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Full Length Research Paper

Studies on the standardization of ripening techniques for oranges

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'Fruits of oranges cultivar' free from any external and internal disorders harvested at physiological green mature stage were utilized for studying its ripening behavior. Initially, fruits were treated with Neem oil (1%). in order to break any pest attack and the treatments were given as foliar spray. Freshly harvested fruit were divided into different lots. The first lot of fruit was treated with ethylene gas as they were exposed to ethylene gas (150 ppm). for 24 h in ripening chamber. Similarly, another lot was treated with various concentrations of ethephon (250, 500, 750, 1000 ppm). primarily in aqueous solution each for 5 min. Immediately, after aforementioned referred treatments, the treated fruits were packed in sanitized plastic crates and stored in ripening chamber in which temperature and RH were maintained at 20 to 25°C and 85 to 95%, respectively. Treatment with ethylene gas (150 ppm). or ethephon (750 ppm). resulted in adequate ripening of fruits after 28 days with most acceptable quality attributes such as flavour, uniform colour, acceptable firmness and extended shelf-life. On the other hand, the untreated lots of fruits were poor in quality attributes. It was observed that timely adopting ripening techniques with ethylene gas or ethephon are better in reducing various postharvest decay and losses and strengthening the economy of farmers all over oranges producing states of the countries.

Key words: Oranges, pre-harvest treatments**,** ripening techniques, ethylene gas, ethephon, overall quality, shelf life.

INTRODUCTION

Orange is one of the most important fruit crops of tropical and subtropical India and the world. Punjab, UP, Maharashtra Tamilnadu, Andhra Pradesh and Gujrat are major states of India where oranges are produced in large numbers. In India, oranges are produced in an area of 515,000 ha with an annual production of 19.21 million tones (Annon, 2010). In India, oranges cultivation has resulted in better economy to growers as a result of which both acre and production has increased from the last three to four years. At present to further enhance the production and quality of oranges in India, an appropriate ripening techniques is urgently required to eliminate the traditional ripening method in which ripening is done through 'calcium carbide' and the use of this chemical is prohibited due to its carcinogenic nature (PFA, 2003). Therefore the present investigation were done to study the ripening techniques by using ethephon and ethylene as an alternate measure for improving the ripening of orange fruits so that the quality fruits with uniform ripening are made available to consumers throughout the years.

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MATERIALS AND METHODS

The fruits of oranges were harvested at slightly green mature stage and most appropriately when the stiffness on fruit surface starts disappearing. The fruits selected were free from any bruising and abrasion damage and were kept in easy free manner so that the abrasion can be avoided. As far as treatment is concerned, in the first lot, 50 kg of fruits were subjected to ethylene gas (150 ppm) using ethylene gas generator (9002, Cavanta, California, USA) and the temp and RH inside the ripening chamber were maintained at 15°C and 85 to 90% RH. Similarly, in the second treatment, lot of 40 kg was directly placed in aqueous solutions of ethephon (250, 500, 750 and 1000 ppm) each for 5 to 7 min. This was followed by

Table 1. Effect of ethylene gas and ethephon treatments on PLW, firmness, TSS, acidic and sensory quality during ripening of oranges.

Ripening period (Days)	Ethylene (100 ppm)	Ethephon				Control	CD (0.05)
		250	500	750	1000		
PLW (n = 3) (%)							
7	1.0	1.0	1.3	1.8	2.1	0.50	T = 0.3
14	1.5	2.1	2.4	2.9	3.8	1.15	S = 0.2
21	2.6	2.9	3.1	4.0	5.2	2.00	T x S = 0.6
28	3.1	3.4	3.7	5.2	6.5	2.5	
Firmness (n = 3) (g-force)							
7	530	580	550	510	510	660	T = 3.2
14	370	420	320	310	305	520	S = 4.0
21	120	170	105	95	80	345	T x S = 5.3
28	66	93	64	48	44	260	
TSS (n = 3) (%)							
7	9.6	96.2	9.4	9.4	9.6	9.2	T = 0.4
14	11.0	11.8	11.0	125.8	12.6	10.0	S = 0.2
21	14.6	13.0	15.6	15.2	15.8	11.0	T x S = 0.9
28	17.0	15.2	18.0	18.4	19.5	12.0	
Acidity (n = 3) (%)							
7	0.36	0.33	0.32	0.30	0.30	0.32	T = NS
14	0.40	0.36	0.38	0.34	0.32	0.35	S = 0.2
21	0.44	0.36	0.40	0.40	0.38	0.40	T x S = NS
28	0.50	0.40	0.44	0.37	0.36	0.38	
Sensory quality (n = 10 panelists)							
7	4.5	4.5	4.5	4.5	4.5	4.0	T = 0.2
14	5.0	5.0	5.0	5.0	5.0	4.0	S = 0.1
21	6.5	6.0	6.5	7.3	7.5	4.0	T x S = 0.3
28	7.5	6.0	7.4	7.0	7.0	4.0	

air drying of fruits under natural air and under fan followed by packing in sanitized plastic crates which were ultimately stored in ripening chamber (20 to 25°C and 90 to 95 per RH). Control fruits lot of 30 kg were also kept under room temperature condition to compare the physiochemical changes over the stipulated period of time. There were 3 replications for each treatment and experiment was laid out in completely randomized design. A 28 -day ripening cycle was followed in which temperature was brought down from 25 to 18°C in 28 days. Ripening behaviour of orange fruits was also studied at 20 to 25°C at well established market conditions as well as at 30 to 35°C at regular market conditions. The observations on various physicochemical attributes were monitored everyday till 28 days. The physiological loss in weight (PLW) of fruit during storage was calculated on initial weight basis and expressed in percent. The fruit firmness was measured with the help of 'texture analyzer (Make Stable Microsystem, UK) using stainless steel probe of 2 mm diameter and results were expressed in g-forcer. The sensory quality of fruit was determined by Hedonic scale (1 to 9 points) as described by Amerine et al. (1965). The total soluble solids were calculated with the help of a Erma Hand Refractometer and express in percent after making the temperature correction at 20°C. Titratable acidity was estimated as per AOAC (1990).

The colour of the fruit was measured with colour difference meter (Hunter Lab, USA) and expressed as L, a, b values (Hunter, 1975). The ripening percentage of the fruits was estimated by counting the total number of ripened fruits on the basis of their appearance and desirable colour.

RESULTS AND DISCUSSION

PLW

The PLW of fruits increased during ripening process (Table 1). The highest PLW was observed with ethephon 1000 ppm (6.5%) during ripening period of 28 days which was followed by ethephon 750 ppm (5.2%) and these treatments resulted in shriveling, softening and over-ripening of fruits and found unsuitable. Ethylene gas (100 ppm) and ethephon (500 ppm) recorded 3.1 and 3.4% weight loss, respectively during ripening period of 28 days leading to adequate ripening and softening of fruits.

Lowest PLW (2.5%) was recorded in control fruits and these fruits were green and hard in texture. The increase in weight loss during ripening of fruits by ethephon or ethylene application may be due to upsurge in respiration rate of the fruit. Mahajan et al. (2008) reported an increased weight loss in guava fruits during ripening process caused by ethylene application.

Firmness

The firmness of fruits declined during ripening period in all treatment (Table 1). Untreated control fruits were hard (260 g-force and remained unripened, while ethephon (1000 ppm). treated fruits were least firm (44 g force). The fruits treated with ethylene gas (100 ppm) and ethephon (500 ppm) registered adequate firmness of 66 and 64 g force, respectively during ripening period of 28 days (Table 1). Firmness is one of the most crucial factors in determining the post-harvest quality of fruits (Shear, 1975). The decrease in firmness during ripening may be due to breakdown of insoluble protopectin into soluble pectin or by cellular disintegration leading to membrane permeability (Brinston et al., 1988). The hard or semi hard orange fruits are not liked by most of the consumers. Therefore, to develop desirable quality, the orange fruits need to be ripened artificially for enhancing consumer acceptability.

Sensory quality

Fruits treated with ethylene gas (100 ppm) recorded 7.5 score on 28th day and were rated as very much desirable and this treatment was very closely followed by ethephon 500 ppm (Table 1). The untreated control fruits were rated poor (4) in taste on 28th day. The improvement in sensory quality with ethylene gas or ethephon treatments may be due to the role of ethylene/ethephon in promoting changes which are important to flavour quality and formation of aroma volatile in climacteric fruit (Pratt and Goeschl, 1969; Medicott et al., 1987; Kulkarni et al., 2004).

TSS

The TSS content of fruits increased during ripening irrespective of treatments (Table 1). The TSS content of oranges were maximum (19.5%) with ethephon 1000 ppm and lowest (13%) in control fruits. The increase in TSS during ripening may result from an increase in concentration of organic solutes as a consequence of water loss (Ryall and Pentzer, 1982). The increase may also be possible due to numerous anabolic and catabolic processes taking place in the fruit preparing it for senescence (Smith et al., 1979). Kulkarni et al. (2004) reported an increase in TSS and sugars in mango fruits treated with ethrel.

Titratable acidity

The acidity values were in the narrow range of 0.3 to 0.45% in all the treatments (Table 1) and differences were not statistically significant.

Fruit colour

The fruits treated with ethylene gas or ethephon solution recorded significant improvement in yellow colour of the peel as indicated by increase in ‘b’ value compared to untreated control which remained greenish soft with dull appearance (Table 2). The fruits treated with ethylene (100 ppm) and ethephon (500 ppm) developed uniform yellow colour, whereas ethephon (750 and 1000 ppm) resulted in deep yellow colour with black spots on fruit surface leading to over-softening of fruits. Ethylene gas and ethephon are treatments and are known to accelerate the chlorophyll degradation and induce yellowness in green tissues of many fruits (Reyes and Paull, 1995; Mahajan et al., 2008).

Ripening

For initial 14 days, the fruits remained hard and green in all the treatments as judged by their visual appearance (Table 2). However, on 21 day there was dramatic increase in ripening of fruits and highest ripening percentage (100%) of oranges fruit was observed after 28 days with ethylene gas (100 ppm) and ethephon (500 ppm) as well as its higher doses while lowest was in control fruits (30%). The role of ethylene in hastening ripening of fruit is evident because it binds to receptor forming an activated complex which leads to a wide variety of physiological responses including ripening (Yang, 1980). The improvement in ripening of orange fruits is due to multifunctional nature of ethylene which triggers a dramatic change during ripening process and ensures faster and uniform ripening in many fruits (Abeles, 1973; Kadar et al., 1994; Kadar and Mitcham, 1994).

Shelf-life studies

The shelf-life studies of orange fruit was carried out to study the post-ripening behaviour of fruit during retail marketing at 16 to 18°C (super market condition) and 30 to 32°C (ordinary market condition). The data on different attributes revealed that orange fruit treated with ethylene gas (100 ppm) or ethephon (500 ppm) can be kept for 28 days at 16 to 18°C and 21 days at 30 to 32°C with optimum weight loss, desirable firmness and highly acceptable colour and organoleptic quality (Table 3). The higher doses of ethephon (750 and 1000 ppm) resulted in shattering of fruits from plant, over-softening and shriveling of fruits.

Table 2. Effect of ethylene gas and ethephon treatments on development of colour and ripening of banana fruits.

Ripening period (days)	Colour value	Ethylene (100 ppm)	Ethephon				Control
			250	500	750	1000	
		Hunter values					
	L	50.2	47.8	58.4	59.6	60.2	46.7
7	a	-7.2	-8.6	-6.8	-5.4	-5.2	-9.6
	b	18.0	17.2	20.2	20.0	22.4	17.2
	L	56.4	49.4	66.7	67.8	69.2	46.9
14	a	-5.0	-5.6	-4.2	-4.0	-3.6	-9.2
	b	20.6	19.8	22.4	23.6	23.0	18.0
	L	63.8	51.6	70.3	69.5	70.8	47.0
21	a	1.30	-4.2	1.5	2.3	2.0	-8.7
	b	25.2	21.5	28.6	29.2	29.8	18.7
	L	74.0	53.3	76.0	71.5	72.0	47.6
28	a	2.27	-3.8	1.7	5.3	5.4	-8.8
	b	29.7	24.5	30.2	31.8	32.1	20.8
		Ripening					
7		0	0	0	0	0	0
14		0	0	0	0	0	0
21		78	30	75	83	88	0
28		100	55	100	100	100	30

Table 3. Effect of ethylene gas and ethephon treatments on shelf life of banana fruits under supermarket (16-18°C) and ordinary market (30-32°C) conditions.

Ripening period (Days) / Eyhylene	Shelf life at 16-18°C					Control
	100	250	500	750	1000	
	PLW (%)					
7	3.5 (5.3)	3.7 (4.9)	3.9 (5.5)	5.9 (6.4)	7.3 (7.8)	3.0 (3.4)
14	3.9 (7.0)	4.0 (6.4)	4.2 (6.7)	6.3 (8.6)	8.0 (10.3)	3.3 (5.7)
21	4.2	4.2	4.6	6.5	8.4	3.7
28	4.7	4.5	4.8	6.7	9.0	4.0
	Firmness (g force)					
7	65 (58)	90 (84)	62 (58)	45 (43)	41 (40)	210 (140)
14	57 (46)	83 (72)	55 (40)	40 (30)	37 (30)	150 (80)
21	53	80	51	36	35	110
28	50	78	47	32	30	83
	TSS (%)					
7	17.4 (17.6)	15.2 (15.4)	18.4 (18.0)	18.4 (18.0)	18.6 (18.0)	13.4 (13.6)
14	18.0 (17.0)	15.6 (15.0)	18.4 (17.0)	18.0 (16.0)	18.0 (16.0)	13.8 (13.0)
21	18.2	16.0	18.6	17.6	18.0	14.0
28	18.6	15.4	19.0	17.2	17.6	14.0
	Acidity (%)					
7	0.46 (0.32)	0.35 (0.30)	0.40 (0.33)	0.35 (0.30)	0.30 (0.28)	0.35 (0.32)

Table 3. Contd.

14	0.40 (0.25)	0.31 (0.20)	0.34 (0.22)	0.31 (0.25)	0.27 (0.21)	0.30 (0.24)
21	0.33	0.28	0.30	0.30	0.22	0.30
28	0.28	0.25	0.26	0.28	0.20	0.28
	Sensory quality (n = 10 panelists)					
7	7.5 (7.2)	6.5 (7.0)	7.5 (7.2)	6.8 (6.5)	6.8 (6.5)	4.5 (5.0)
14	7.8 (7.0)	7.0 (6.5)	7.5 (6.8)	6.5 (6.0)	6.5 (6.0)	5.0 (5.5)
21	7.5	6.2	7.8	6.5	6.5	5.5
28	7.0	6.0	7.2	6.0	6.0	6.0

Conclusion

Exposure of green mature orange fruits to ethylene gas (100 ppm) for 24 h or dipping in ethephon solution (500 ppm) for 5 min followed by storage at 16 to 18°C and 90 to 95% RH ensures faster and uniform ripening in 28 days with development of pleasant colour and consumer acceptability.

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