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INFLUENCE OF GROWTH REGULATORS ON THE SHELF LIFE OF SWEET ORANGE CV. SATHGUDI

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Abstract

At present there is high domestic market potential for sweet oranges. Post harvest treatment of fruits with growth regulators, fungicides and wax help in the reduction of losses due to wastage. Hence, the present study was undertaken to study the influence of growth regulators on the shelf life of sweet orange at College of Horticulture, Rajendranagar. Sathgudi fruits were treated with the 2,4-D 500ppm + wax 6%, GA_3 500ppm + wax 6%, Benzyl adenine 50ppm + wax 6% and wax 6%. Various physico-chemical parameters like physiological loss in weight (PLW), juice content, peel content, firmness, spoilage, colour index, shelf life, total soluble solids, acidity, sugars and ascorbic acid were analysed at an interval of 5 days. It was observed that the fruits treated with BA 50ppm + wax 6% recorded the lowest PLW, spoilage, colour index thereby improved the shelf life compared to control fruits. The highest juice content, peel content and firmness was recorded in BA 50ppm + wax 6% compared to other treated fruits and lowest in control fruits. The lowest TSS, total sugars and highest ascorbic acid content was observed in BA 50ppm + wax 6% treated fruits. Thus, the analysis of various physico-chemical parameters indicated that BA 50ppm + wax 6% preserved the quality of sweet orange compared to other treated fruits. From the present study, it can be concluded that the fruits treated with BA 50ppm + wax 6% has improved the shelf life (18.48 days) by 45.86 percent over control (12.67 days).

Key words : Growth regulators, physico-chemical parameters, shelf life, TSS, acidity.

Introduction

Citrus spp. belong to the family Rutaceae and sub-family Aurantoidae (Swingle and Reece, 1967) are native to the tropical and sub tropical regions of South-East Asia, particularly India and China. North-East India is the native place of many citrus species (Davies and Albrigo, 2003). Sweet orange cv. Sathgudi (*Citrus sinensis* Osbeck.) is one of the most important citrus fruits grown in Andhra Pradesh in an area of 1,94,395 ha with an annual production of 26,24,333 tonnes (Anonymous, 2008). It is extensively grown in Nalgonda, Prakasam, Anantapur, Cuddapah, Kurnool, Chittor, Mahabubnagar and North circar districts of Andhra Pradesh (Singh, 2001).

Sweet orange from Andhra Pradesh is exported to the marketing centres of other states namely Bangalore, Trivandrum, Madras, Nagpur, Bombay, New Delhi and Calcutta etc. However, considerable quantity of exported oranges gets spoiled (25 - 30%) during transit due to bulk transportation (Biswas, 1989). In a developing country like India, postharvest losses of citrus fruits are 25 - 30% due to the unscientific practices of harvesting, handling, packaging, transport and storage. Modern packaging containers involving use of corrugated fibre board boxes (CFB) in lieu of conventional wooden boxes has shown tremendous effects on preserving shelf-life as well as maintaining the quality of citrus fruits during long term storage and long distance transport. Chemicals like plant growth regulators (PGRs) as post harvest treatments have proved to be a useful tool in delaying ripening. Growth regulators such as auxins, gibberellins and cytokinins have been classified as non-specific ethylene inhibitors (Majumdar *et al*. 1981). Postharvest treatments like wax coating with fungicides have contributed to minimize postharvest losses and enhance the shelf life of citrus fruits (Sonkar *et al.*, 2008). However, there was no report regarding the influence of growth regulators in combination with wax coating on the shelf life of cv. Sathgudi. In view of the above, the present study was

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taken to study the influence of growth regulators on shelf-life of sweet orange.

Materials and Methods

Mature uniform size sweet orange fruits used for the present study were obtained from the farmers field located at Tipparthi village, Nalgonda district and the experiment was carried out in Postharvest technology laboratory, College of Horticulture, Rajendranagar. The best combination of growth regulator treatments has been used for the experiment. The fruits were washed, air-dried, immersed in the growth regulator for two minutes and then with fungicidal wax emulsion for about a minute and kept in the corrugated fibre board boxes (CFB) at room temperature. The sweet orange fruits were treated with 2,4-D 500ppm + wax 6%, GA_3 500ppm + wax 6%, BA 50ppm + wax 6% and wax 6%. Untreated fruits were used as control. Each treatment was replicated five times with thirty fruits per replication.

Physiological loss in weight (PLW) was calculated by taking the weight of the marked fruits (5 no.) on 0^{th} day is taken as initial weight. The weight of the same marked fruits (5 no.) was recorded from each replication at subsequent intervals taken as final weight is subtracted from initial weight for the whole period. The loss of weight in grams in relation to the initial weight was expressed as percentage. The visible symptoms of rotting and shrivelling on the number of fruits over total fruits were recorded at periodical intervals and cumulative spoilage was determined in terms of percent spoiled fruits. The stage where more than 40% of the stored fruits became unfit for consumption was considered as end of shelf life and expressed as mean number of days. The juice was extracted from the sample fruits with the help of juice extractor and strained through single mesh filter to remove rag, seeds and left over waste. Strained juice was weighed and percentage of juice content per fruit was worked at regular intervals. The peel separated from the rag portion of the rind was weighed and expressed as the per cent peel weight. A pocket penetrometer was used to record the firmness and obtained direct readings in kg/cm^2. The colour of the fruits was determined by the visual observation. Changes in the colour (surface of fruit) was measured based on the following score. (Green - 1; Yellowish green – 2; Greenish yellow – 3; Yellow – 4; Orange – 5). Juice content, peel content and colour index was determined as per the procedure given by Ladaniya, (2008). Total soluble solids (TSS) were measured by hand refractometer (0-32°Brix). Titrable acidity, total sugars and ascorbic acid were determined as per the procedure described by Ranganna (1986).

The experimental design was completely randomized design (CRD) with factorial concept and the fruits were analysed to observe physico-chemical changes for every 5 days. The data were subjected to statistical analysis by using analysis of variance (ANOVA) to assess the significance at 0.05 per cent level by employing the Statistical package for Agricultural Workers (STAT OP Sheoran).

Results and Discussion

Initial physico-chemical characteristics of sweet orange fruits

Initial fruit characteristics were represented in the table 1 by taking the average value of ten randomly selected fruits on first day. The average fruit weight of sweet orange cv. sathgudi was 210.00 g, juice content and peel content were 47.90 % and 28.72%, respectively. The firmness of the fruit was 7.69 kg/cm^2. The fruit juice had total soluble solids of 8.60° Brix, titrable acidity of 0.98% and total sugars of 4.00%. The ascorbic acid content of Sathgudi fruit per 100ml of the juice was 64.10 mg.

The lowest PLW was observed in BA 50ppm + wax 6% (7.57) and highest PLW in control (12.50) fruits (table 2). It was observed that there was no significant difference in PLW between the 2,4-D 500ppm + wax 6% (8.08) and GA_3 500ppm + wax 6% (8.21) treated fruits. There was a significant increase in the PLW from 5^{th} day (4.71) to 15^{th} day (13.22) of storage. The lowest PLW in BA 50 ppm + wax 6% may be due to the fact that BA reduces the rate of respiration which was in close conformity with Bhardwaj *et al*. (2005) in Nagpur santra treated with BA 100 ppm. Farooq and Hulamani (2001) observed lower PLW in Arkavati grape bunches treated with Kinetin at 30 ppm. On all the days of storage, fruits treated with growth regulators in combination with wax irrespective of their concentrations recorded significantly lower PLW than untreated fruits. The fruits treated with BA 50ppm + wax 6% (30.95) has recorded the lowest spoilage compared to other growth regulator treated fruits and highest in control fruits (51.13) (table 2). Lowest spoilage was observed in BA 50 ppm treated guava fruits by Jayachandran *et al.* (2007) and BA 20 and 50 ppm treated mango fruits by Prasanna lakshmi (2005). There was an increase in the spoilage from 5^{th} day (11.41) to 25^{th} day (76.63). Spoilage increased with increase in duration of storage period due to Shrivelling, Alternaria rot, Blue mold and Black mold similar to observed by Ladaniya (2008) in citrus fruits.

The juice and peel content in terms of percent was presented in the table 3. Higher juice (45.93) and peel

Table 1 : Initial fruit characteristics.

Average fruit weight (g)	210.00
Juice content (%)	47.90
Peel content (%)	28.72
Firmness (kg/cm^2)	7.69
TSS (°Brix)	8.60
Titrable acidity (%)	0.98
Total sugars (%)	4.00
Ascorbic acid (mg/100ml)	64.10

content (27.31) was observed in the BA 50ppm + wax 6%. The lower juice (39.08) and peel content (24.13) was recorded in control fruits compared to treated fruits due high respiratory losses. Juice and peel content was found to be highest in the BA 50ppm + wax 6% fruits due to the less respiration rate there by less moisture loss compared to other growth regulators. Maximum retention of juice content upto 42nd day of storage was observed by Bhardwaj *et al*. (2005) in Nagpur Santra treated with BA 100 ppm. With increase in the duration of storage

Table 2 : Influence of growth regulators on physiological loss in weight (PLW %) and spoilage (%) of sweet orange cv. Sathgudi.

Treatments	PLW (%)				Spoilage (%)					
	Days after storage				Days after storage					
	5	10	15	Mean	5	10	15	20	25	Mean
Growth regulator with fungicidal wax										
T_1 - 2,4-D 500 ppm + wax 6%	4.35	7.74	12.14	8.08^{c}	9.07	15.29	37.91	53.32	72.12	37.54^{d}
T_2 - GA_3 500 ppm + wax 6%	4.38	7.95	12.30	8.21^{c}	11.00	25.69	39.79	59.58	75.23	42.26^{c}
T_3 - BA 50 ppm + wax 6%	4.04	7.41	11.27	**7.57^{d}**	6.60	10.51	30.23	43.58	63.85	**30.95^{e}**
T_4 - Wax 6%	4.34	8.90	13.33	8.86^{b}	13.23	26.91	42.44	65.44	83.47	46.30^{b}
T_5 - Control	6.44	14.02	17.05	12.50^{a}	17.16	32.93	44.85	72.22	88.48	51.13^{a}
Mean	4.71^{r}	9.20^{q}	13.22^{p}		11.41^{t}	22.27^{s}	39.04^{r}	58.83^{q}	76.63^{p}	
	F - test	C.D. (0.05)	SE(m)		F - test	C.D (0.05)	SE(m)			
Treatments (T)	*	0.40	0.14		*	3.93	1.38			
Days (D)	*	0.31	0.11		*	3.93	1.38			
Interactions (T X D)	*	0.70	0.24		N.S.	—	3.09			

*Significant at P = 0.05 level. Means followed by same alphabet are not statistically significant. N.S. : non - significant.

Table 3 : Influence of growth regulators on juice content (%) and peel content (%) of sweet orange cv. Sathgudi.

Treatments	Juice content (%)				Peel content (%)			
	Days after storage				Days after storage			
	5	10	15	Mean	5	10	15	Mean
Growth regulator with fungicidal wax								
T_1 - 2,4-D 500 ppm + wax 6%	45.96	45.00	43.71	44.89^{b}	27.51	27.12	26.37	27.00^{ab}
T_2 - GA_3 500 ppm + wax 6%	45.85	44.61	43.46	44.64^{b}	27.45	26.47	25.75	26.56^{bc}
T_3 - BA 50 ppm + wax 6%	46.73	46.01	45.04	**45.93^{a}**	27.96	27.31	26.67	27.31^{a}
T_4 - Wax 6%	45.51	43.94	42.16	43.87^{c}	27.12	26.26	25.54	26.31^{c}
T_5 - Control	44.67	41.11	31.45	39.08^{d}	26.29	24.66	21.44	24.13^{d}
Mean	45.75^{p}	44.13^{q}	41.17^{r}		27.27^{p}	26.37^{q}	25.15^{r}	
	F - test	C.D. (0.05)	SE(m)		F - test	C.D. (0.05)	SE(m)	
Treatments (T)	*	0.85	0.29		*	0.55	0.19	
Days (D)	*	0.66	0.23		*	0.43	0.15	
Interactions (T × D)	*	1.47	0.51		*	0.95	0.33	

*Significant at P = 0.05 level. Means followed by same alphabet are not statistically significant.

Table 4 : Influence of growth regulators on firmness (kg/cm^2) and visual colour index of sweet orange cv. Sathgudi.

Treatments	Firmness (kg/cm^2)				Colour index			
	Days after storage				Days after storage			
	5	10	15	Mean	5	10	15	Mean
Growth regulator with fungicidal wax								
T_1 - 2,4-D 500 ppm + wax 6%	7.10	6.50	5.50	6.37^b	1.33	1.68	1.96	1.66^d
T_2 - GA_3 500 ppm + wax 6%	7.03	6.17	5.27	6.16^b	1.36	1.86	2.04	1.75^c
T_3 - BA 50 ppm + wax 6%	7.37	6.90	6.23	**6.83^a**	1.28	1.54	1.85	**1.56^e**
T_4 -Wax 6%	6.67	5.90	4.80	5.79^c	1.39	1.91	2.27	1.86^b
T_5 - Control	6.40	4.87	3.77	5.01^d	1.42	2.57	3.72	2.57^a
Mean	6.91^p	6.07^q	5.11^r		1.36^r	1.91^q	2.37^p	
	F - test	C.D (0.05)	SE(m)		F - test	C.D (0.05)	SE(m)	
Treatments (T)	*	0.23	0.08		*	0.07	0.03	
Days (D)	*	0.18	0.06		*	0.05	0.02	
Interactions (T × D)	*	0.40	0.14		*	0.13	0.04	

*Significant at P = 0.05 level. Means followed by same alphabet are not statistically significant.

Table 5 : Influence of growth regulators on the shelf life (days) of sweet orange cv. Sathgudi.

Treatments	Shelf life (Days)	Per cent increase in shelf life over control
T_1 - 2,4-D 500 ppm + wax 6%	15.86^b	25.18
T_2 - GA_3 500 ppm + wax 6%	15.18^b	19.81
T_3 - BA 50 ppm + wax 6%	**18.48^a**	**45.86**
T_4 -Wax 6%	14.17^{bc}	11.84
T_5 - Control	12.67^c	—
F - test	*	—
C.D (0.05)	2.34	—
SE(m)	0.73	—

*Significant at P = 0.05 level. Means followed by same alphabet are not statistically significant.

period, juice content and peel content decreased significantly from 5th day to 15th day. Reduction in the juice and peel content was directly correlated with the reduction in moisture content of the fruit. These results are in confirmation with those reported by Shekarappa Angadi and Shanta Krishnamurthy (1992) in Coorg mandarin.

The firmness of the treated fruits was maintained better than untreated fruits (table 4). However, relatively higher firmness was recorded in BA 50ppm + wax 6% (6.83) and lower in control (5.01) fruits. The firmness of the fruits maintained for a longer period in BA 50ppm + wax 6% reflecting the retarded nature of ripening. The results were in line with the findings of Jayachandran *et al.* (2007) in guava fruits treated with BA 50 ppm over the control fruits. Significant decrease in the firmness was observed at consecutive intervals of storage from 5th day (6.91) to 15th day (5.11) of storage. The firmness levels were always higher at initial days which decrease gradually, due to the degradation of cell wall components as supported by Ladaniya and Sonkar (1997) in Nagpur mandarin. The visual colour score was found more in control fruits (2.57) and lowest in BA 50ppm + wax 6% (1.56) (table 4). Colour index was found to be less in BA 50ppm + wax 6% indicating that BA reduces the senescence and ethylene production thereby ripening of the fruits as stated by Sukumar Reddy (2009) in guava. Ahmed (1998) observed that the change in colour was slow in BA 100 ppm treated mango cv. Baneshan. There was a significant increase in colour index value starting with 1.36 on 5th day to 2.37 on 15th day of storage. This was due to the breakdown of chlorophyll followed by a subsequent increase in orange and yellow pigments *i.e.* carotenoids in the peel, as stated by Ladaniya (2008).

The maximum shelf life was recorded in BA 50ppm + wax 6% (18.48 days) followed by 2,4-D 500ppm + wax 6% (15.86 days) which was onpar with GA_3 500ppm + wax 6% (15.18 days) (Table 5). The minimum shelf life of 12.67 days was observed in control fruits which was onpar with wax 6% (14.17) fruits. Shelf life of BA treated fruits was improved due to delay in ethylene production and may be due to inhibition of alternative

Table 6 : Influence of growth regulators on TSS (°B) and titrable acidity (%) of sweet orange cv. Sathgudi.

Treatments	TSS (°B)				Titrable acidity (%)			
	Days after storage				Days after storage			
	5	10	15	Mean	5	10	15	Mean
Growth regulator with fungicidal wax								
T_1 - 2,4-D 500 ppm + wax 6%	8.82	8.97	9.32	9.04^{bc}	0.92	0.89	0.86	0.89^{b}
T_2 - GA_3 500 ppm + wax 6%	8.81	9.01	9.35	9.06^{b}	0.94	0.92	0.89	**0.92^{a}**
T_3 - BA 50 ppm + wax 6%	8.77	8.94	9.21	**8.98^{c}**	0.93	0.89	0.87	0.90^{ab}
T_4 -Wax 6%	8.74	9.02	9.45	9.07^{b}	0.91	0.89	0.85	0.88^{b}
T_5 - Control	9.59	9.83	10.51	9.98^{a}	0.89	0.83	0.80	0.84^{c}
Mean	8.95^{r}	9.16^{q}	9.57^{p}		0.92^{p}	0.88^{q}	0.86^{q}	
	F - test	C.D. (0.05)	SE(m)		F - test	C.D. (0.05)	SE(m)	
Treatments (T)	*	0.07	0.03		*	0.02	0.008	
Days (D)	*	0.06	0.02		*	0.02	0.006	
Interactions (T × D)	*	0.13	0.04		N.S.	-	0.013	

*Significant at P = 0.05 level. Means followed by same alphabet are not statistically significant. N.S. : non-significant.

Table 7 : Influence of growth regulators on total sugars (%) and ascorbic acid content (mg/100ml) of sweet orange cv. Sathgudi.

Treatments	Total sugars (%)				Ascorbic acid content (mg/100ml)			
	Days after storage				Days after storage			
	5	10	15	Mean	5	10	15	Mean
Growth regulator with fungicidal wax								
T_1 - 2,4-D 500 ppm + wax 6%	4.10	4.69	5.99	4.93^{b}	58.67	57.96	55.51	57.38^{ab}
T_2 - GA_3 500 ppm + wax 6%	4.14	4.59	5.73	4.82^{b}	58.88	55.51	53.05	55.81^{bc}
T_3 - BA 50 ppm + wax 6%	3.84	4.44	5.42	**4.57^{c}**	59.49	57.96	56.12	**57.86^{a}**
T_4 -Wax 6%	4.05	4.66	5.86	4.86^{b}	56.43	54.59	52.75	54.59^{c}
T_5 - Control	4.74	6.22	7.29	6.08^{a}	55.51	49.68	44.38	49.85^{d}
Mean	4.17^{r}	4.92^{q}	6.06^{p}		57.80	55.14	52.36	
	F - test	C.D. (0.05)	SE(m)		F - test	C.D. (0.05)	SE(m)	
Treatments (T)	*	0.16	0.05		*	1.68	0.58	
Days (D)	*	0.12	0.04		*	1.30	0.45	
Interactions (T × D)	*	0.27	0.09		*	2.91	1.01	

*Significant at P = 0.05 level. Means followed by same alphabet are not statistically significant.

respiration. Shelf life was found to be more in guava fruits treated with BA 25 or 50 ppm by Jayachandran *et al.* (2007) and in mango fruits treated with BA 20 and 50 ppm by Prasanna Lakshmi (2005).

Significant difference in TSS and titrable acidity was observed among the treatments and between the days of storage (table 6). Relatively the higher TSS was observed in untreated control fruits (9.98) due to the hydrolysis of polysaccharides at faster rate compared to the treated fruits and the lowest was recorded in BA 50ppm + wax 6% (8.98). With the increase in the duration of storage period, TSS increased from the 5th day (8.95) to 15th day (9.57) of storage. Similarly, minimum increase in TSS was reported by Bhardwaj *et al.* (2005) in Nagpur mandarin treated with 100 ppm BA. There was no significant difference in TSS between the BA 50ppm + wax 6% and 2,4-D 500ppm + wax 6%. There was a

significant increase in TSS from 5th day (8.95) to 15th day (9.57) of storage. Titrable acidity was found to be more in GA_3 500ppm + wax 6% (0.92), which was onpar with BA 50ppm + wax 6% (0.90) and lowest in control fruits (0.84). Retention of acidity was more in GA_3 500 ppm + wax 6% and BA 50 ppm + wax 6% due to delay in physiological ageing and alteration in metabolism, which ultimately resulted in higher retention of acidity. Similar results were observed by Raghava Rao and Chundawat (1984) in banana fruits treated with Kinetin and GA_3. There was a significant decline in the titrable acidity from 5th day (0.92) to 15th day (0.86) of storage due to the utilisation of acids in the respiration process similar to reported by Ansari and Feridoon (2008) in Valencia orange.

The total sugars were significantly highest in control (6.08) and lowest in BA 50ppm + wax 6% (4.57) (table 7). Higher sugar content in control was due to the rapid respiration rate which indirectly caused moisture loss thereby increasing sugar content. Ahmed (1998) observed lower sugar content by post harvest application of BA 100 ppm in mango and Bhardwaj *et al.* (2005) in Nagpur mandarin. Sharma and Dashora (2001) reported the minimum total sugar content in 2% mustard oil emulsion + 100 ppm BA treated guava fruits while the maximum in control. There was no significant difference in total sugar content among the 2,4-D 500ppm + wax 6%, GA_3 500ppm + wax 6% and wax 6% treated fruits. In the present study, there was a significant increase in total sugar content from 5th (4.17) to 15th (6.06) day of storage due to the conversion of acids to sugars. In the present study highest ascorbic acid content was observed in the BA 50ppm + wax 6% (57.86), which was onpar with highest retention of ascorbic acid content on 42nd day of storage in Nagpur santra treated with BA 100 ppm. A significant declining trend in the ascorbic acid content was noticed from 5th day (57.80) to 15th day (49.85) of storage (table 7). The reduction in ascorbic acid content might be due to the activity of oxidative enzymes during storage.

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