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Short communication
Studies on shelf life extension of sweet oranges (*Citrus sinensis* L.)

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Abstract: Attempts were made to extend the shelf life of sweet oranges after harvesting by treating with 50, 100 and 150 ppm of giberellic acid (GA_3) with or without 500 ppm of fungicide (bavistin) and wrapping with LDPE bags of 20% vents for a period of 24 days. There was a significant improvement ($P<0.05$) in reduction of PLW and shriveling and increase in TSS and overall acceptability of sweet oranges treated with 100 ppm of GA_3 with 500 ppm of bavistin and wrapped in LDPE bags than rest of the treatments and control with shelf life of 24 days.

Keywords: Sweet orange, shelf life, giberellic acid, fungicide, shriveling, LDPE

Introduction

A sweet orange (*Citrus sinensis* L.) is an important fruit crop of Maharashtra state of India. It is grown on an area of 55,000 ha with 6.5 lakh tones of production per year. The area under this fruit crop is increasing rapidly as a result of dynamic employment guarantee scheme launched by Government of Maharashtra for fruit crops. However, there are heavy post harvest losses of this fruit since it has shortest shelf life of 5-7 days. It is necessary to increase the shelf life to utilize the huge production for processing into value added products and for exports with sufficient storage period in domestic as well as export market. Singh and Chundawat (1991) have tried giberellic acid (GA_3) successfully for extension of shelf life of *Kesar* mangoes. Ahmed and Khan (1987) and Ladaniya (2003) reported increase in shelf life of sweet orange fruits with fungicidal treatment. However, the studies on shelf life extension of sweet oranges with special reference to *Nucellar* cultivar with GA_3 and fungicide and wrapping with low density polyethylene (LDPE) bags are scanty. Efforts have been made in this investigation to extend shelf life of sweet oranges with low cost technology like GA_3, fungicide and wrapping with LDPE bags, the modified atmospheric packaging (MAP).

Materials and Methods

The sweet orange (Cv. *Nucellar*) fruits were harvested at physiological stage of maturity from commercial orchards of Aurangabad district of Maharashtra state, packed in corrugated fiber boxes (CFB) and brought to the laboratory. The fruits were washed with clean water and subjected to various treatments viz. T_1 (Control-plain water dip), T_2 (150 ppm GA_3), T_3 (150 ppm GA_3 + wrapping with LDPE bags), T_4 (150 ppm GA_3 + 500 ppm bavistin + wrapping with LDPE bags), T_5 (100 ppm GA_3), T_6 (100 ppm GA_3 + wrapping with LDPE bags), T_7 (100 ppm GA_3 + 500 ppm bavistin + wrapping with LDPE bags), T_8 (50 ppm GA_3), T_9 (50 ppm GA_3 + wrapping with LDPE bags), T_{10} (50 ppm GA_3 + 500 ppm bavistin + wrapping with LDPE bags).

The LDPE bags (150 gauge) used for packaging in all the treatments were having 5% vents. After treatments, the fruits were stored for 24 days at ambient condition (27 ± 2^0C). During storage, 3 fruits from each treatment were specially marked for judging Physiological Loss in Weight (PLW), Total Soluble Solids (TSS), visual shriveling and overall acceptability. The observations were recorded after every 6 days. The PLW was measured by weighing the fruits at regular intervals and expressed in percentage. The TSS content of sweet orange juice was determined with digital hand held Refractometer (Model Pal-3, Atago make, Tokyo, Japan) and expressed as ^{0}Brix.

The shriveling in fruits and overall acceptability of fruit juice with respect to color, flavor and taste were organoleptically evaluated by a semi-trained panel of 10 judges using 10 point Hedonic scale (Amerine *et al.,* 1965). The data were statistically analyzed by the method of Panse and Sukhatme (1985) and the significance was drawn at 5% level of probability.

Results and Discussion

The data pertaining to PLW of fruits and TSS content of fruit juice presented in Table 1 indicate

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Table 1. Effect of GA_3 with or without bavistin and LDPE wrapping on PLW and TSS of sweet oranges during storage

Treatments		Storage period (days)			
		6	**12**	**18**	**24**
PLW	T_1	3.5	7.5	16.3	25.7
	T_2	1.5	2.5	4.9	7.9
	T_3	0.9	1.5	3.0	4.9
	T_4	0.8	1.2	2.9	3.9
	T_5	1.4	1.9	2.5	5.2
	T_6	1.1	1.7	2.9	5.0
	T_7	0.9	1.3	3.0	4.0
	T_8	1.5	2.6	5.4	8.2
	T_9	1.2	1.5	3.3	5.3
	T_{10}	0.9	1.4	3.2	4.6
TSS	T_1	10.6	11.1	11.5	11.4
	T_2	10.5	10.9	11.2	11.3
	T_3	10.4	10.7	10.9	11.5
	T_4	10.3	10.5	10.8	11.5
	T_5	10.5	11.0	11.2	11.1
	T_6	10.5	10.9	11.0	11.3
	T_7	10.4	10.5	10.9	11.6
	T_8	10.5	11.0	11.3	11.3
	T_9	10.4	10.9	11.0	11.5
	T_{10}	10.4	10.6	10.9	11.7

		Treatments	Storage period (days)
PLW	SE±	1.909	2.259
	CD at 5%	3.953	4.677
TSS	SE±	0.079	0.094
	CD at 5%	0.164	0.194

Initial TSS content was 10.1 0Brix.

a rapid increase in PLW in fruits dipped in plain water (control) in T_1 up to 24 days of storage period. However, when the fruits were treated with 150 ppm GA_3+ 500 ppm bavistin and wrapped in LDPE bags (T_4), the increase in PLW was significantly ($P<0.05$) least than rest of the treatments. The PLW was also found minimum in fruits treated with either GA_3 or bavistin or both and wrapped in LDPE bags. The low PLW was recorded in wrapped fruits which might be due to the packing material which has arrested the loss of moisture from fruits due to evaporation. The GA_3 acts as anti-senescence agent while bavistin in addition to antifungal activity has anti-senescence characteristics and due to the combined effects of these, the PLW might have been decreased considerably in fruits treated with these. Ladaniya (2003) studied the shelf life of sealed packed sweet orange fruits in heat shrinkable film (LDPE) and stored the fruits in CFB boxes at 25 ± 5^0C and 40-45%RH. He observed the weight loss of 1.60% in fruits wrapped in LDPE over the unwrapped control fruits (25.51%). Similarly Sakhale *et al* (2009) have also reported that the GA_3 treatment in Kesar mangoes at 100 ppm concentration coupled with 8% calcium chloride and 500 ppm bavistin proved to be beneficial for desirable sensorial quality parameters and better extended shelf life with least incidence of diseases.

In the present investigation, minimum PLW in the treatment T_4 could be because of dipping of sweet orange in GA_3 and bavistin and also wrapping with LPDF bags. Dipping of sweet orange in these solution and further wrapping might have resulted in lowest PLW (3.9%) as against 25.7% PLW in T_1 where in the fruits were given only a plain water dipping treatment (control).

The data in Table 1 further indicate the least but significant variation ($p<0.05$) in the contents of TSS in fruit juice during storage. The higher TSS was recorded in fruits treated with GA_3 and/or bavistin and wrapped in LDPE bags than those treated with different GA_3 concentrations and / or bavistin. The sweet oranges being non climacteric fruits do not show any marked variation in ethylene production and respiration and hence no marked changes in TSS contents were recorded in fruits under different treatments. Ahmad and Khan (1987) studied the effect of waxing and stored in cellophane- lined boxes and reported lesser increase in TSS and greater decrease in total solids (TS) in waxed mandarin compared to unwaxed ones. Similarly Tariq *et al.* (2001) reported higher weight loss in unwashed citrus fruits than washed and all sealed fruits were lower in weight loss than unwrapped fruits.

Dipping in chemical solution and fungicide and further wrapping with LDPE resulted a significant decrease in PLW and increase in the TSS of sweet orange in present study which are fairly coincided with the reports of Ahmad and Khan (1987) and Tariq *et al.* (2001).

The data in Table 2 show very low shriveling trend in fruits treated with GA_3 alone or coupled with bavistin and wrapped in LDPE bags (T_7, T_6, T_4 and T_3). The LDPE bags decreased the water loss from fruits and due to reduction in water vapor transmission rate, the least shriveling might have been resulted in such treatments. The anti-senescence property of GA_3 and bavistin also might have shared to reduce shriveling of fruits. Farooqui *et al.* (1979) studied the effect of PE and some other lining materials on the shelf life extension of citrus fruit and reported significant weight loss reduction and maintenance of external appearance (shriveling).

The data in Table 2 show that GA_3 and bavistin treated and LDPE wrapped fruits recorded highest score for overall acceptability. The treatments with GA_3, bavistin and wrapping resulted in modified atmosphere and this might have resulted in better score (significant $p<0.05$) for overall acceptability, which was a combined effect of PLW, TSS, shriveling and other sensory quality parameters.

The untreated fruits had lowest shelf life of 7 days. The fruits treated with GA_3 alone or with bavistin or wrapped in LDPE bags had better shelf life. The shelf life of sweet oranges in days in descending order was T_4 and T_7 =24 days, T_{10} = 21 days, T_3 = 19 days, T_9 =

17 days, T_2 and T_5 = 13 days, and T_8 =11 days.

Table 2. Effect of GA_3 with or without bavistin and LDPE wrapping on shriveling and overall acceptability of fruits during storage

Treatments		Storage period (days)			
		6	**12**	**18**	**24**
Visual shriveling	T_1	9.0	7.0	5.0	4.0
	T_2	9.3	9.3	7.3	5.5
	T_3	9.5	9.5	9.3	9.0
	T_4	9.6	9.5	9.4	9.1
	T_5	9.2	9.0	7.9	6.0
	T_6	9.5	9.5	9.4	9.2
	T_7	9.6	9.6	9.5	9.5
	T_8	9.2	9.2	7.5	5.0
	T_9	9.1	9.1	8.4	5.1
	T_{10}	9.2	9.2	8.0	7.5
Overall acceptability	T_1	8.9	8.6	6.7	4.0
	T_2	8.5	8.4	8.0	7.0
	T_3	8.9	9.0	9.0	8.6
	T_4	8.9	9.0	9.2	9.0
	T_5	9.0	9.0	8.8	6.5
	T_6	8.9	9.0	8.4	8.2
	T_7	9.0	9.0	9.5	9.8
	T_8	8.9	9.0	8.3	6.0
	T_9	9.0	8.9	8.5	8.4
	T_{10}	8.9	8.9	8.9	8.5

	Treatments		Storage period (days)
Visual Shriveling	SE±	0.520	0.615
	CD at 5%	1.076	1.273
Overall Acceptability	SE±	0.419	0.495
	CD at 5%	0.867	1.026

Conclusion

It can be concluded that GA_3 treatment to sweet oranges at 100 ppm coupled with bavistin at 500 ppm followed by wrapping in LDPE bags with 5% vents (T_7) proved to be beneficial for desirable sensorial quality and better shelf life.

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