International Journal of Agriculture, Environment & Biotechnology
Citation: IJAEB: 7(4): 895-902 December 2014
DOI Number: 10.5958/2230-732X.2014.01402.8

HORTICULTURE

Response of baramasi lemon to various post-harvest treatments

Simranbir Kaur[1], S.K. Jawandha[2*] and Harminder Singh[3]

Department of Fruit Science, Punjab Agricultural University, Ludhiana - 141004, Punjab, India

*Corresponding author : skjawandha@pau.edu

Paper No. 283 Received : 15 June, 2014 Accepted: 14 November, 2014 Published: 15 December, 2014

Abstract

Baramasi lemon is an attractive fruit for its unique flavor and acidity. Harvesting period of winter crop of Baramasi lemon coincides with the cooler part of the year and there is low consumption of lemon fruits during winters, which leads to the glut in the market. Baramasi lemons are sensitive to chilling injury and it is difficult to store in the commercial cold stores. So, there is a need to enhance the shelf-life of Baramasi lemon fruits at ambient conditions. Keeping this in view, an experiment was conducted during 2014 to study the effect of chemicals and modified atmosphere packaging on the storage life and quality of Baramasi lemon fruits. Mature green Baramasi lemon fruits of uniform size and colour were harvested and treated with gibberellic acid (25, 50 &75 ppm), boric acid (1, 2 and 3%) and sodium benzoate (2, 3 and 4%) and packed in low density polyethylene (LDPE) bags. Fruit were analyzed for various physico-chemical characteristics after 15, 30, 45 and 60 days of storage. Results revealed that minimum spoilage and total soluble solids (TSS) and maximum physiological weight loss reduction, palatability rating, acidity were recorded in gibberellic acid @ 75 ppm + LDPE packaging during the entire storage period. It can be concluded that gibberellic acid @ 75 ppm along with LDPE packaging was found to be most effective in extending the post-harvest life of Baramasi lemon fruits at ambient conditions for 60 days.

Highlights

- Postharvest treatment of gibberellic acid @ 75 ppm + LDPE packaging enhanced the storage life and quality of Baramasi lemon fruits up to 60 days under ambient conditions.

Keywords: Baramasi lemon, gibberellic acid, boric acid, LDPE packaging, storage life

Citrus is one of most important fruit among the tropical and sub-tropical fruits of the world. India is the major producer of limes and lemons and it is considered to be probable origin place of lemons Tanaka, (1958). Lime and Lemon are grown in tropical and subtropical regions of India occupying an area of 279.3 (000) ha with an annual production of 2476.0 (000) MT (Anon 2014). Lime and lemon have high medicinal value 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. Harvesting period of winter crop of Baramasi lemon coincides with the cooler part of the year and there is low consumption of lemon fruits during winters, which leads to glut in the market and low returns to growers. Baramasi lemons are sensitive to chilling injury and it is difficult to store in the commercial cold stores which are generally operated at low temperatures. So, there is a need to enhance the shelf-life of Baramasi lemon fruit at ambient conditions.

Internationally, several post-harvest technologies have been introduced to control fruit disorders, maintain optimum fruit quality, freshness and minimize the losses (Krochta, 1997; Hagenmaier, 2002; Bajwa and Anjum, 2007). The most common used technologies are polyethylene packaging, use of fungicides and growth regulators, emulsion coatings and chlorination (Perez *et al.,* 2002; Thakur *et al.*, 2002). Modified atmosphere packaging is very effective in lowering the degree of gaseous exchange resulting reduced rate of respiration, transpiration and other metabolic processes of the fruits (Zagory and Kader, 1988). Jawandha *et al.*,2014 reported that Low density polyethylene packaging (LDPE) was found to be most effective in maintaining the best quality Baramasi lemon fruits for 50 days storage at ambient conditions.

Several growth regulators and other chemicals also have been reported to extend the post harvest life of many fruits (Khadar *et al.*, 1988). Some efforts have been made to in direction by employing certain chemicals/plant growth hormones to hasten or delay ripening, to reduce losses and to improve and maintain the colour and quality by slowing down the metabolic activities of the fruit (Ben-Yehoshua *et al.*, 1981). These chemicals are reported to arrest the growth and spread of micro organisms by reducing the shriveling which ultimately leads to an increased shelf life and maintain the marketability of the fruit for a longer period (Ben-Yehoshua *et al.,* 1981). In view of the above reports, the present study has been 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

The experiment was conducted in the Department of fruit Science, Punjab Agricultural University, Ludhiana during 2014. The mature green winter Baramasi lemon fruits of uniform size and colour were harvested in the month of January and transported to the Post-harvest laboratory, Department of fruit science. The fruits were washed in chlorinated water and subjected to various 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 (Sodium benzoate @ 2% + LDPE bags), T_8 (Sodium benzoate @ 3% + LDPE bags), T_9 (Sodium benzoate @ 4% + LDPE bags), T_{10} [Control (water dip + LDPE bags)] and T_{11} [Control (water dip and unpacked)] for five minutes in the aqueous solutions. For storage studies 1.0 kg fruits 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 various physico-chemical characteristics:

Physiological loss in weight: The PLW was calculated on initial weight basis. The percent loss in weight after each storage interval was calculated by subtracting final weight from initial weight of the fruits and then converted into percentage value. The cumulative loss in weight was calculated on fresh weight basis.

PLW % = (Initial fruit wt.-Final fruit wt.)/(Initial fruit wt) × 100

Spoilage percentage: Spoilage percentage was calculated by counting the total number of fruits that had spoiled in each replication and total number of fruits per replication at each storage interval.

Spoilage (%) = (Number of spoiled fruits)/(Total number of fruits) × 100

Palatability rating: The fruits were rated for this character by a panel of five judges on the basis of external appearance and freshness of fruit button. A Nine point 'Hedonic scale' described by Amerine *et al.*, (1965) was used for its inference in which 9 for extremely desirable, 8 for Very much desirable, 7 for moderately desirable, 6 for slightly desirable, 5 for neither desirable or undesirable,4 for slightly undesirable, 3 for moderately undesirable, 2 for Very much undesirable and extremely undesirable.

Table 1. Effect of chemicals and modified atmosphere packaging on physiological loss in weight (PLW) Baramasi lemon fruits at ambient conditions

Treatment	Physical loss in weight				
	Storage interval (Days)				
	15	30	45	60	Mean
T_1 Gibberellic acid @ 25 ppm	0.25	0.29	0.33	0.39	0.31
T_2 Gibberellic acid @50 ppm	0.21	0.24	0.28	0.33	0.26
T_3 Gibberellic acid @75 ppm	0.19	0.22	0.25	0.29	0.23
T_4 Boric acid @ 1%	0.28	0.33	0.38	0.44	0.35
T_5 Boric acid @ 2%	0.24	0.28	0.32	0.36	0.30
T_6 Boric acid @ 3%	0.22	0.26	0.30	0.35	0.28
T_7 Sodium benzoate @ 2%	0.31	0.36	0.43	0.50	0.40
T_8 Sodium benzoate @ 3%	0.27	0.32	0.37	0.43	0.34
T_9 Sodium benzoate @ 4%	0.25	0.29	0.34	0.40	0.32
T_{10} Control (water dip+ LDPE)	0.34	0.40	0.49	0.56	0.44
T_{11} Control (water dip) unpacked	4.60	7.31		27.55	13.59
Mean	0.65	0.93	1.67	2.87	

CD at 5% level Treatment: 0.26
Storage: 0.15 Storage × Treatment: 0.51

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

Treatment	Spoilage (%)				
	Storage interval (Days)				
	15	30	45	60	Mean
T_1 Gibberellic acid @ 25 ppm	0	0	0	0	0
T_2 Gibberellic acid @50 ppm	0	0	0	0	0
T_3 Gibberellic acid @75 ppm	0	0	0	0	0
T_4 Boric acid @ 1%	0	0	0	0	0
T_5 Boric acid @ 2%	0	0	0	0	0
T_6 Boric acid @ 3%	0	0	0	0	0
T_7 Sodium benzoate @ 2%	0	0	0	3.52	0.88
T_8 Sodium benzoate @ 3%	0	0	0	0	0
T_9 Sodium benzoate @ 4%	0	0	0	0	0
T_{10} Control (water dip+ LDPE)	0	0.15	4.10	8.53	3.19
T_{11} Control (water dip) unpacked	0	13.7	18.6	30.3	15.6
Mean	0	1.25	2.06	3.85	

CD at 5% level Treatment: 0.29
Storage: 0.18 Storage × Treatment: 0.59

Total soluble solids (TSS): Total soluble solids were determined from the juice at room temperature with the help of hand refractometer (Model Erma, Japan) and expressed in percent. The readings were corrected with the help of temperature correction chart at 20°C temperature (A.O.A.C., 1990).

Acidity: For determining acid content, 2 ml of juice was diluted to 10 ml with distilled water and titrated against 0.1N sodium hydroxide solution using phenolphthalein as an indicator. The acid content was expressed as percentage of citric acid in juice by using the following formula.

Acidity (%) = 0.0067 × (Volume of 0.1 N NaOH used)/(Volume of juice taken) × 100

Statistical Analysis: The data were analyzed statistically by Completely Randomized Block design (CRD) as described by Singh *et al.*, (1998).

Results and Discussion

The results of the present study "Response of Baramasi lemons to various Post-harvest treatments" are given as follows:

Physiological loss in weight (PLW)

The data presented in Table 1, showed a rapid increase in PLW in control (water dipped and unpacked) fruits during entire storage period. However, when the fruits were treated with 75 ppm GA3 and wrapped in LDPE bags the increase in

PLW was significantly reduced as compared to other treatments. The PLW was also found minimum in fruits treated with GA3 @ 75 ppm and wrapped in LDPE bags. Reduction in PLW in sealed fruits might be due to retardation in evaporation and respiration processes. The polyethylene film created the semi-permeable barrier around the fruits and water saturated atmosphere inside the bag. The chemical application, coupled with LDPE sealing was effective in reducing weight loss. It might be due to blocking of stomatal apertures and lenticels, thereby reducing the rate of respiration and transpiration. Plastic films prevent the dehydration and maintain the fruits in fresh conditions and thereby allowing the fruit storage at ambient conditions. The maximum loss in weight was recorded in unwrapped fruits because the fruits were subjected to higher rate of respiration. This higher respiration rate resulted in higher transpiration of water from the fruit surface which led to increase in percentage of weight loss (Sabir *et al.*,2004). A similar reduction in the physiological loss in weight (PLW) of gibberellic acid treated tomato fruits was recorded by Srividya *et al.*,(2014) during 45 days ambient storage. Results of this study also corelates with studty of Jawandha *et al.*,(2012) who reported that gibberellic acid treated and CFB packed ber fruits recorded minimum PLW reduction at the end of 30 days storage.

Spoilage

The data on spoilage percentage of Baramasi lemon fruits affected by different treatments during storage are represented in Table 2. Data shows that spoilage percentage increased with the progression of storage period. A significant effect of chemical treatments on spoilage of fruits was recorded, as no spoilage was recorded up to 60 days in all the chemical treatments except sodium benzoate @ 2%, but fruits under control (both LDPE packed and unpacked) showed spoilage after 30 days of storage. Baramasi lemon fruits treated with gibberellic acid (25, 50 and 75ppm), boric acid (1, 2 and 3%) and sodium benzoate (3 and 4%) + LDPE packaging treatments recorded zero spoilage throughout the storage period of 60 days at ambient conditions. The maximum spoilage was noticed in untreated and unpacked control fruits

Table 3. Effect of chemicals and modified atmosphere packaging on Palatability rating of Baramasi lemon fruits at ambient conditions

Treatment	Palatability rating (1-9)				
	Storage interval (Days)				
	15	30	45	60	Mean
T_1 Gibberellic acid @ 25 ppm	6.43	7.38	7.45	6.71	7.00
T_2 Gibberellic acid @50 ppm	6.38	7.50	7.63	7.34	7.20
T_3 Gibberellic acid @75 ppm	6.34	7.56	7.75	7.58	7.28
T_4 Boric acid @ 1%	7.18	7.30	7.17	5.93	6.89
T_5 Boric acid @ 2%	6.49	7.42	7.37	6.92	7.02
T_6 Boric acid @ 3%	6.40	7.46	7.47	7.10	7.10
T_7 Sodium benzoate @ 2%	7.38	7.29	6.91	5.26	6.71
T_8 Sodium benzoate @ 3%	7.33	7.31	7.02	5.60	6.81
T_9 Sodium benzoate @ 4%	7.27	7.35	7.25	6.03	6.97
T_{10} Control (water dip+ LDPE)	7.42	7.23	6.72	5.05	6.60
T_{11} Control (water dip) unpacked	7.58	6.62	5.57	3.25	5.75
Mean	6.92	7.32	7.11	6.01	

CD at 5% level **Base value:** 6.21

Storage: 0.08 Treatment: 0.14 Storage × Treatment: 0.28

ranging from 13.7-30.3% during 30 to 60 days of storage. The reduction in decay of fruits in polyethylene film may be due to reduction in vapour condensation (Ben-Yehosusha *et al.,* 1998). The present study confirms the results of Reddy *et al.*, (2008) who noticed the minimum spoilage in low density polyethylene film packed Acid lime fruits and Jawandha *et al.,* (2014) who reported that LDPE packed Baramasi Lemon fruits recorded minimum spoilage at the end of 50 days storage as compared to HDPE and CFB packed fruits. Exogenous application of gibberellic acid has been reported to delay post-harvest decay in citrus fruits (Ben-Yehoshua *et al.*, 1995) by maintaining flesh firmness and retarding senescence (Valero *et al.*, 1998).

Palatability rating

The overall acceptability of Baramasi lemon fruits was judged from button (calyx plus disc) freshness, appearance, acidity and juice content of fruit. The average palatability rating of fruits increased continuously up to 30 days of storage, afterwards a gradual decline was observed till the end of 60 days storage. The gibberellic acid @ 75 ppm + LDPE packed fruits maintained highest score for overall acceptability during the entire period of storage. In this treatment, all the fruits retained green buttons even after 60 days. It might be due to anti-senescence property of GA_3 and reduced water vapor transmission rate in LDPE bags which attributes to overall fruit health. The results of present study are fairly coincided with the findings of Cunninghan *et al.,* (2004) and Sakhale and Kapse, (2012) in citrus. who studied that that GA_3 and bavistin treated followed by LDPE wrapped sweet orange fruits maintained highest score for overall acceptability which was the combined effect of shriveling and juice percentage. Tarabih M E and El-Metawally, (2014) studied the effect of boric acid and jojoba oil on shelf life of Washington navel fruits and he noticed highest palatability rating of treated fruits during the period of 45 days.

Table 4. Effect of chemicals and modified atmosphere packaging on Total Soluble Solids (TSS) Baramasi lemon fruits at ambient conditions

Treatment	Total Soluble Solids (%)				
	Storage interval (Days)				
	15	30	45	60	Mean
T_1 Gibberellic acid @ 25 ppm	7.43	7.50	7.59	7.66	**7.54**
T_2 Gibberellic acid @50 ppm	7.32	7.41	7.52	7.56	**7.45**
T_3 Gibberellic acid @75 ppm	7.29	7.36	7.45	7.51	**7.40**
T_4 Boric acid @ 1%	7.58	7.66	7.73	7.80	**7.68**
T_5 Boric acid @ 2%	7.41	7.48	7.57	7.64	**7.52**
T_6 Boric acid @ 3%	7.37	7.45	7.53	7.60	**7.48**
T_7 Sodium benzoate @ 2%	7.61	7.69	7.80	7.89	**7.74**
T_8 Sodium benzoate @ 3%	7.54	7.62	7.71	7.78	**7.66**
T_9 Sodium benzoate @ 4%	7.49	7.53	7.62	7.69	**7.58**
T_{10} Control (water dip + LDPE)	7.65	7.72	7.86	7.97	**7.80**
T_{11} Control (water dip) unpacked	7.76	7.85	8.01	8.14	**7.94**
Mean	**7.49**	**7.57**	**7.67**	**7.74**	

CD at 5% level Treatment: 0.21 Storage: 0.13 Storage × Treatment:
Base value: 7.20

Table 5. Effect of chemicals and modified atmosphere packaging on Titratable acidity Baramasi lemon fruits at ambient conditions

Treatment	Titratable acidity (%)				
	Storage interval (Days)				
	15	30	45	60	Mean
T_1 Gibberellic acid @ 25 ppm	5.14	5.23	5.18	5.14	5.17
T_2 Gibberellic acid @50 ppm	5.09	5.28	5.33	5.37	5.26
T_3 Gibberellic acid @75 ppm	5.04	5.29	5.36	5.42	5.27
T_4 Boric acid @ 1%	5.23	5.27	5.12	5.01	5.15
T_5 Boric acid @ 2%	5.13	5.25	5.21	5.17	5.19
T_6 Boric acid @ 3%	5.11	5.26	5.32	5.27	5.24
T_7 Sodium benzoate @ 2%	5.23	5.19	5.07	4.91	5.10
T_8 Sodium benzoate @ 3%	5.19	5.24	5.14	5.02	5.14
T_9 Sodium benzoate @ 4%	5.16	5.26	5.16	5.08	5.16
T_{10} Control (water dip+ LDPE)	5.25	5.14	4.94	4.63	4.98
T_{11} Control (water dip) unpacked	5.28	5.11	4.26	3.36	4.51
Mean	5.16	5.22	5.09	4.94	

CD at 5% level Treatment: 0.15
Storage: 0.45 Storage × Treatment: 0.31
Base value: 4.98

Total soluble solids (TSS)

Data presented in Table 4, shows an increase in total soluble solids of Baramasi lemon fruits with progression of storage period at ambient conditions. The perusal of data revealed that TSS content of Baramasi lemon fruits increased up to 60 days of storage. The mean minimum total soluble solids content (7.40%) was found in gibberellic acid @ 75 ppm treated and LDPE bagged fruits, followed by gibberellic acid @ 50 ppm + LDPE packaging treatment and the mean maximum TSS content (7.94%) was recorded in untreated and unpacked control fruits. The increase in total soluble solids with advancement of storage period may be due to numerous catabolic processes taking place in fruits during ripening and senescence processes. The reason for increase in TSS could be attributed to water loss and hydrolysis of starch and other polysaccharides to soluble form of sugars. Wills *et al.*,(1980); Wani, (1997) reported that starch gets hydrolysis into mono and disaccharides, which in turn may lead to an increase in TSS. The delayed increase in TSS over longer periods of time in gibberellic acid treated fruits might be attributed to anti-senescent properties of gibberellic acid, which delayed the ethylene production, senescence process and simultaneously delayed the conversion of starch into sugars. The results on total soluble solids in present study are in agreement with the findings of Bisen *et al.*, (2012) in Kagzi lime fruits. Kaur *et al*., (2013) studied that different packaging materials maintained the perfect balance between sugars and acids of pear fruits up to 75 days of storage.

Titratable Acidity

The mean titratable acidity of Baramasi lemon fruits showed an increasing trend up to 30 days of storage and then decrease in acidity was observed by the end of 60 days storage at ambient conditions. The maximum acidity (5.27%) was recorded in gibberellic acid @ 75 ppm, followed by gibberellic acid @ 50 ppm (5.26%) treatment and minimum titratable acidity (4.51%) was noticed in untreated and unpacked control fruits. During entire storage period, the highest titratable acidity was maintained by fruits treated with gibberellic acid @ 75 ppm ranging from 5.04%-5.42% and lowest acidity was recorded in control fruits which ranged from 5.28%-3.36%. These findings are in conformation Cohen *et al*., (1990) in 'Eureka' lemons and Singh and Singhrot, (1994) in Baramasi lemon.

The decrease in titratable acids during storage may be attributed to utilization of organic acids in pyruvate decarboxylation reaction occurring during the ripening process of fruits (Rhodes *et al*., 1968 and Pool *et al*., 1972). When the fruits are treated with chemicals and wrapped in films, the lowering of acidity was delayed, which might be due to effect of gibberellic acid and LDPE packaging films that delayed the respiratory and ripening process. High level of acid retention also seems to be associated with lower rate of respiration in LDPE bags. The results also corroborates with the finding of Bisen *et al*., (2012) in Kagzi lime fruits.

Conclusion

It can be concluded from the study that Baramasi lemon fruits treated with gibberellic acid @ 75 ppm and packed in LDPE bags can be safely stored up to 60 days at ambient conditions.

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