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Quality Characterization of Mandarin (*Citrus reticulata* Blanco) During Storage

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Abstract—*Quality characterization of mandarin was done with the objective to analyze and find out best treatment among different combinations of pretreatments and packaging during storage at ambient conditions (19 to 25°C). Twenty treatment combinations consisting of four types of chemicals (2,4-D 50 ppm, 2,4-D 100 ppm, GA_3 50 ppm, and GA_3 100 ppm) and three types of packaging materials (Corrugated boxes, perforated polythene and newspaper) and their combinations were used in the study. Maximum values for titrable acidity (0.624%), TSS (13.12^0 Brix), total sugars (9.56%) and ascorbic acid (14.17 mg/100 ml juice) were obtained to the treatment with 2,4-D 100 ppm with perforated polythene on 20th day of storage. Maximum scores for colour and overall acceptability were observed in the treatment combination with2, 4-D 100 ppm and corrugated fibre board boxes.*

Keywords*: Ascorbic acid, Mandrin, TSS, 2,4-D, and Overall acceptability*

1. INTRODUCTION

Loose skinned oranges, belonging to the species *Citrus reticulata* Blanco are commonly known as mandarins. Mandarin is native to tropical and subtropical region of South-East Asia. Mandarins are eaten to allay fever. The roasted pulp is prepared as a poultice for skin diseases. Generally, mandarins are harvested in 32-36 weeks after the fruit is set; otherwise there is every possibility of shriveling of fruits and heavy drops. The maturity of harvested fruits has an important role on shelf life, quality and market price. Hence, certain standards of maturity must be kept in mind while harvesting the fruits. However, the most commonly used measures to access maturity for harvesting the Mandarin is peel colour. Fruits are considered mature, if they have a yellow orange colour on 25% or more of the fruit surface. The peel colour improved with advancement of maturity (Sonkar and Ladania, 1995). It is available from mid October to January end in Malwa region of Madhya Pradesh. If we use appropriate packaging materials and suitable chemicals for storing of the fresh fruits, we can increase the shelf-life of mandarin. They can be transported to local and short distant markets with minimum physiological loss in weight.

Market value of citrus fruits is controlled by its quality, which is dependent on its external and internal characteristics. Maintaining quality is one of the main factors in increasing sales (Kitagawa and Kawada, 1992). Huge harvest of produce during peak harvesting season creates glut and the growers are compelled to sell it in the local or nearby markets at throwaway rates. Hence, mandarin packaging using various packaging materials, storage and value addition is a solution to benefit the farmer of the Malwa region of Madhya Pradesh. There are certain chemicals, which reduce the ethylene production (respiration rate) and growth of micro-organisms so as to increase the shelf life of mandarin. Fruit colour retained greenness of buttons in Nagur mandarin with 2, 4-D treatment (Ladania and Sonkar, 1996). Therefore, keeping these points in view a study on packaging and storage of mandarin is planned to access the quality characteristics of mandarin when subjected to different treatments with plant growth regulators.

2. MATERIALS AND METHODS

An investigation was conducted at the Department of Post Harvest Management, College of Horticulture, Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior during 2010-2011. For different treatment combinations, one level of variety, five levels of pre-treatments and four levels of methods of packaging were used. Thus, in the present investigation a total of 20 treatment combinations on storage were made. The experimental details and various treatment combinations are presented in Table1.

Evenly sized, uniform and fully matured fruits of mandarin cv. Nagpur were harvested from the field of a farmer Shri Rajendra Patidar of Jaora, Ratlam (M.P.) and brought to the laboratory for the purpose of experiment. A sample of 2 kg mandarin fruits/pack was weighed before packaging and storage. For a single replication 40 kg fruits were used in the experiment. Damaged, diseased, and immature fruits were sorted out. Selected fruits were washed with the help of running tap water. Thus for three replications a total of 120 kg mandarin was used for the experiment.

Preparation of chemical solution

For preparation of 50 and 100 ppm 2, 4-D solution, 0.5 and 1 g crystals of 2,4-D were dissolved in 10 ml of alcohol respectively. Thereafter, 1 litre of distilled water was added to it. Similarly, for 50 and 100 ppm GA_3 solution, 0.5 and 1 g crystals of GA_3 were dissolved in 10 ml of alcohol respectively. Thereafter, 1 litre of distilled water was added to it.

Pretreatment

The washed fruits were dipped in above prepared chemical solutions for five minutes. After pre-treatment the fruits were dried at room temperature for one hour.

Packaging and Storage

After moisture removal the mandarin fruits were packed in different packaging material (corrugated boxes, perforated polythene and newspaper) @ 2 kg/pack. After packaging the fruits were stored at ambient room temperature (16-22°C) and relative humidity (70-80%). The treated fruits were subjected to various physico-chemical observations at 0, 5^{th}, 10^{th}, 15^{th} and 20^{th} day of storage as described in succeeding sub-sections.

Organoleptic characteristics of fresh and stored mandarin

The mandarin fruit is stored over a period of 20 days were subjected to organoleptic evaluation by a panel of six judges following hedonic rating tests as described by Ranganna (1978).

Biochemical characteristics of fresh and stored mandarin

Acidity

Acidity was determined by diluting the known weight of fresh juice of mandarin fruit sample (sample was weight and ground well with a pestle and mortar) and titrating the sample against standard 0.1 NaOH using phenolphthalein as the indicator. Appearance of light pink colour denotes the end point. The acidity was calculated by using following formula and expressed in percent.

$$\text{Acidity (\%)} = \frac{1 \times \text{Normality of NaOH} \times \text{Equivalent weight of acid} \times \text{Titer}}{10 \times \text{Weight of the sample}} \times 100$$

Ascorbic acid

The ascorbic acid content of fresh and stored fruits was determined by diluting the known quantity of the fruit juice with 4% metaphosphoric acid and filtered through filter paper and titrating with 2, 6-dichlorophenol indophenol dye solution (A.O.A.C., 1960) until the stable light pink colour was obtained. Standardization of 2, 6-dichlorophenol indophenol dye solution was done by titrating it against standard ascorbic acid solution. For this purpose 100 mg of ascorbic acid was dissolved in 4% metaphosphoric acid and the volume was made to 100 ml from this 10 ml of ascorbic acid solution was used for titration. The result was calculated by the following formula and expressed in mg ascorbic acid (vitamin C) per 100 ml of fruit juice.

$$\text{Ascorbic acid} \left({}^{\text{mg}}/_{100\text{ ml}}\right) = \frac{\text{Titer} \times \text{Dye equivalent} \times \text{Dilution}}{\text{Weight of the sample}} \times 100$$

Total sugars

For estimation of total sugar content, 100 ml of sample was weighed and sugar was extracted with hot 80% ethanol, twice (5 ml each time). Supernatant was collected and evaporated by keeping it on a water bath at 80°C. Total sugars was determined by using anthrone reagent method. To 0.5 ml of this supernatant (100 times diluted), 5 ml of anthrone reagent was added then heated for 10 to15 min in a water bath, cooled to room temperature and absorbance was measured at (620 nm). The amount of sugars present in the sample was compared against standard curve prepared from glucose. The total sugars content was expressed in percentage basis (Ranganna, 1978).

Total soluble solids (TSS)

The total soluble solids content was measured at room temperature with the help of Abbe refractometer (Fuzhou, made in China). For this purpose a drop of fruit juice is placed on the prism of refractometer and values obtained were corrected at 20 °C.

Temperature and relative humidity

Ambient temperature was determined with the help of minimum and maximum thermometer (Zeal -Made in England, Capacity - 0^{o}C to 50^{o}C). Relative humidity was measured through digital hygrometer (make Vista Biocell Pvt. Ltd. New Delhi, INDIA). Dry bulb and wet bulb temperatures were also used to calculate the relative humidity with the help of psychometric chart.

Statistical Analysis

To test the significance of variation in the data obtained, the analysis of variance technique was adopted as suggested by Fisher (1950) for Completely Randomized Design. Significance of the difference in the treatment effect was tested through "F" test.

3. RESULTS AND DISCUSSION

Chemical characteristics

Fresh mandarin

Quality characteristics of fresh mandarin viz., acidity, ascorbic acid, reducing sugars, total sugars and total soluble solids were determined shown in table 2.

Stored mandarin

Chemicals characteristics of stored mandarin viz. acidity, ascorbic acid, total sugars and T.S.S. were determined and data presented in Table 3 and 4.

Titrable acidity

An examination of Table 3 reveals that the pre-treatments significantly affected the acidity of mandarin. The minimum acidity (0.598%) was recorded in treatment T0 and the maximum (0.613%) was recorded in T_2 after twenty days of storage. The maximum acidity (0.614%) was recorded in P_2 and minimum (0.596%) in P_0 after twenty days of storage. Acidity of fruits decreased with the advancement of storage period. When all the individual treatments were combined, their effect was found to be significant. Combined application of 2, 4-D 100 ppm with perforated polythene (T_2P_2) resulted in maximum acidity as compared to maximum in control (T_0P_0) at the end of storage period i.e. 20th day. It might be due to low degree of oxidation of organic acids in perforated polythene bags.

Ascorbic acid

Among various chemical parameter, ascorbic acid or vitamin 'C' is very important qualitative parameter of mandarin fruits. The minimum ascorbic acid (12.45 mg/100 ml juice) was recorded in treatment T_0 and the maximum (13.13 mg/100 ml juice) was recorded in T_2 after twenty days of storage. The maximum acidity (13.17 mg/100 ml juice) was recorded in P_1 and minimum (11.87 mg/100 ml juice) in P_0 after twenty days of storage. The maximum (14.17 mg/100 ml juice) ascorbic acid was obtained in T_2P_1 and minimum (11.87 mg/100 ml juice) in T_0P_0 after twenty days of storage. In the present study, ascorbic acid content in mandarin fruit was significantly affected by different chemicals, packaging materials and their combinations throughout the storage period up to 20th day. The ascorbic acid content of fruits decreased with advancement of storage period. However, various chemical and packaging materials used in the present study helped in reducing the loss of vitamin 'C' during storage fruits. The decrease in ascorbic acid during storage is probably due to the process of oxidation of ascorbic acid to dehydro-ascorbic acid by enzyme ascorbic-nase (Das and Desh, 1967). The reduction in the loss of vitamin 'C' content of mandarin fruits due to various chemical and packaging materials treatment as obtained in present study may be due to reduction in the rate of evapo-transpiration, which normally results in volatile dissipation of ascorbic acid during storage. The control (T_0P_0) showed lower retention of ascorbic acid while the higher retention of ascorbic acid content of fruits was observed in 2,4-D 100 ppm + corrugated boxes (T_2P_1).

Total soluble solids (TSS)

Minimum TSS (11.55^0 Brix) was recorded in treatment T_2 and the maximum (12.60^0 Brix) was recorded in T_0 after twenty days of storage. TSS (^{0} Brix) of stored mandarin was significantly affected by packaging methods. The maximum TSS (12.52^0 Brix) was recorded in P_0 and minimum (11.47^0 Brix) in P_2 after twenty days of storage. The maximum (13.12^0 Brix) TSS (^{0} Brix) was obtained in T_0P_0 and minimum (10.95^0 Brix) in T_2P_2 after twenty days of storage. It is clear from the data that TSS content of fruits was increased with advancement of storage period. The minimum increase in TSS of fruits during storage period is desirable for preservation of good fruit quality. The minimum TSS content was observed in 2,4-D 50 ppm + perforated polythene (T_2P_2) on 20th day of storage, however it was maximum in control (T_0P_0). Deka (1990) reported that the rate of increase in TSS was slower in perforated polythene as compared to no packaging. Increase in TSS with advancement of storage may be accounted to the moisture loss, hydrolysis of polysaccharides and concentration of juice as a result of dehydration.

Total sugars

A minimum total sugar content of 9.56% was obtained in T_2P_2 and maximum (10.80%) in T_0P_0 after twenty days of storage. It is comprehensible from the data that total sugar of fruits was increased with advancement of storage period. Combined effect of chemical and packaging materials was found to be non-significant during the storage period. The minimum content of total sugars was observed in 2,4-D 100 ppm + perforated polythene (T_2P_2) on 20th day of storage, however it was maximum in control (T_0P_0). The effectiveness of application of different chemicals, packaging materials and their combination might be due to fact that some acids being converted into sugars during respiration conversion of starch (polysaccharides) into sugars (monosaccharide).

Organoleptic characteristics

Sensory parameters such as fruit colour, texture, flavor and overall acceptability scores were maximum for the fruits treated with fruit treated with 2,4-D 100 ppm + corrugated boxes (T_2P_1). The maximum score for colour (4.24) was obtained in T_2P_2 and minimum (2.87) in T_0P_0 after twenty days of storage. Maximum colour retention by T_2P_1 might be due to inhibition of chlorophyll conversion into carotenoids, lycopene and β –carotene (Siddiqui *et al.*, 1997; Mandhyan, 1999). Marketability of the produce depends on overall acceptability and it was highest for T_2P_1. Maximum value for overall acceptability was obtained in T_2P_1 (4.97) and minimum in T_0P_0 (3.57) after twenty days of storage. This might be due to the fact that packaging prevents the direct evapo-transpiration and lowered the physiological loss in weight (Sonkar and Ladaniya, 1999; Ladaniya, 2001 and Choudhary and Dhaka, 2005).

4. CONCLUSION

The combined application of 2, 4-D 100 ppm with perforated polythene (P_2T_2) proved to be best post harvest treatment for storage of mandarin from the point of fruit quality in terms of total soluble solids (TSS), acidity and total sugars content during storage on 20th day of storage. Therefore, it may be recommended that before transportation, growers and retailers shall pack the mandarin fruits in perforated polythene with 2.5 mm holes after the chemical treatment with 2, 4-D 100 ppm.

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Table 1: Experimental details

Variety	Nagpur
Pre-treatment	1. Untreated (Without any chemical treatment) (T0)
	2. Dipping in 2,4-D 50 ppm (T1)
	3. Dipping in 2,4-D 100 ppm (T2)
	4. Dipping in GA3 50 ppm (T3)
	5. Dipping in GA3 100 ppm (T4)
Packaging materials	1. Untreated (Without any packaging material) (P0)
	2. Corrugated fiber box (P1)
	3. Perforated polythene (P2)
	4. Individual wrapping with newspaper (P3)
Total No. of treatment combinations	20
No. of replications	3
Quantity of fruits per pack	2 kg
Total number of treatments	20 x 3 = 60
Experimental design	Factorial CRD
Observations recorded at	0, 5th, 10th, 15th and 20th day of storage

Table 2: Quality characteristics of fresh mandarin

S. No.	Characteristics	Value
1.	Acidity (%)	0.89
2.	Ascorbic acid (mg/100ml)	17.4
3.	Total sugars (%)	10.3
4.	T.S.S. (0Brix)	7.4
5.	Colour	9.5
6.	Overall acceptability	9.8

Table 3: Effect of pre-treatments, packaging materials and their combination on acidity (%) and ascorbic acid content (mg/100 ml of juice) of mandarin

Treatments	Acidity (%)				Ascorbic acid content (mg/100 ml)			
	5 DAS	10 DAS	15 DAS	20 DAS	5 DAS	10 DAS	15 DAS	20 DAS
T0	0.838	0.748	0.668	0.598	15.68	14.38	13.28	12.45
T1	0.849	0.759	0.679	0.609	15.91	14.62	13.51	12.67
T2	0.853	0.764	0.686	**0.613**	16.35	15.03	13.95	**13.13**
T3	0.847	0.757	0.677	0.608	15.73	14.43	13.33	12.49
T4	0.846	0.756	0.676	0.606	15.72	14.43	13.32	12.49
S.Em±	0.002	0.002	0.002	0.0019	0.04	0.037	0.034	0.027
CD at 5%	0.0055	0.00553	0.007	0.0057	0.12	0.106	0.098	0.078
P0	0.836	0.746	0.666	0.596	15.10	13.80	12.70	11.87
P1	0.849	0.759	0.679	0.609	16.40	15.10	14.00	**13.17**
P2	0.853	0.764	0.686	**0.614**	15.70	14.40	13.30	12.50
P3	0.849	0.759	0.679	0.609	15.50	14.20	13.10	12.27
S.Em±	0.0017	0.00173	0.0021	0.0018	15.63	14.33	13.23	12.40
CD at 5%	0.0049	0.005	0.0059	0.0051	16.40	15.13	14.00	13.13
T0 P0	0.821	0.731	0.651	0.581	15.10	13.80	12.70	11.87
T0 P1	0.845	0.755	0.675	0.605	16.40	15.10	14.00	13.17
T0 P2	0.847	0.757	0.677	0.607	15.70	14.40	13.30	12.50
T0 P3	0.840	0.750	0.670	0.600	15.50	14.20	13.10	12.27
T1 P0	0.839	0.749	0.669	0.599	15.63	14.33	13.23	12.40
T1 P1	0.854	0.764	0.684	0.614	16.40	15.13	14.00	13.13
T1 P2	0.853	0.763	0.683	0.613	15.83	14.53	13.43	12.60
T1 P3	0.849	0.759	0.679	0.609	15.77	14.47	13.37	12.53
T2 P0	0.838	0.748	0.668	0.598	15.50	14.20	13.10	12.27
T2 P1	0.856	0.766	0.686	0.616	17.40	16.10	15.00	**14.17**
T2 P2	0.864	0.776	0.706	**0.624**	16.30	14.97	13.90	13.10
T2 P3	0.855	0.765	0.685	0.615	16.20	14.83	13.80	12.97
T3 P0	0.837	0.747	0.667	0.597	15.63	14.33	13.23	12.40

T3 P1	0.845	0.755	0.675	0.605	16.13	14.83	13.73	12.90
T3 P2	0.856	0.767	0.687	0.621	15.43	14.13	13.03	12.20
T3 P3	0.849	0.759	0.679	0.609	15.30	14.00	12.90	12.07
T4 P0	0.844	0.754	0.674	0.604	15.70	14.40	13.30	12.43
T4 P1	0.845	0.755	0.675	0.605	16.37	15.10	13.97	13.13
T4 P2	0.846	0.756	0.676	0.606	15.43	14.13	13.03	12.20
T4 P3	0.850	0.760	0.680	0.610	15.37	14.07	12.97	12.20
S.Em+	0.0038	0.0039	0.0047	0.0040	0.075	0.074	0.068	0.054
CD at 5%	0.0109	0.0111	0.0134	0.0113	0.215	0.211	0.195	0.155

Table 4: Effect of pre-treatments, packaging materials and their combination on TSS (° Brix) and Total sugars (%) of mandarin

Treatments	TSS (° Brix)				Total sugars (%)			
	5 DAS	10 DAS	15 DAS	20 DAS	5 DAS	10 DAS	15 DAS	20 DAS
T0	9.31	10.67	11.96	12.60	8.05	8.85	9.46	9.95
T1	8.70	10.06	11.35	12.00	7.90	8.70	9.30	9.80
T2	8.25	9.61	10.88	**11.55**	7.83	8.62	9.22	**9.72**
T3	8.58	9.94	11.22	11.87	7.93	8.73	9.33	9.83
T4	8.59	9.91	11.24	11.88	7.87	8.67	9.27	9.77
S.Em±	0.0265	0.0337	0.0295	0.0267	0.047	0.048	0.047	0.047
CD at 5%	0.0757	0.0963	0.0843	0.0762	0.136	0.136	0.136	0.136
P0	9.22	10.55	11.87	12.52	8.00	8.80	9.41	9.90
P1	8.67	10.03	11.30	11.97	7.88	8.68	9.28	9.78
P2	8.18	9.54	10.83	**11.47**	7.83	8.62	9.22	**9.72**
P3	8.67	10.03	11.31	11.95	7.96	8.76	9.36	9.86
S.Em±	0.0237	0.0301	0.0264	0.0238	0.0425	0.0425	0.0424	0.1212
CD at 5%	0.0677	0.0861	0.0754	0.0681	0.1214	0.1215	0.1212	0.1214
T0 P0	9.82	11.18	12.47	13.12	8.18	8.98	9.61	10.08
T0 P1	9.11	10.47	11.76	12.41	8.07	8.87	9.47	9.97
T0 P2	8.99	10.35	11.64	12.29	7.92	8.72	9.32	9.82
T0 P3	9.30	10.66	11.95	12.56	8.05	8.85	9.45	9.95
T1 P0	9.03	10.39	11.68	12.33	7.99	8.79	9.39	9.89
T1 P1	9.02	10.38	11.67	12.32	7.77	8.57	9.17	9.67
T1 P2	8.04	9.40	10.69	11.34	7.86	8.66	9.26	9.76
T1 P3	8.69	10.05	11.34	11.99	7.97	8.77	9.37	9.87
T2 P0	9.03	10.39	11.68	12.33	7.73	8.53	9.13	9.63
T2 P1	8.15	9.51	10.71	11.45	7.85	8.65	9.25	**9.75**
T2 P2	7.65	9.01	10.30	**10.95**	7.69	8.46	9.06	9.56
T2 P3	8.17	9.53	10.82	11.47	8.04	8.84	9.44	9.94
T3 P0	9.10	10.46	11.75	12.40	8.06	8.86	9.46	9.95
T3 P1	8.53	9.89	11.18	11.83	7.89	8.69	9.29	9.79
T3 P2	8.11	9.47	10.76	11.38	7.84	8.64	9.24	9.74
T3 P3	8.58	9.94	11.20	11.88	7.95	8.75	9.35	9.85
T4 P0	9.10	10.30	11.75	12.40	8.05	8.85	9.45	9.95
T4 P1	8.53	9.89	11.18	11.83	7.83	8.63	9.23	9.73
T4 P2	8.11	9.47	10.76	11.41	7.84	8.64	9.24	9.74
T4 P3	8.60	9.96	11.25	11.86	7.77	8.57	9.17	9.67
S.Em+	0.0529	0.0674	0.0590	0.0533	0.0949	0.0950	0.0948	0.0950
CD at 5%	0.1513	0.1926	0.1686	0.1523	0.2713	0.2716	0.2711	0.2714