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Effect of chemicals and modified atmosphere packaging on selected physico-chemical characteristics of Baramasi lemon fruits at ambient conditions

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Abstract

The effect of chemicals and modified packaging material on physico-chemical characteristics of stored Baramasi lemon (*Citrus limon* L. Burm) fruits at ambient conditions was studied during 2014 in Post-harvest Laboratory, Department of Fruit Science, Punjab Agricultural University, Ludhiana. The mature green winter Baramasi lemon fruits of uniform size and colour were harvested and treated with gibberellic acid (GA_3- 25, 50 & 75 ppm), boric acid (BA- 1, 2 & 3 %), sodium benzoate (SB- 2, 3 & 4%) and packed in low density polyethylene (LDPE) film. After packaging, fruits were kept at ambient conditions for 60 days and analyzed for various physical and chemical parameters after 15, 30, 45 and 60 days of storage. GA_3 @ 75 ppm treated and LDPE packed fruits showed better results in respect of juice percentage (46.59%), peel percentage (42.67%), TSS: acid ratio (1.39), vitamin C (51.75) and total sugar content (2.29%). Based on results of this study, it can be concluded that GA_3 @ 75 ppm + LDPE packaging to be the most suitable treatment in improving physico-chemical traits i.e. storage quality, ripening and shelf-life for 60 days at ambient conditions.

Key words

Baramasi lemon, Gibberellic acid, LDPE packaging, Shelf life, Storage life

Introduction

Citrus is one of the most important fruit among the tropical and sub-tropical fruits of the world. Baramasi lemon (*Citrus limon* L. Burm) is an evergreen citrus fruit plant. Lime and Lemon are occupy an area of 279.3 (000) ha with an annual production of 2476.0 (000) MT (Anon 2014a). In Punjab, lime and lemon are grown on 632.0 ha with annual production 4830.0 MT (Anon 2014b). Lemon is an attractive fruit for its unique flavor and acidity. Lime and lemon have high medicinal values and industrial use as it is a rich source of vitamin C. Baramasi lemon (*Citrus limon* L. Burm) is well adapted to agro-climatic conditions of Punjab and it bears twice a year i.e. July-August and January-February with a sparse flowering and fruiting throughout the year. Harvesting period of winter crop of Baramasi lemon coincides with cooler part of the year, which leads to the glut in market and low returns to growers. Baramasi lemons are sensitive to chilling injury, so it is difficult to store in the commercial cold stores. In common citrus varieties, chilling injury manifests in various forms including scald-like discoloration, watery breakdown and pitting (Porat *et al.* 2004). There is a need to enhance the shelf-life of Baramasi lemon fruit at ambient conditions. Lemons undergo various physiological changes during storage and the main factors governing storage life of fruits are fruit quality, weight loss and decay.

Internationally, several post-harvest technologies have been introduced to control fruit disorders, maintain optimum fruit quality, freshness and minimize the losses (Hagenmaier 2002; Bajwa and Anjum 2007). The most commonly used technologies are polyethylene packaging, use of fungicides & growth regulators, emulsion coatings and chlorination *etc*. Perez *et al.* (2002); Thakur *et al.* (2002).

Modified atmosphere packaging is an ideal preservation technique (Mangaraj and Goswami 2009) and is known to have great potential in extending the post harvest life of fruits and vegetables (Thompson 1998). Modified atmosphere packaging is very effective in controlling degree of gaseous exchange and interact with physiological processes of commodity resulting in reduced rate of respiration, transpiration and other metabolic processes of fruits (Lange 2000) thereby allowing lower physiological weight loss, reducing decay incidence and maintaining retention of colour and texture of fruits during extended shelf life (Sharma *et al.,* 2010).

Some efforts have been made by employing certain chemicals/plant growth hormones to hasten or delay ripening, reduce losses, improve new and maintain once of quality by slowing down the metabolic activities of the fruit (Ben-Yehoshua *et al.* 1981). The use of plant growth regulators in improving citrus fruit quality is well documented in literature (Pozo *et al*. 2000; Fidelibus *et al*. 2002). Ladaniya (2003) observed increase in shelf life of sweet orange fruits with fungicidal treatment. Keeping in this view, the present investigation was undertaken to evaluate the potential of post-harvest treatments of chemicals and modified atmosphere packaging to enhance the storage life and quality of Baramasi lemon fruits at ambient conditions.

Materials and Methods

Experimental site: The present studies were carried out during 2014 in the Post-harvest Laboratory, Department of Fruit Science, Punjab Agricultural University, Ludhiana.

Experimental details: Mature green Baramasi lemon fruits of uniform size and colour were harvested in the month of January. The fruits were surface sterilized in chlorinated water so as to reduce the microbial infection. Washed and selected fruits were subjected to various post-harvest treatments *viz*. T_1 (GA_3 @ 25 ppm + LDPE bags), T_2 (GA_3 @ 50 ppm + LDPE bags), T_3 (GA_3 @ 75 ppm + LDPE bags), T_4 (Boric acid @ 1% + LDPE bags), T_5 (Boric acid @ 2% + LDPE bags), T_6 (Boric acid @ 3% + LDPE bags), T_7 (SB @ 2% + LDPE bags), T_8 (SB @ 3% + LDPE bags), T_9 (SB @ 4% + LDPE bags), T_{10} [Control (water dip + LDPE bags)] and T_{11} [Control (water dip and unpacked)] for 5 min in aqueous solutions. For storage studies 1.0 kg fruit from each replication of each treatment were packed in low density polyethylene packaging (LDPE) bags. The bags were sealed with electric sealer and kept at ambient conditions for 60 days. Fruit samples were analyzed after 15, 30, 45 and 60 days of storage for following physico-chemical characteristics:

Juice and Peel Percentage: Peel was removed and weighed. The fruit juice was extracted with help of citrus juicer and strained through mesh and weighed. The juice and peel of percentage was calculated on fresh weight basis.

TSS: acid ratio: TSS acid ratio was calculated by dividing the values of TSS with the corresponding values of titratable acidity.

Vitamin C: Vitamin C (ascorbic acid) content was determined by using detective dye 2,6 dichlorophenol indophenol (DCPIP) visual titration method (Ranganna, 1994).

Total sugars: Total sugars of fruits were estimated according to the method described by A.O.A.C. (1990). Total sugars were calculated and expressed in percentage.

Statistical analysis: Data were analyzed statistically by Completely Randomized Block design (CRD) as described by Singh *et al*. (1998).

Table 1.: Effect of chemicals and modified atmosphere packaging materialon peel percentage of Baramasi lemon fruits at ambient conditions

Treatment	Peel (%)				
	Storage interval (Days)				
	15	30	45	60	Mean
T_1 Gibberellic acid @ 25 ppm	46.07	44.46	42.29	41.11	43.48
T_2 Gibberellic acid @50 ppm	48.23	46.43	44.45	43.29	45.60
T_3 Gibberellic acid @75 ppm	48.63	47.36	45.61	44.78	46.59
T_4 Boric acid @ 1%	44.38	41.24	39.11	39.07	40.95
T_5 Boric acid @ 2%	46.69	44.67	43.16	41.89	44.10
T_6 Boric acid @ 3%	47.33	45.74	43.82	42.79	44.92
T_7 Sodium benzoate @ 2%	43.70	40.07	38.21	38.62	40.15
T_8 Sodium benzoate @ 3%	44.89	42.65	39.76	39.48	41.69
T_9 Sodium benzoate @ 4%	45.34	43.98	41.38	40.66	42.84
T_{10} Control (water dip+ LDPE)	42.74	39.51	36.30	37.68	39.05
T_{11} Control (water dip) unpacked	40.06	31.25	29.45	18.20	29.74
Mean	45.27	42.48	40.32	38.87	

CD at 5% level Treatment: 0.81 Storage: 0.48 Storage × Treatment: 1.62 Base value: 50.12%

Table 2.: Effect of chemicals and modified atmosphere packaging on juice percentage of Baramasi lemon fruits at ambient conditions

Treatment	Juice (%)				
	Storage interval (Days)				
	15	**30**	**45**	**60**	**Mean**
T_1 Gibberellic acid @ 25 ppm	40.46	41.69	40.52	39.52	40.53
T_2 Gibberellic acid @50 ppm	39.57	43.24	43.61	42.54	42.21
T_3 Gibberellic acid @75 ppm	39.21	43.41	44.17	43.92	42.67
T_4 Boric acid @ 1%	41.43	40.51	38.69	37.64	39.56
T_5 Boric acid @ 2%	40.23	42.29	40.34	40.26	40.78
T_6 Boric acid @ 3%	40.12	42.86	43.41	41.19	41.89
T_7 Sodium benzoate @ 2%	41.65	40.42	37.80	36.56	39.10
T_8 Sodium benzoate @ 3%	41.76	40.74	38.92	37.93	39.83
T_9 Sodium benzoate @ 4%	40.87	41.07	39.71	38.20	39.96
T_{10} Control (water dip+ LDPE)	42.06	39.89	37.39	34.02	38.34
T_{11} Control (water dip) unpacked	44.38	39.02	27.63	18.36	32.84
Mean	40.98	41.37	39.29	37.28	

CD at 5% level Treatment: 0.72 Storage: 0.49 Storage × Treatment: 1.56 Base value: 38.14%

Table 3.: Effect of chemicals and modified atmosphere packaging on TSS: Acid ratio of Baramasi lemon fruits at ambient conditions

Treatment	TSS: Acid ratio				
	Storage interval (Days)				
	15	**30**	**45**	**60**	**Mean**
T_1 Gibberellic acid @ 25 ppm	1.44	1.43	1.46	1.49	1.45
T_2 Gibberellic acid @50 ppm	1.43	1.40	1.41	1.41	1.41
T_3 Gibberellic acid @75 ppm	1.42	1.39	1.38	1.38	1.39
T_4 Boric acid @ 1%	1.45	1.45	1.50	1.55	1.48
T_5 Boric acid @ 2%	1.45	1.42	1.45	1.47	1.44
T_6 Boric acid @ 3%	1.44	1.40	1.41	1.44	1.42
T_7 Sodium benzoate @ 2%	1.45	1.48	1.53	1.60	1.51
T_8 Sodium benzoate @ 3%	1.45	1.45	1.50	1.54	1.48
T_9 Sodium benzoate @ 4%	1.44	1.43	1.47	1.51	1.46
T_{10} Control (water dip+ LDPE)	1.45	1.51	1.59	1.72	1.56
T_{11} Control (water dip) unpacked	1.47	1.52	1.88	2.42	1.82
Mean	1.45	1.44	1.50	1.58	

CD at 5% level Treatment: 0.15 Storage: 0.18 Storage × Treatment: 0.23 Base Value: 1.48

Table 4.: Effect of chemicals and modified atmosphere packaging on vitamin C content of Baramasi lemon fruits at ambient conditions

Treatment	Vitamin C (mg 100 ml^{-1} juice)				
	Storage interval (Days)				
	15	**30**	**45**	**60**	**Mean**
T_1 Gibberellic acid @ 25 ppm	49.05	50.74	48.73	46.61	**48.78**
T_2 Gibberellic acid @50 ppm	50.13	51.61	52.19	51.66	**51.44**
T_3 Gibberellic acid @75 ppm	50.49	52.03	52.37	52.02	**51.75**
T_4 Boric acid @ 1%	47.67	49.48	44.28	41.42	**45.71**
T_5 Boric acid @ 2%	49.52	51.32	49.27	46.93	**49.26**
T_6 Boric acid @ 3%	49.88	51.29	51.57	47.85	**50.15**
T_7 Sodium benzoate @ 2%	47.29	47.25	43.54	40.47	**44.63**
T_8 Sodium benzoate @ 3%	48.32	49.93	46.39	44.81	**47.36**
T_9 Sodium benzoate @ 4%	48.85	50.12	47.69	45.56	**48.05**
T_{10} Control (water dip+ LDPE)	46.73	45.61	42.30	39.38	**43.50**
T_{11} Control (water dip) unpacked	44.56	44.18	39.42	37.12	**41.32**
Mean	**48.40**	**49.55**	**46.97**	**44.91**	

CD at 5% level Treatment: 0.81 Storage: 0.48 Storage × Treatment: 1.62 **Base Value**: 44.13 mg/100 ml juice

Table 5.: Effect of chemicals and modified atmosphere packaging on total sugars (%) of Baramasi lemon fruits at ambient conditions

Treatment	Total sugars (%)				
	Storage interval (Days)				
	15	30	45	60	Mean
T_1 Gibberellic acid @ 25 ppm	2.28	2.38	2.52	2.68	**2.46**
T_2 Gibberellic acid @50 ppm	2.20	2.26	2.38	2.53	**2.34**
T_3 Gibberellic acid @75 ppm	2.16	2.24	2.32	2.47	**2.29**
T_4 Boric acid @ 1%	2.40	2.56	2.73	2.97	**2.66**
T_5 Boric acid @ 2%	2.26	2.37	2.53	2.61	**2.44**
T_6 Boric acid @ 3%	2.23	2.34	2.47	2.57	**2.40**
T_7 Sodium benzoate @ 2%	2.47	2.60	2.82	3.04	**2.73**
T_8 Sodium benzoate @ 3%	2.36	2.43	2.61	2.85	**2.56**
T_9 Sodium benzoate @ 4%	2.31	2.40	2.58	2.75	**2.51**
T_{10} Control (water dip+ LDPE)	2.52	2.72	2.93	3.10	**2.81**
T_{11} Control (water dip) unpacked	2.69	3.00	3.47	3.86	**3.25**
Mean	**2.35**	**2.48**	**2.66**	**2.85**	

CD at 5% level Treatment: 0.15 Storage: 0.09 Storage × Treatment: 0.31 **Base Value**: 2.11%

Results and Discussion

The results regarding physico-chemical parameters are presented in Table 1-5. The untreated and unpacked control fruits showed an entirely different pattern as it displayed fast senescence and ripening rate. On the other hand, chemical treated and LDPE packed fruits were acceptable even after 60 days of ambient storage. With slow ripening, the rate of change in all physico-chemical was also very slow. It was also observed that all the treatments differed in their effect on quality parameters at each storage interval.

Data presented in Table (1.) shows the effect of chemicals and modified atmosphere packaging on peel percentage of Baramasi lemons stored at ambient conditions. It was noticed that peel percentage of Baramasi lemon fruit declined with advancement of storage period. Treatments GA_3 @ 75 & 50 ppm and BA @ 1 & 2% treatment were superior in maintenaning of peel of fruit. The average maximum peel percentage (46.59%) was found in GA_3 @ 75 ppm treated and LDPE packed fruits, followed by GA_3@ 50 ppm treatment. The average minimum peel percentage (29.74%) was recorded in untreated and unpacked control fruits. During the entire storage period, maximum peel percentage was recorded in GA_3@ 75 ppm treated and LDPE packed fruits, which ranged between 48.63-44.78%.Interaction between treatments and storage period was found significant. All the LDPE sealed fruits recorded higher peel percentage as compared to non-sealed fruits at ambient conditions. This might be due to reduced physiological weight loss hence more peel percentage. Randhawa *et al.* (1999) recorded the higher peel percentage in 'Duncan' and 'Foster' Grapefruit, 'Kinnow' mandarin and 'Jaffa' sweet orange wrapped individually in high density polyethylene film over control fruits.

The effect of different chemicals and modified atmosphere packaging on juice percentage of Baramasi lemon fruits presented in Table 2. Data revealed that LDPE packaging was highly effective for maintaining the juice percentage. Post-harvest treatments of GA_3 @ 75 ppm and 50 ppm along with LDPE packaging significantly lowered the reduction of juice percentage as compared to untreated and unpacked control fruits. The mean maximum juice percentage (42.67%) was recorded in GA_3 @ 75ppm + LDPE packaging treatment, which was followed by GA_3 @ 50 ppm treatment, whereas average minimum juice percentage (32.84%) was recorded in control (water dip and unpacked) fruits.

Interaction between treatments and storage period was found significant. The inclination in juice content might be due to slow ripening of GA_3 coated and LDPE wrapped fruits which resulted reduced transpiration and respiration losses, thus higher juice percentage. In polyethylene film more loss of moisture from rind as compared to flesh of the fruit (Ladaniya, 2008) resulted in increase of juice mass (%). Reddy *et al.* (2008), who reported that low density polyethylene packaging was most effective in preventing the reduction in juice and acidity content of acid lime and Khalid *et al.* (2012) who found that GA_3 significantly increased the juice yield and decreased the rag percentage of Kinnow fruit.

Data presented on the effect of treatments on TSS: acid ratio of Baramasi lemon fruits stored at ambient conditions given in Table 3. The average TSS: acidity ratio decreased up to 30 days of storage after that an increase was recorded. The mean minimum TSS:acid ratio (1.44%) was observed after 30 days of storage and average maximum (1.58%) value was recorded after 60 days of storage. Post-harvest treatment of chemicals and modified atmosphere material significantly delayed the increase in TSS: acid ratio as compared to unpacked control fruits. The mean minimum (1.39) TSS: acidity ratio was retained by fruits treated with GA_3 @ 75 ppm along with LDPE packaging, whereas the average maximum TSS: acidity (1.82) ratio was recorded in untreated and unpacked control fruits. Interaction between treatments and storage period was found to be significant. The obtained results are in agreement with Rab *et al.* (2010) who studied TSS: acid ratio of sweet orange fruit packed in polyethylene bags and found minimum increase in TSS: acid ratio in polyethylene, cellophane and polyethylene green bags, while maximum increase in ratio was recorded in control fruits.

Data presented in atmosphere packaging of Table (4) shows the effect of chemicals and modified atmosphere packaging on vitamin C content of Baramasi lemon fruit sorted at ambient conditions. Regarding the effect of GA_3, BA, SB and LDPE packaging on vitamin C, results obtained showed that average ascorbic acid (vitamin C) content of fruits rose up to 30 days of storage, afterwards a decrease was recorded by the end of 60 days storage. The mean maximum vitamin C (51.75 mg100^{-1} ml juice) was recorded in fruits treated with GA_3 @ 75 ppm along with LDPE bags, followed by GA_3 @ 50 ppm + LDPE packaging treatment (51.44 mg) and the mean minimum (41.32 mg) vitamin C content was observed in untreated and unpacked control fruits.

Maximum ascorbic acid might be due to metabolic changes and increasing percentage of acidity under LDPE packaging and chemicals coating. The modified atmosphere packaging and GA_3 helped in reducing the rate of respiration and ripening which resulted in dissipation of ascorbic acid to dehydro ascorbic acid during storage. These findings are in conformation with El-Monem *et al.* (2003) in guava and Bisen *et al.* (2012) in Kagzi lime. Minimum (41.32 mg/100 ml juice) ascorbic acid content in untreated and unpacked control fruits was possibly due to rapid conversion of ascorbic acid in to dehydro ascorbic acid in to presence of enzymes ascorbinase. The results corroborates with the finding of Kaur and Singh (2012) in Baramasi lemon fruits. The influence of polyethylene films on maintaining higher ascorbic acid content in citrus fruits has also been reported by Ladaniya and Singh (2001) and Ladaniya (2003).

Data regarding the effect of chemicals and modified atmosphere packaging material on total sugars of Baramasi lemon fruits stored at ambient conditions is presented in table (5). Total sugars showed a progressive increasing trend up to 60 days of storage in all the treatments. The average minimum total sugars (2.29%) were recorded in GA_3 @ 75 ppm + LDPE packaging treatment and average maximum (3.25%) total sugar content was found in untreated and unpacked control fruits. During the entire storage period, mean minimum total sugars were recorded in fruits treated with GA_3 @ 75 ppm. An increase in total sugars in juice during post harvest storage may be due to cell wall hydrolysis by various enzymes such as pectinase, cellulase or hemicellulase (Echeverria and Valich 1989). Polyethylene packing delayed breakdown of starch and slowed down the formation of reducing and total sugar (Hiwale and Singh 2003). The results of total sugars reported in the present study is in agreement with the findings of Nirupama *et al.* (2010) in tomato and Kaur and Singh (2012) in Baramasi lemon, who concluded that fruits wrapped in HDPE film maintained lowest reducing sugar content at the end of storage.

Thus, can be concluded that Baramasi lemon fruits treated with GA_3 @ 75 ppm and packed in LDPE bags can be safely stored up to 60 days at ambient conditions.

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