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SHRINK WRAPPING: AN INNOVATIVE TECHNOLOGY FOR ENHANCING SHELF LIFE AND QUALITY OF POMEGRANATE

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ABSTRACT

Pomegranate fruits are rich in quality characteristics like antioxidant and phenol compounds. Generally pomegranate fruits could be stored for longer duration at specified atmospheric conditions. But at ambient storage the fruit got shrinkage, turned brown with white portions and discolor of the arils and skin. Wrapping of fruits with a heat-shrinkable film (29µm thickness) followed by storage at ambient conditions, (18-30^{o}C, 55-60% RH) for 60 days influence the quality of fruits. Control fruits were found deteriorate at a very high rate, in their physical appearance as well as nutrition quality. Wrapped fruits showed minor changes in nutritional value in respect of total phenols, anthocyanins and antioxidant activity during 60 days at ambient conditions, whereas non-wrapped fruits deteriorated earlier at similar storage conditions. Freshness and firmness of the fruit were retained and weight loss greatly reduced by shrink wrapping, whereas acidity, total soluble solids and vitamin C of the shrink-wrapped fruits were lower than that of non-wrapped fruits during 60 days of storage at ambient conditions. Shrink wrapping also reduced the respiration rate of the fruit.

Keywords:
Kandhari, Bhagwa, Shrink wrap film, Antioxidant.

INTRODUCTION

Pomegranate (*Punica granatum L.*) is grown in semiarid regions like *Maharashtra*, *Karnataka* and *Gujarat* regions in *India*. It is a rich source of phenolics and antioxidants, which help to protect us from different ailments. Several varieties are being grown in India among them *'Kandhari'* and *'Bhagwa'* are common.

The edible parts of pomegranates (approximately 50% of total fruit weight) comprise 80% juice and 20% seeds. Fresh juice contains 85% water, 10% sugars (mainly fructose and glucose), pectins, ascorbic acid, polyphenolic flavonoids, anthocyanins, amino acids and minerals (Roy and Waskar, 2005). Storage conditions of fruit can affect the rind, in form of necrotic pitting and discoloration and induce paleness to the arils and browning to the white segments portion (Elyatem and Kader, 1984). Husk scald another postharvest physiological disorder, Generally it develops faster and more severely in fruit stored at temperatures of 6–10 ◦C than in fruit stored at lower temperatures (Ben-Arie and Or, 1986). Water dipping at 45^{O}C has been shown to reduce chilling injury and increase the ratio of unsaturated/saturated fatty acids of membranes and the concentrations of putrescine and spermidine (Mirdehghan et al., 2007). High temperature pre-storage conditioning as well intermittent warming also can prevent chilling injury symptoms and decay incidence (Artés et al., 2000). Controlled atmosphere (CA) storage as well as modified atmosphere (MA) packaging, has been shown to reduce chilling injury and husk scald symptoms (Ben-Arie and Or, 1986; Artés et al., 2009; Nanda et al., 2001; Hess-Pierce and Kader, 2003). Decay, caused by various pathogens such as Aspergillus spp., Alternaria spp., Penicillium spp., and especially Botrytis cynerea, which develops at the recommended storage conditions (5–8 ◦C and 90–95% RH)

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(Roy and Waskar, 2005), is another major cause of postharvest loss.

Shrink wrapping is a new technique for post harvest handing of fruits and vegetables. This technology delays physiological deterioration of fruits and also prevents condensation of droplets within the package. Shrink-wrapping provides optimum gas and humidity to the produce for maintaining quality during the transit and storage. As a result, it doubles or sometimes triples storage life of the fruits under proper storage conditions. Such unit packs also provide protection against abrasion and maintain attractive appearance of the product. The main objective of this research work is to see the effect of (i) shrink wrapping on reducing the loss of visible quality of pomegranate during storage, mainly occurred by weight loss and husk scald, (ii) assessment of nutritional and functional properties of juice of pomegranate cultivars of *'Kandhari'* and *'Bhagwa'*.

Materials and methods

Procurement of fruits

Fully ripened pomegranate fruits were harvested from an orchard of the *Regional Horticulture Research Station, YS Parmer University of Agriculture and Technology, Bajaura, Himachal Pradesh*. The fruits were brought from *Himachal Pradesh* to *Indian Agricultural Research Institute, New Delhi*. The experiment was conducted in the *Division of Food Science and Postharvest Technology, Indian Agricultural Research Institute, New Delhi, India*.

Sorting of fruits

Fruits free from blemishes, visible external damage, average size and having uniformity of colour and size were sorted.

Treatments

The healthy fruits were divided in two lots one for shrink wrapping and another for non-wrapping (control). Six replications were prepared for the measurement of destructive and non destructive characters of wrapped and non-wrapped fruits. Replicated fruits were packed in to consumer packets made up of hard brown paper. The packs were covered with the shrink wrap film and sealing by using electrical sealer. Then the packs were kept into shrink wrap tunnel (machine) at the conditions of temperature around 150^{o}C for 15 seconds. These conditions made the film tightly wrap around the packs and the packs then stored at room conditions for came into normal temperature of the packs.

Storage conditions

Packed fruits were stored at laboratory conditions (temperature range 18-30^{o}C, relative humidity 55-60%) and were subjected for analysis at 20 days of interval during the 60 days of storage.

Respiration rate

For carbon dioxide determination, a combined CO_2/O_2 analyser (Combi Check 9800-1, PBI-Dansensor A/S, Denmarck) was used. The fruits contained in jars and placed for some time for accumulation of CO_2/O_2, needle inserted in one of the two septa of the jar and took the reading of CO_2/O_2. Respiration rate were expressed as micro litre CO_2 kg^{-1} hr^{-1}.

Firmness, weight loss, juice content, juice colour, subjective assessment

Firmness was determined by using a texture analyzer (Model: TA+Di, Stable micro systems, UK) using compression test adopted by. First peak force (N) in the force deformation curve was taken as firmness of the sample.

The fruits weight was determined by using three digits electronic balance. The weight loss was calculated by took initial weight of fruit and minus with the intervals weight of the fruit and expressed in per cent.

Arils were removed from the fruits by manually and 100 arils were counted by verbally and juice was extracted by using mixer and grinder and filtered through muslin cloth. The filtered juice was measured in graduated measuring cylinder and expressed in per cent.

The juice colour was determined using the *Hunter Lab System* (*Model: Miniscan XE Plus; Hunter Associates Laboratory, Inc., Reston, VA*) and expressed in L^* values (0, dark; 100, white), a^* values (negative value, green; positive value, red) and b^* values (negative, blue; positive, yellow).

Sensory quality for freshness, aril colour, juiciness and flavour of fruits was evaluated by a panel of eight assessors at harvest and after 3.5, 9 and 12 weeks of storage kept at 25, 15 and 8°C, respectively. The evaluation was done on a scale of 1–5, where 5=very good (like very much with harvest freshness, bright pink juicy arils and without any off flavour) and 1= very bad (dislike completely with desiccated fruits with brown tough peel, brown colour arils with low juiciness and becoming dry). Scores of 3 (like moderately with retention of freshness, colour and juiciness of arils) and above were considered acceptable for commercial purposes.

Chemical analysis

Chemical analysis were carried out for the juice obtained by squeezing the arils with a commercial juicer and filtered through muslin cloth. Before analyses, the juice was centrifuged at 10,000 rpm for 15 minutes and the supernatant taken for analysis.

Total soluble solids, titratible acidity, ascorbic acid

Total soluble solids were determined using a *hand-held Refractometer* (*Model: Fisher Scientific™ RFM742; Fisher Scientific India Ltd., Delhi*) on a scale of 0 – 50, and the values were expressed in ^{o}Brix with compensate to 20°C. Titratable acidity was determined

according to the *Ranganna* with using 0.1N NaOH alkali and expressed in per cent (%). Ascorbic acid was determined using 2, 6-dichlorophenol-indophenol dye titrimetric method (Ranganna 2000). 10-g sample was blended with 3% HPO_3 to a final volume of 100 mL. Blend was centrifuged and an aliquot of 10 mL was taken for titration with the standard dye to a pink colour endpoint. Results were expressed as milligrams of ascorbic acid/100 g.

Total phenols, antioxidant capacity, anthocyanin

Total phenols were estimated using Folin-ciocalteu reagent (Singleton *et al*. 1999). Added to 200 µL of the aril juice (80% ethanol) were 2.8 mL of double distilled water, 0.5 mL of Folin-ciocalteu reagent (1N) and after three minutes 2.0 mL of 20% Na_2CO_3 solution mixed. The mixture was allowed to stand for 60 min in dark conditions and absorption was measured at 760 nm against a reagent blank in UV-visible spectrophotometer (JASCO V-670, Ishikawa-machi, Hachioji-shi, Tokyo, Japan). Results were expressed as gallic acid equivalent (mg GAE/100 g).

The cupric ion reducing antioxidant capacity of pomegranate juice was determined according to the method of Apak *et al*. (2004). Briefly, according to the protocol, 0.1 mL of sample was mixed with 1 mL each of $CuCl_2$ solution (1.0×10^{-2} mol/l), neocuproine alcoholic solution (7.5×10^{-3} mol/l) and NH_4Ac(1 mol/l, pH 7.0) buffer solution and 1 mL of water to make the final volume of 4.1 mL. After 30 min, the absorbance was recorded at 450 nm against the reagent blank. Standard curve was prepared using different concentrations of Trolox. The results were expressed as µmol TE/g, using molar absorptivity of Trolox as 1.67 × 104 l/mol/cm.

Total anthocyanins content was determined by pH differential method using two buffer solutions; potassium chloride buffer (pH 1.0, 0.025 M) and sodium acetate buffer (pH 4.5, 0.4 M), as described by Wrolstad *et al*. (2005). Aril juice (1 mL) were mixed with 9 mL of buffers and read against water as a blank at 520 and 700 nm. Results were expressed as milligrams of cyanidin-3-glucoside (molar absorptive coefficient = 26,900 and molecular weight = 449.2) equivalents per kilogram of fresh weight of juice. Total anthocyanins content was calculated as follows; ([A × MW × DF × 1000]/MA × 1), where DF is the dilution factor, MW is molecular weight and MA is molar absorptive coefficient.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) considering the experimental plan as two factorial complete randomized block design. Mean separations were carried out according to the Duncan's multiple range test at $P \leq 0.05$. All analyses were performed using SAS 9.2 (SAS Institute, Cary, NC, USA).

RESULTS

Respiration rate, firmness

Respiration rate increased in both wrapped and non-wrapped fruits during storage but wrapped fruits showed that less rise in respiration rate than non-wrapped fruits. Wrap fruits of *Kandhari* (16.7 ± 0.1) and *Bhagwa* (18.7 ± 0.02) exhibited less respiration rate during storage in comparison to non-wrapped fruits (19.7 ± 0.3; 19.5 ± 0.4) respectively.

During the storage days the aril firmness was decreased in both wrapped and non-wrapped fruits but wrapped fruits showed that lesser loss in aril firmness than non-wrapped fruits. Wrap fruits of *Kandhari* (18.9 ± 0.1) and *Bhagwa* (16.7 ± 0.02) exhibited very less in firmness in comparison to non-wrapped fruits (17.6 ± 0.3; 16.7 ± 0.4) respectively.

Weight loss and Juice content

During the storage days the weight loss was decreased in both wrapped and non-wrapped fruits but wrapped fruits showed that very less loss than non-wrapped fruits. Wrap fruits of *Kandhari* (1.5 ± 0.1) and *Bhagwa* (2.7 ± 0.02) exhibited very less loss in weight in comparison to non-wrapped fruits (27.2 ± 0.3; 21.8 ± 0.4) respectively.

Similarly wrapped Kandhari (70.5 ± 0.3 %) and Bhagwa (70.1 ± 0.3%) fruits yielded high juice content than non-wrapped fruits (46.3 ± 0.4%; 49.2 ± 0.2%) respectively after the end of 60 days of storage. The weight loss and juice content is the only physical characteristics of the pomegranate that much more affected during the storage days. But shrink wrapping was found significantly beneficial for reduction of weight loss and juice content.

Colour

The hunter 'a' value of juice changed during the storage period. The hunter 'a' values of wrapped and non-wrapped was decreased with increase of storage days, but decrease was more in non-wrapped fruits. After 60 days of storage the hunter 'a' value of juice of shrink wrapped *'Kandhari'* and *'Bhagwa'* were observed higher (41 ± 4.6; 48 ± 3.8) than non-wrapped *'Kandhari'* and *'Bhagwa'* (30 ± 5.6; 34 ± 3.6) fruits respectively.

Total soluble solids, titratable acidity, ascorbic acid

A decrease trend was shown in the total soluble solids contents during the storage. Shrink wrapped fruits exhibited slightly lesser loss in TSS than non-wrapped fruits. The higher TSS was found in shrink wrapped *'Bhagwa'* (16.1 ± 0.1) and *'Kandhari'* (15.2 ± 0.1) than non-wrapped *'Bhagwa'* (14.1 ± 0.3) and *'Kandhari'* (12.1 ± 0.2) after 60 days of storage.

Table 1. Hunter 'a' value of pomegranates stored at ambient conditions for 60 days

Parameters	Kandhari					Bhagwa				
	Storage days				C.D.	Storage days				C.D.
	Initial	20th	40th	60th		Initial	20th	40th	60th	
Hunter 'a' value										
Shrink wrap	54±2.8	52±0.6	46±4.1	41±5.6	4.6	62±3.6	57±0.9	44±2.6	48±3.6	3.6
Non-wrapped	54±2.8	49±2.6	38±3.7	31±2.4	3.1	62±3.6	53±2.8	41±1.9	34±1.1	3.4

Table 2. Physiological loss in weight and juice content of pomegranates stored at ambient conditions for 60 days.

Characters and treatment	Kandhari					Bhagwa				
	Storage days				C.D.	Storage days				C.D.
	Initial	20th	40th	60th		Initial	20th	40th	60th	
PLW (%)										
Shrink wrap	-	0.4 ± 0.1	1.0 ± 0.2	1.5 ± 0.1	0.51	-	0.8 ± 0.05	1.5 ± 0.03	2.7 ± 0.02	0.12
Non-wrapped	-	11.5 ± 0.3	19.3 ± 0.8	27.2 ± 0.3	1.72	-	9.6 ± 0.1	17.2 ± 0.6	21.8 ± 0.4	1.36
Juice Content (%)										
Shrink wrap	75.6 ± 0.1	74.4 ± 0.6	72.3 ± 0.2	70.5 ± 0.3	1.11	75.3 ± 0.1	74.1 ±0.1	72.3 ±0.7	70.1 ± 0.3	1.26
Non-wrapped	75.6 ± 0.1	63.7 ± 0.5	55.2 ± 0.3	46.3 ± 0.4	1.18	75.3 ± 0.1	61.7 ± 0.9	55.4 ± 0.7	49.2 ± 0.2	1.90

Table 3. Total soluble solids, acidity and ascorbic acid contents of pomegranates stored at ambient conditions for 60 days.

Characters and treatment	Kandhari					Bhagwa				
	Storage days				C.D.	Storage days				C.D.
	Initial	20th	40th	60th		Initial	20th	40th	60th	
Total soluble solids (°Brix)										
Shrink wrap	16.0 ± 0.1	15.7± 0.2	15.5 ± 0.1	15.2 ± 0.1	0.41	17.1 ± 0.3	16.5 ± 0.2	16.2 ± 0.2	16.1 ± 0.1	0.38
Non-wrapped	16.0 ± 0.2	15.5 ± 0.1	14.9 ± 0.2	12.1 ± 0.2	0.38	17.1 ± 0.2	16.5 ± 0.3	15.8 ± 0.1	14.1 ± 0.3	0.38
Acidity (%)										
Shrink wrap	0.48 ± 0.01	0.47 ± 0.01	0.42 ± 0.01	0.36 ± 0.0	0.02	0.47 ± 0.01	0.41 ± 0.02	0.37 ± 0.01	0.32 ± 0.01	0.02
Non-wrapped	0.48 ± 0.01	0.46 ± 0.01	0.36 ± 0.03	0.28 ± 0.0	0.04	0.47 ± 0.01	0.39 ± 0.02	0.32 ± 0.02	0.32 ± 0.02	0.01
Ascorbic acid (mg 100^{-1} ml FW)										
Shrink wrap	23.7 ± 0.1	22.5 ± 0.1	19.9 ± 0.2	19.6 ± 0.1	0.46	30.8 ± 0.6	29.7 ± 0.2	28.1 ± 0.3	26.9 ± 0.3	1.20
Non-wrapped	23.7 ± 0.1	18.8 ± 0.1	14.0 ± 0.2	9.7 ± 0.1	0.41	30.8 ± 0.6	27.2 ± 0.5	22.8 ± 0.7	19.2 ± 0.4	1.83

Table 4. Subjective analysis of pomegranates stored at ambient conditions for 60 days.

Characters and treatment	Kandhari					Bhagwa				
	Storage days				C.D.	Storage days				C.D
	Initial	20th	40th	60th		Initial	20th	40th	60th	
Taste										
Shrink wrap	8.0 ± 1.0	7.8 ± 1.2	7.4 ± 0.1	7.2 ± 0.1	0.23	8.3 ± 0.3	7.8 ± 0.2	7.2 ± 0.2	6.4 ± 0.1	0.42
Non-wrapped	8.0 ± 1.2	7.2 ± 0.8	6.9 ± 0.2	6.0 ± 0.2	0.83	8.3 ± 0.2	7.6 ± 0.3	7.0 ± 0.1	6.0 ± 0.3	0.35
Flavour										
Shrink wrap	7.9 ± 0.9	7.5 ± 1.4	7.1 ± 0.9	6.8 ± 0.9	0.62	8.0 ± 1.1	7.2 ± 0.8	6.9 ± 0.8	6.2 ± 1.3	0.22
Non-wrapped	7.9 ± 0.9	6.6 ± 1.0	6.1 ± 1.2	5.4 ± 1.0	0.44	8.0 ± 1.3	7.0 ± 0.8	6.4 ± 0.7	5.9 ± 1.0	0.11
Visual appearance										
Shrink wrap	7.5 ± 1.3	7.0 ± 1.1	6.7 ± 0.2	6.5 ± 0.1	0.47	8.3 ± 0.6	8.0 ± 0.2	7.6 ± 0.3	7.4 ± 0.3	1.70
Non-wrapped	7.5 ± 1.1	6.5 ± 0.1	6.0 ± 0.2	5.5 ± 0.1	0.44	8.3 ± 0.6	7.8 ± 0.5	7.4 ± 0.7	7.0 ± 0.4	1.35

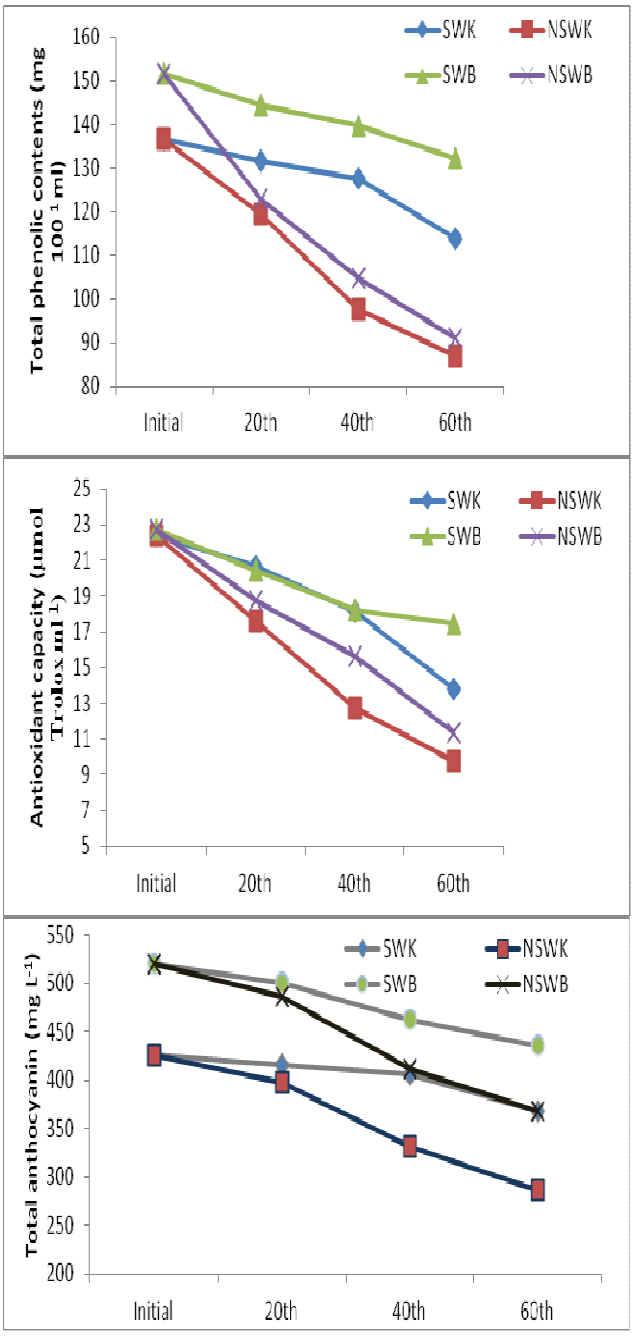

Fig.: I. Total phenolic contents, antioxidant capacity and total anthocyanin contents of pomegranates stored at ambient conditions for 60 days.

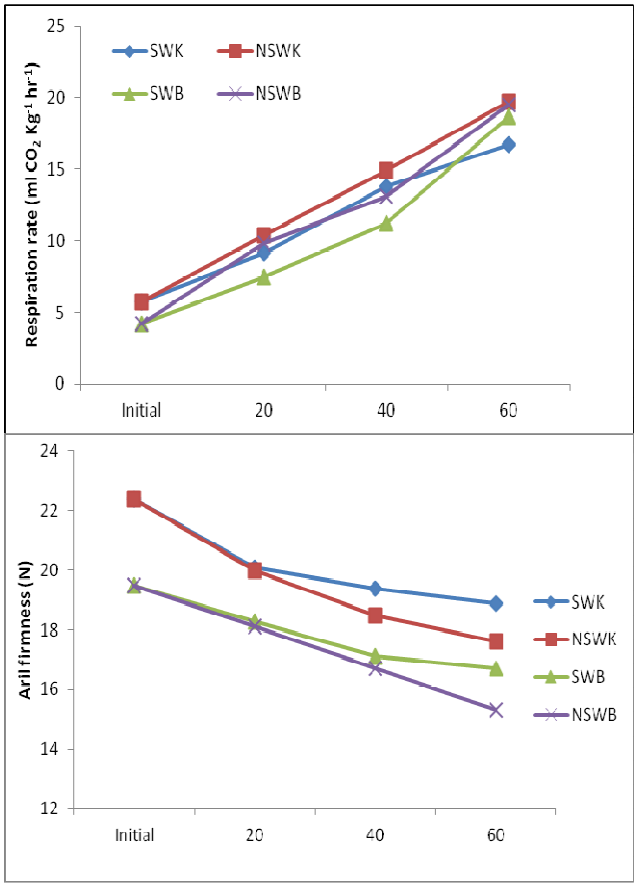

Fig.: II. Respiration rate and aril firmness of pomegranates stored at ambient conditions for 60 days.

There was a decrease in acidity both in wrapped and non-wrapped fruits during storage. The decrease in acidity was significantly less in wrapped fruits juice than in non-wrapped fruit juice. The acidity was found more in wrapped *'Kandhari'* and *'Bhagwa'* fruits (0.36 ± 0.01; 0.32 ± 0.02) whereas acidity was recorded less in non-wrapped (0.28 ± 0.01; 0.32 ± 0.01) fruits during the storage period.

A decrease pattern was observed in ascorbic acid contents during the storage in both wrapped and non-wrapped fruits. Shrink wrapped fruits showed better in concentrations of ascorbic acid than non-wrapped fruits. The ascorbic acid was retain more in shrink wrapped *'Kandhari'* and 'Bhagwa' (19.6 ± 0.1; 26.9 ± 0.3 mg/ml) than non shrink wrapped 'Kandhari' and 'Bhagwa' fruits had less (9.7 ± 0.1; 19.2 ± 0.4 mg/ml).

Total phenols, antioxidant capacity, anthocyanin

Loss in total phenolic contents (TPC) was less in wrapped fruits than non wrapped fruits. Wrapped *'Kandhari'* and 'Bhagwa' (113.53 ± 1.36; 132.16 ± 2.65 mg 100 ml^{-1} GAE) fruits retain more phenolic content than non-

wrapped Kandhari and Bhagwa fruits (86.92 ± 1.17; 91.06 mg 100 ml^{-1} GAE. (Fig. I).

Wrapped *'Kandhari'* and 'Bhagwa' fruits had highest in antioxidant capacity after end of storage period (13.64 ± 1.43; 17.43 ± 2.11 µmol Trolox ml^{-1}) than non-wrapped *'Kandhari'* and 'Bhagwa' fruits (9.76 ± 0.95; 11.39 ± 1.59 µmol Trolox ml^{-1}). (Fig. I).

Interestingly, the observed changes in total anthocyanins coincided with the trends observed in the antioxidant capacity exhibited by the fruits during postharvest storage. During the storage days the total anthocyanin contents of wrapped *'Kandhari'* (337.48 ± 32.64 mg L^{-1}) and 'Bhagwa' (435.61 ± 35.43) remain higher than non-wrapped *'Kandhari'* (285.71 ± 28.11 mg L^{-1}) and 'Bhagwa' fruits (367.93 ± 28.71). (Fig. I).

Subjective assessment

Visual appearance was strongly affected by weight loss and skin browning. In control fruit the loss of visual quality was seen during 20 days of storage, whereas at the end of the 30 days of storage fruits were found unmarketable. Shrink-wrapping preserved fruit freshness, although objective measurements of juice showed significant changes in total soluble solids and acidity. Panelists detect differences in sweetness and flavours at after each intervals of storage period. while some off-flavour was perceived in control fruit at the last assessment.

DISCUSSION

Pomegranate fruit had relatively low respiration rate, which declined during storage period. Elyatem and Kader (1984), Ben-Arie et al. (1986), Koksal (1989), Artes et al. (1996) also noted a decline in respiration rate of pomegranates during storage. Shrink wrapping significantly reduced the respiration rate, this might be due to better barrier properties of shrink wrap against atmospheric moisture.

The firmness of pomegranate fruit was maintained throughout the storage period when they were shrink-wrapped. Similar pattern of firmness in shrink wrapping of several fruits and vegetables have been reported by (Risse, 1989), (Ben-Yehoshua et al., 1985) in lemons and peppers. Firmness was maintained significantly better when the fruits were wrapped. The non-wrapped fruits became tough, desiccated and less firm.

Weight loss was low in the shrink wrap fruits in comparison to non-wrap fruits. This might be due to less transpiration and respiration rate in shrink wrap fruits. Reduction in weight loss by shrink wrapping was also reported. Nanda et al. (2001) observed similar results in the 'Ganesh' cultivar. The reduction in loss in weight and retention of juice content in wrapped fruits might be due to lower transpiration rate. Similar juice percentage during storage of grapefruit were observed by Padule and Keskar (1988).

The hunter 'a' value was low in non-shrink wrapped fruits than wrapped fruits this might be due to browning of arils, higher transpiration rate in non-wrapped fruits, decrease in phenolic compounds and anthocyanins which imparts the colour of the arils (Table 1). Elyatem and Kader (1984), Gil et al. (1996) have also reported no significant differences in juice colour of pomegranate fruit stored at 0 or 5°C up to 10 weeks and at 5°C up to 6 weeks.

A decreasing trend in total soluble solids was observed in both wrapped and non-wrapped fruits. This might be due to decrease in sugar content. Similar trend has been reported by *Padule and Keskar* (1988), *Artes et al*. (1998, 2000) in *'Ganesh'* and *'Mollar'* cultivars respectively. Similarly, *S. Nanda et al*. (2001) observed that there was decrease in soluble solids contents in Cv. *'Ganesh'* after storage.

As pomegranate is a non climacteric fruit, loss in acid occurred with ongoing metabolism, in agreement with that observed in *'Wonderful'* (*Kader et al.*, 1984) and *'Mollar'* (*Artes et al.* 1998, 2000) cultivars of pomegranate. (Table 3). *Koksal* (1989), *Waskar et al.* (1999), *Artes et al.* (2000) noted similar observations in different cultivars of pomegranate under different storage conditions. However, *Gil et al.* (1996) did not find any significant difference in the acidity of *'Mollar'* pomegranates during cold storage at 5°C for 6 weeks. This might be due to higher rates of respiration in non-wrapped fruit as compared to a reduced rate in wrapped fruit.

Koksal (1989) also reported significant loss in vitamin C content in pomegranate fruits (*cv. Gok Bahce*) stored at higher temperatures. *Dhalla and Hanson* (1988) also reported a gradual decrease in the vitamin C content of Pro-long- treated *'Julie'* mangoes during storage at 25°C. Shrink wrapped fruits showed higher ascorbic acid in comparision of non-wrap fruits, this might be due to the lower transpiration rate in shrink wrapped fruits (Table 3).

Phenolic content decreased with increase in storage period. However the decrease was less in shrink wrapped fruits than non-wrapped fruits. Reduction in total phenolic contents during postharvest storage could be attributed to phenolic degradation as a result of enzymatic activities occurring in the fruit as previously reported in other fruit such as *'rowanberries'* (*Baltacioglu et al., 2011*). Our findings are also in agreement with the report by *Sayyari et al.* (2011).

Total antioxidant decreased with increase in storage period. However the decrease was less in shrink wrapped fruits than non-wrapped fruits. This

might be due available of high levels of total phenolic concentrations including flavonoids, anthocyanins and other polyphenol compounds (*Kulkarni and Aradhya*, 2005; *Ayhan and Esturk*, 2009) (Fig. I A).

4. Conclusion

Shrink wrapping of pomegranate fruits maintained freshness and extended storage life of pomegranate fruits at ambient conditions. The shrink wrapped fruits could be stored for a period of 60 days at (18-30^{o}C, RH 55-60%) without much deterioration in quality characteristics. Hence, shrink wrap film (29µm thickness) could be used for '*Kandhari'* and '*Bhagwa'* cultivars for maintaining the quality and higher shelf life of pomegranate fruits.

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