technology Research Station, SKLTSHU, Rajendranagar, Hyderabad. The experiment was conducted by washing the minimally processed pomegranate arils with antioxidants *viz*., sodium hypochlorite (SH) 200 ppm, ascorbic acid (AA) and citric acid (CA) having treatments and then packed in polypropylene bags then stored at low temperatures 5^0C and 15^0C with the experimental design was complete randomized block design with factorial concept and replicated thrice.

Two washing treatments were tested including distilled water, SH and solutions of AA and CA. After peeling, seeds were divided into uniform groups (120 g) and each were dipped in 5L of appropriate solution. Washing treatments were carried out at 23^0C. Arils were dipped in sodium hypochlorite 200 ppm for 5 min followed by dipping for 30 sec. in a solution of AA 5000 ppm and CA 5000 ppm and then arils were air dried for 30 min at 23^0C to remove residual water and then they were packed in polypropylene bags before analysis. The following parameters were analysed.

Total soluble solids (^{0}Brix)

The percentage of total soluble solids was determined by using ERMA hand refractrometer by placing a drop of the filtered juice on the prism of the refractrometer and observing the coincidence of shadow of the sample with the reading on the scale and expressed as °Brix. (Ranganna, 1986).

Brix–acid Ratio

The brix–acid ratio was arrived at by dividing the total soluble solids with titratable acidity of the pomegranate arils and the mean values were computed.

Reducing sugars (%)

Reducing sugars were determined by the method of Lane and Eyon (AOAC, 1965). Twenty five ml of fruit juice was taken and transferred to 250 ml volumetric flask. Two ml of lead acetate solution (45 %) was added to flask for precipitation of the colloidal matter. The potassium oxalate (22 %) 2ml was added to this solution to precipitate the lead and the volume made up to 250 ml using distilled water.

The contents were then filtered through whatman No. 1 filter paper after testing a little of filtrate for its freedom from lead by adding a drop of potassium oxalate. Reducing sugars in the lead free solution was taken in burette and titrated against 10 ml of standard Fehling's solution mixture of A and B (1:1) using methylene blue as an indicator till the end point was indicated by the formation of brick red precipitate.

The titration was carried out by keeping the Fehling's solution boiling on the heating mantle. The results were expressed as per cent reducing sugar. 10 ml of Fehling solution = 0.05 glucose.

Total sugars (%)

Total sugars were determined following the method described by Lane and Eyon (AOAC, 1965). A quantity of 50 ml lead free filtrate was taken in a 100 ml volumetric flask and to it 5 ml of concentrated HCL was added, mixed well and then kept for 24 hours at room temperature. Acid was then neutralized with NaOH using a drop of phenolphthalein as an indicator till the pink colour persisted for at least few seconds. Then volume made up to 100 ml. Total sugars were then estimated by taking this solution in a burette and titrating it against standard Fehling's solution mixture of A and B (1:1) using methylene blue as an indicator and taking brick red colour as an end point.

Ascorbic acid (mg/100g)

Ascorbic acid was estimated by the method presented by Ranganna (1986). Ten ml of fruit juice was taken in a 100 ml volumetric flask and the volume made up with 3 per cent Meta phosphoric acid. Ten ml of the aliquot was taken and titrated with standard dye (2, 6.dichlorophenol indophenol dye) to a pink red. The ascorbic acid was expressed as mg ascorbic acid/100 g.

Anthocyanins (mg equivalent to cynadin3-glucoside)

The total anthocyanins and the degradation index for pomegranate juice were determined by adopting the pH differential method given by Fuleki and Francis (1968).Five ml of the fruit juice was taken and diluted to 50 ml, two dilutions were made, one with pH 1.0 buffer (25 : 67 – 0.2 N Kcl – 0.2 N Hcl) and the other with pH 4.5 buffer (100 : 60 : 90 : 1 N sodium acetate – 1 N Hcl water). The samples were allowed to equilibrate for two hours. The absorbance of each dilution was measured on spectrophotometer at 510 nm and 700 nm using distilled water as blank. The absorbance (A) of the sample is given as:

$$A = (A_{510} - A_{700})\ pH\ 1.0 - (A_{510} - A_{700})\ pH\ 4.5$$

The anthocyanin concentration in the sample is

calculated as Cyanidin-3-glucoside equivalent.

$$\text{Anthocyanin pigment (mg/litre)} = \frac{(A \times MW \times DF \times 1000)}{E \times 1}$$

A = Absorbance

MW = Molecular weight of cyanidin-3-glucocide = 449.2

DF = Dilution Factor

E = Extinction coefficient (26,900)

Degradation index is calculated by using following equation

$$DI = \frac{(A_{510} - A_{700})\ pH\ 1.0}{A}$$

The data obtained was subjected to statistical analysis as per the procedure outlined by Panse and Sukhatme (1985).

Results and Discusuion

Total soluble solids (^{0}Brix): The TSS of arils was gradually decreased with each successive storage period and significantly maximum value was recorded in C_1 *i.e.* arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{0}C (16.05) and minimum TSS was noticed in C_{10} arils stored at 15 ± 1^{0}C without washing and packaging (15.81). Maximum and minimum TSS value was observed on 0 day (16.12) over 6th day (15.77). Treatments like C_1, C_2, C_3 and C_4 were continued from day 9 to day 15 and among them, maximum TSS was observed in C_1 (15.57) *i.e.* arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{o}C and minimum TSS was observed in C_4 (15.46) *i.e.* arils washed with chlorinated water 200 ppm + citric acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1^{0}C. Maximum TSS was observed on 9th day (15.71) and minimum on 15th day (15.33) (table-1).

In the experiment, decrease in TSS at advanced stage was owing to the increased rate of respiration in later stage of storage (Mukerjee and Dutta, 1967). Lower temperature reduces the activity of degradative enzymes responsible for buildup of TSS, whereas lower respiration at lower temperature results in highest retention of TSS at cool chamber and cold storage. (Raja Krishna Reddy *et al.* 1999, Santha Krishna Murthy, 1993 and Baviskar *et al.* 1995.)

Brix-acid ratio: It is evident from data from the table-1 that the brix-acid ratio of arils significantly increased with each successive treatment. Significantly minimum brix-acid ratio was recorded in C_1 (42.41) *i.e.* arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{o}C whereas maximum brix-acid ratio was noticed in C_{10} (54.99) *i.e.* arils stored at 15 ± 1^{0}C without washing and packaging.

With respect to storage period, minimum and maximum brix-acid ratio was observed on 0 day (41.78) and 6th day (51.49). Treatments like C_1, C_2, C_3 and T_4 were continued from day 9 to day 15 and among them C_1 (45.94) *i.e.* arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{0}C recorded minimum brix-acid ratio and maximum brix-acid ratio was seen in C_2 (54.28) *i.e.* arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1^{0}C. Minimum and maximum brix-acid ratio was observed on 9th day (48.00) was on par with12th day (49.80) and 15th day (53.15).

The brix-acid ratio decreased significantly in all treatments mainly due to increase in titrable acidity during storage (Artes *et al*., 1996; Hess-Piece and Kader, 2002).

Sugars (%): There was significant difference among the treatments with respect to reducing sugars (table-2). It is evident from the data that reducing sugars of arils significantly decreased with each successive storage period. Significantly maximum sugar content (reducing & total) was recorded in C_1 (7.48 & 8.41) *i.e.* arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{o}C and minimum sugars (reducing & total) was noticed in C_{10} (7.24 & 8.10).

With respect to storage period maximum and minimum sugar content (reducing & total) was observed on 0 day (7.62 & 8.54) over 6th day (6.68 & 7.98). Treatments (C_1, C_2, C_3 and C_4) were continued from day 9 to day 15 and among them maximum sugars (reducing & total) was seen in C_1 *i.e.* arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{o}C (6.89 & 7.80) whereas C_4 arils washed with chlorinated water 200 ppm + citric acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1^{o}C recorded minimum sugars (6.79 & 7.68). Maximum and minimum sugars (reducing & total) were observed on 9th day (7.01 & 7.88) and 15th day (6.68 & 7.63). There was a gradual increase in total sugars and reducing sugars which reached its maximum at ripe stage and there after decreased gradually (Bindu Praveena., 2013).

The sugars decreased as the storage period proceeded. This may be due to utilization of sugars in respiration as suggested by Pool *et al.* (1972). The higher level of sugars on initial day would have stimulated carbon flow through glycolysis, increasing cytoplasmic pyruvate and thereby other TCA intermediates, leading to an increase in NAD(P)H in the matrix and ultimately

Table 1: Combined effect of washing, packaging and storage temperature on Total soluble solids (oBrix) and Brix-Acid Ratio (replace) of pomegranate arils *cv.* Bhagwa.

Treatments	Storage period (days)															
	Total soluble solids (°Brix)								Brix-Acid Ratio							
	Day 0	Day 3	Day 6	Mean	Day 9	Day 12	Day 15	Mean	Day 0	Day 3	Day 6	Mean	Day 9	Day 12	Day 15	Mean
C_1	16.12	16.08	15.95	16.05^{a}	15.76	15.57	15.38	15.57^{a}	41.78	43.45	41.97	42.41^{a}	43.97	45.79	48.06	45.94^{a}
C_2	16.12	16.01	15.88	16.00^{abc}	15.69	15.49	15.31	15.50^{ab}	41.78	44.47	46.70	44.32^{a}	49.31	49.97	54.68	51.32^{bc}
C_3	16.12	16.04	15.91	16.02^{ab}	15.72	15.53	15.34	15.53^{a}	41.78	43.35	45.46	43.51^{a}	47.89	50.10	51.13	49.71^{b}
C_4	16.12	15.97	15.84	15.98^{abcd}	15.65	15.46	15.27	15.46^{b}	41.78	45.63	48.00	45.14^{ab}	50.79	53.31	58.73	54.28^{c}
C_5	16.12	15.76	15.63	15.84^{d}	-	-	-		41.78	54.35	57.89	51.34^{cd}	-	-	-	
C_6	16.12	15.91	15.78	15.94^{abcd}	-	-	-		41.78	48.21	50.90	46.97^{abc}	-	-	-	
C_7	16.12	15.84	15.71	15.89^{cd}	-	-	-		41.78	51.10	54.17	49.02^{bc}	-	-	-	
C_8	16.12	15.87	15.74	15.91^{bcd}	-	-	-		41.78	48.09	50.77	46.88^{abc}	-	-	-	
C_9	16.12	15.81	15.68	15.87^{d}	-	-	-		41.78	51.00	54.06	48.95^{bc}	-	-	-	
C_{10}	16.12	15.72	15.59	15.81^{d}	-	-	-		41.78	58.22	64.96	54.99^{d}	-	-	-	
Mean	16.12^{a}	15.90^{b}	15.77^{c}		15.71^{a}	15.51^{b}	15.33^{c}		41.78^{a}	48.79^{b}	51.49^{c}		48.00^{a}	49.80^{a}	53.15^{b}	
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
Treatments (T)	0.04		0.11		0.03		0.08		1.70		4.81		1.14		3.34	
Days (D)	0.02		0.06		0.02		0.07		0.93		2.64		0.99		2.90	
T x D	0.06		NS		0.05		NS		2.95		NS		1.98		NS	

Figure with same alphabets did not differ significantly; NS–Not significant. (-) indicates spoilage of aril on particular day.

C_1 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{0}C

C_2 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1^{0}C

C_3 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{0}C

C_4 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1^{0}C

C_5 – Arils stored at 5 ± 1^{o}C without washing and packaging

C_6 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 80 guage bags and stored at 15 ± 1^{0}C

C_7 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 150 guage bags and stored at 15 ± 1^{0}C

C_8 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 80 guage bags and stored at 15 ± 1^{0}C

C_9 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 150 guage bags and stored at 15 ± 1^{0}C

C_{10} – Arils stored at 15 ± 1^{0}C without washing and packaging

Table 2: Combined effect of washing, packaging and storage temperature on reducing sugars (%) and total sugars (%) of pomegranate arils *cv.* Bhagwa.

Treatments	Storage period (days)															
	Reducing sugars (%)								Total sugars (%)							
	Day 0	Day 3	Day 6	Mean	Day 9	Day 12	Day 15	Mean	Day 0	Day 3	Day 6	Mean	Day 9	Day 12	Day 15	Mean
C_1	7.62	7.58	7.23	7.48^{a}	7.05	6.89	6.73	6.89^{a}	8.54	8.49	8.21	8.41^{a}	7.94	7.78	7.69	7.80^{a}
C_2	7.62	7.51	7.16	7.43^{ab}	6.98	6.82	6.66	6.82^{bc}	8.54	8.41	8.13	8.36^{ab}	7.86	7.69	7.61	7.72^{bc}
C_3	7.62	7.55	7.21	7.46^{ab}	7.03	6.87	6.71	6.87^{ab}	8.54	8.46	8.18	8.39^{a}	7.91	7.75	7.66	7.77^{ab}
C_4	7.62	7.48	7.13	7.41^{abc}	6.95	6.79	6.63	6.79^{c}	8.54	8.37	8.09	8.33^{abc}	7.82	7.66	7.57	7.68^{c}
C_5	7.62	7.28	6.93	7.28^{de}	-	-	-		8.54	8.08	7.79	8.14^{e}	-	-	-	
C_6	7.62	7.45	7.09	7.39^{abcd}	-	-	-		8.54	8.29	8.01	8.28^{abcd}	-	-	-	
C_7	7.62	7.37	7.02	7.34^{bcd}	-	-	-		8.54	8.17	7.89	8.20^{cde}	-	-	-	
C_8	7.62	7.41	7.06	7.36^{bcd}	-	-	-		8.54	8.22	7.94	8.23^{bcde}	-	-	-	
C_9	7.62	7.22	6.87	7.32^{cde}	-	-	-		8.54	8.13	7.85	8.17^{de}	-	-	-	
C_{10}	7.62	7.34	6.99	7.24^{e}	-	-	-		8.54	8.03	7.72	8.10^{e}	-	-	-	
Mean	7.62^{a}	6.84^{b}	6.68^{c}		7.01^{a}	6.84^{b}	6.68^{c}		8.54^{a}	8.27^{b}	7.98^{c}		7.88^{a}	7.72^{b}	7.63^{c}	
	S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%		S.Em±		CD at 5%	
Treatments (T)	0.04		0.12		0.02		0.05		0.04		0.13		0.02		0.06	
Days (D)	0.02		0.06		0.02		0.04		0.02		0.07		0.02		0.05	
T x D	0.07		NS		0.03		NS		0.08		NS		0.03		NS	

Figure with same alphabets did not differ significantly; NS–Not significant. (-) indicates spoilage of aril on particular day.

C_1 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{0}C

C_2 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1^{0}C

C_3 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{0}C

C_4 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1^{0}C

C_5 – Arils stored at 5 ± 1^{o}C without washing and packaging

C_6 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 80 guage bags and stored at 15 ± 1^{0}C

C_7 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 150 guage bags and stored at 15 ± 1^{0}C

C_8 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 80 guage bags and stored at 15 ± 1^{0}C

C_9 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 150 guage bags and stored at 15 ± 1^{0}C

C_{10} – Arils stored at 15 ± 1^{0}C without washing and packaging

Table 3: Combined effect of washing, packaging and storage temperature on ascorbic acid (mg/g) of pomegranate arils *cv.* Bhagwa.

Treatments	Storage period (days)							
	Ascorbic acid (mg/g)							
	Day 0	Day 3	Day 6	Mean	Day 9	Day 12	Day 15	Mean
C_1	8.76	8.64	8.26	8.55[a]	7.88	7.65	7.56	7.70[a]
C_2	8.76	8.55	8.17	8.49[ab]	7.79	7.56	7.47	7.61[bc]
C_3	8.76	8.61	8.23	8.53[a]	7.85	7.62	7.53	7.67[ab]
C_4	8.76	8.52	8.14	8.47[ab]	7.76	7.53	7.44	7.58[c]
C_5	8.76	8.29	7.91	8.32[ab]	-	-	-	
C_6	8.76	8.47	8.09	8.44[ab]	-	-	-	
C_7	8.76	8.35	7.97	8.36[ab]	-	-	-	
C_8	8.76	8.44	8.06	8.42[ab]	-	-	-	
C_9	8.76	8.38	8.02	8.38[ab]	-	-	-	
C_{10}	8.76	8.21	7.83	8.27[b]	-	-	-	
Mean	8.76[a]	8.45[b]	8.07[c]		7.82[a]	7.59[b]	7.50[b]	
	S.Em±		CD at 5%		S.Em±		CD at 5%	
Treatments (T)	0.05		0.24		0.02		0.06	
Days (D)	0.03		0.08		0.02		0.05	
T x D	0.08		NS		0.04		NS	

Figure with same alphabets did not differ significantly; NS–Not significant. (-) indicates spoilage of aril on particular day.
C_1 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1°C
C_2 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1°C
C_3 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1°C
C_4 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1°C
C_5 – Arils stored at 5 ± 1°C without washing and packaging
C_6 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 80 guage bags and stored at 15 ± 1°C
C_7 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 150 guage bags and stored at 15 ± 1°C
C_8 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 80 guage bags and stored at 15 ± 1°C
C_9 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 150 guage bags and stored at 15 ± 1°C
C_{10} – Arils stored at 15 ± 1°C without washing and packaging

stimulating oxidase activity, an enzyme responsible for the alternative pathway of respiration (Nanda *et al.*, 2001). In control low sugars were recorded due to exposure of fruit to atmosphere and concomitant increase in respiration. This could be due to slow ripening process in modified atmospheric packaging which leads to slow build-up of the sugars (Bindu Praveena., 2013).

Ascorbic Acid (mg 100 g^{-1}): There was significant difference among the treatments with respect to ascorbic acid (Table-3). It is evident from the data that the ascorbic acid of arils significantly decreased with each successive storage period.

Significantly maximum ascorbic acid content was recorded in C_1 (8.55 mg 100 g^{-1}) *i.e.* arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1°C while minimum ascorbic acid was noticed in C_{10} (8.27 mg 100 g^{-1}) arils stored at 15 ± 1°C without washing and packaging.

With respect to storage period, maximum and minimum ascorbic acid content was observed on 0 day (8.76 mg 100 g^{-1}) over 6th day (8.07 mg 100 g^{-1}). Treatments like C_1, C_2, C_3 and C_4 were continued from day 9 to day 15 and among them maximum ascorbic acid content was seen in C_1 (7.70 mg 100 g^{-1}) whereas C_4 minimum ascorbic acid (7.58 mg 100 g^{-1}) . Maximum and minimum ascorbic acid was observed on 9th day (7.82 mg 100 g^{-1}) and 15th day (7.50 mg 100 g^{-1}) was on par with 12th day (7.59 mg 100 g^{-1}).

Ascorbic acid is an unstable vitamin and is destroyed in the presence of oxygen (especially when fruits are damaged), light, alkalinity, enzyme phenolase and elevated temperature (Coultate, 2007). Arils stored at low temperature maintain higher level of ascorbic acid content than those stored at ambient temperature indicating the slow degradation of ascorbic acid due to inhibition of activity oxidizing enzymes like ascorbic acid oxidase, peroxidase and catalase at low temperature thus resulting in higher retention at the end of shelf life (Mapson, 1970).

Table 4: Combined effect of washing, packaging and storage temperature on anthocyanin (mg 100 g^{-1}) of pomegranate arils cv. Bhagwa.

Treatments	Storage period (days)							
	Anthocyanin (mg 100 g^{-1})							
	Day 0	Day 3	Day 6	Mean	Day 9	Day 12	Day 15	Mean
C_1	31.38	30.62	29.74	30.58^{a}	29.16	28.55	27.43	28.38^{a}
C_2	31.38	29.36	28.74	29.83^{abcd}	28.05	27.32	26.56	27.31^{bc}
C_3	31.38	30.16	29.08	30.21^{a}	28.64	27.74	27.14	27.84^{ab}
C_4	31.38	29.64	28.94	29.99^{ab}	27.86	27.08	26.34	27.09^{c}
C_5	31.38	27.86	27.13	28.79^{ef}	-	-	-	
C_6	31.38	29.86	28.52	29.92^{abc}	-	-	-	
C_7	31.38	28.13	28.02	29.18^{cde}	-	-	-	
C_8	31.38	28.74	27.51	29.21^{bcde}	-	-	-	
C_9	31.38	28.06	27.76	29.07^{de}	-	-	-	
C_{10}	31.38	27.15	26.65	28.39^{f}	-	-	-	
Mean	31.38^{a}	28.96^{b}	28.21^{c}		28.43^{a}	27.67^{b}	26.87^{c}	
	S.Em±		CD at 5%		S.Em±		CD at 5%	
Treatments (T)	0.28		0.78		0.24		0.70	
Days (D)	0.15		0.43		0.21		0.61	
T x D	0.48		NS		0.42		NS	

Figure with same alphabets did not differ significantly; NS–Not significant. (-) indicates spoilage of aril on particular day.
C_1 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{0}C
C_2 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1^{0}C
C_3 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{0}C
C_4 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 150 guage bags and stored at 5 ± 1^{0}C
C_5 – Arils stored at 5 ± 1^{o}C without washing and packaging
C_6 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 80 guage bags and stored at 15 ± 1^{0}C
C_7 – Arils washed with chlorinated water 200 ppm + Ascorbic acid then packed in Polypropylene 150 guage bags and stored at 15 ± 1^{0}C
C_8 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 80 guage bags and stored at 15 ± 1^{0}C
C_9 – Arils washed with chlorinated water 200 ppm + Citric acid then packed in Polypropylene 150 guage bags and stored at 15 ± 1^{0}C
C_{10} – Arils stored at 15 ± 1^{0}C without washing and packaging

Anthocyanins (mg 100 g^{-1}): Significant difference among the treatments with respect to anthocyanin as depicted in Table-4. It is evident from the data that the anthocyanin of arils significantly decreased with each successive storage period. Significantly maximum anthocyanin content was recorded in C_1 (30.58) *i.e.* arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1^{o}C and minimum anthocyanin was noticed in C_{10} (28.39) *i.e.* arils stored at 15 ± 1^{o}C without washing and packaging. Maximum and minimum anthocyanin value was observed on 0 day (31.38) over 6th day (28.21).

Treatments like C_1, C_2, C_3 and C_4 were continued from day 9 to day 15 and among them maximum anthocyanin was seen in C_1 (28.38) and minimum anthocyanin content was recorded in C_4 (27.09). Maximum and minimum anthocyanin was observed on 9th day (28.43) and 15th day (26.87).

Anthocyanins are water soluble pigments that are located in vacuoles and confer a range of colors from orange to purple. A general trend of a decrease in total anthocyanin content was observed as the storage time increased for all treatments (Jaiswal *et al*., 2009). A slight decrease in the anthocyanin content and to a small pigmentation of the washing liquids, indicating that some leakage of juice from arils, which might have been slightly damaged by the peeling procedure, had occurred (Gill *et al*., 1996). The anthocyanins responsible for the pigmentation of pomegranate arils were isolated and identified as 3,5-diglycoside-delphidin (DP 3,5) and 3 glycoside (DP 3), cyanidin3, 5-diglycoside (cy 3,5) and 3 glycoside, pelargonidin-3, 5- diglycoside and 3 glycoside (Du *et al*.1975).

Anthocyanins content was decrease as the storage period increased. The increase could be due to the concentration of pigments due to loss of moisture. Concomitant to the loss in moisture an initial raise in TSS was also noticed. Waskar and Khurdiya (1987) proposed that this might be due to hydrolysis of protective 3-

glucoside linkages to give unstable anthocyanins.

Conclusion

'Combined effect of washing, packaging and storage temperatures on quality of Minimally processed pomegranate arils *cv*. Bhagwa was studied and it was concluded that arils washed with chlorinated water 200 ppm + ascorbic acid then packed in Polypropylene 80 guage bags and stored at 5 ± 1°C showed superior quality parameters interms of TSS, sugars, ascorbic acid and anthocyanin content.

Acknowledgement

Thanks to Dr. Y.S.R Horticultural University for financial assistance and advisory committee for technical advice.

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