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Storage Behavior of Juice Prepared from Nagpur Mandarin Orange (*Citrus reticulata*)

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ABSTRACT

The present investigation was carried out during 2015–2016 at Post Harvest Technology Centre, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. The storage behavior of juice extracted by screw type pulper using different preservative levels packed in different packaging materials and stored at ambient and cold storage was studied. The data regarding chemical composition revealed that there was increase in TSS, acidity, total sugars, reducing sugars while pH, ascorbic acid, decreased in all treatment combination of juice during 180d of storage. The sensory scores *viz*., colour, flavour, taste and overall acceptability of juice during 180d of storage was decreased in all treatment combination. The microbial quality *viz*., yeast and mould count were found to be increased during 180d of storage. The microbial growth was observed within acceptable level in all treatment combination of juice stored in cold storage and 350 ppm sodium benzoate treated juice packed in glass bottle stored in ambient conditions (T7). The Nagpur mandarin juice could be stored for 180d at cold storage (5±2°C) by using 350ppm sodium benzoate packed in glass bottles (T16, S2P3B1) followed by juice packed in PET bottles (T17, S2P3B2) was found to be superior in respect of chemical composition, sensory evolution and microbial quality.

Key Words: Chemical Composition, Juice, Mandarin, Nagpur, Orange, Packaging, Sensory Evaluation, Quality.

INTRODUCTION

Mandarin orange (*Citrus reticulata* Blanco) is one of the most popular citrus fruit having attractive bright colour, appealing taste and flavour, also known as the mandarin, kinnow. In Maharashtra, mandarin is grown in an area of 1.35 lakh ha area with the production of 7.425 lakh MT with the productivity of 5.5 MT per hectare (Anonymous, 2015). Mandarin orange, a world famous cultivar popularly known as *Nagpur Santra* is the main cash and fruit crop is grown on a large scale in Amravati and Nagpur division of Maharashtra and famous for its taste and quality (Bhargavaramireddy and Balakrishnan, 2014). A single orange is said to have about 170 phyto nutrients and over 60 flavonoids with anti-cancer, anti-tumor, anti-inflammatory, blood clot inhibiting and antioxidant properties. These properties are due to the phyto- vitamins and nutrients present in the citrus fruits (Aslin, 2014). Nagpur mandarin orange is the most important commercial cultivars containing abundant juice, 4 to 11 seed (Chattopadhyay, 2007). Presently, 95 per cent of the production goes for fresh fruit market. It is notable that due to poor post-harvest infrastructure, wastage of mandarin is around 25-30 per cent and that only 5 per cent of the total production is processed presently (Anonymous, 2015). Therefore, the present investigation was carried out to study the storage behavior of juice prepared from Nagpur mandarin orange.

MATERIALS AND METHODS

Juice preparation

Fully ripened, mature, fresh and sound fruits

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were procured from Nagpur mandarin orange growers located in Ahmednagar district of Maharashtra for preparation of juice. The fruits were washed with tap cold water and then removed the peel manually. The juice of mandarin orange was extracted by using screw type pulper. The peeled fruits were fed into juice extractor. The juice and the pomace were separated and collected separately in two outlets. The juice was filtered through a clean muslin cloth. The extracted juice was pasteurized at 65°C for 15min by adding sodium benzoate as a preservative. Then, at that temperature juice was filled in the pre-sterilized 200 mL glass bottles, 200 mL pet bottles, 200mL stand pouches and sealed with crown cork and pouch sealer. All packed juice samples were sterilized. The sterilized packed juice was stored at ambient (19.80-27.60°C and 43.00-70.60% R.H.) and cold (5±2°C and 92-95% R.H.) condition for a period of 180d.

Observations recorded

Physical parameters of fresh mandarin fruit

The physical parameters such as fruit weight (g), peel weight (g), seed weight (g), juice weight (g), pomace weight (g), peel thickness (cm), fruit length (cm), fruit breadth (cm) and segment (pcs) were recorded.

Chemical analysis

The chemical parameters such as TSS, titratable acidity, pH, ascorbic acid (vitamin C), total sugars and reducing sugars were determined by the standard method as suggested by A.O.A.C. (1990) and Ranganna (2005).

Experimental detail

The experimental details were shown below for preparation and storage of juice.

1.	Crop	:	Mandarin Orange
2.	Variety	:	Nagpur Orange
3.	Design	:	Factorial Complete Randomized Design (FCRD)
4.	Replications	:	Three
5.	Storage	:	Ambient Storage (S1) and Cold Storage (5±2°C) (S2)
6.	Preservative Levels	:	Sodium Benzoate: 150 (P1), 250 (P2), 350 ppm (P3)
7.	Packaging	:	Glass Bottles (200 mL) (B1), Pet Bottles (200 mL) (B2), Stand Pouch (200 mL) (B3)
8.	No. of Treatment Combinations	:	2x3x3 =18

9. Treatment detail

Treatment	Treatment Combinations	Treatment	Treatment Combinations
TI	S1P1B1	T10	S2P1B1
T2	S1P1B2	T11	S2P1B2
T3	S1P1B3	T12	S2P1B3
T4	S1P2B1	T13	S2P2B1
T5	S1P2B2	T14	S2P2B2
T6	S1P2B3	T15	S2P2B3
T7	S1P3B1	T16	S2P3B1
T8	S1P3B2	T17	S2P3B2
T9	S1P3B3	T18	S2P3B3

Sensory evaluation

For assessing sensory quality attributes, evaluation was carried by panel of 8-10 judges by using 9-point hedonic scale as given by Amerine *et al* (1979) and Ranganna (2005).

Microbial quality

The microbial (yeast and mould) analysis of Nagpur mandarin juice was carried out as suggested by Adedeji and Oluwana (2013).

Statistical analysis

The experiments were planned and carried out using Factorial Completely Randomized Design (FCRD) with three replications for the statistical significance according to the procedure given by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Physico-chemical composition of fresh fruit

The data revealed that the fresh Nagpur mandarin had 128.8 g fruit weight, 19.59 g peel weight (15.21%), 3.10 g seed weight (2.41%), 68.39 g juice weight (53.09%), 37.72g pomace weight (29.29%), 0.24 cm peel thickness, 5.6 cm fruit length, 6.21 cm fruit breath, 11 pieces of segments, 10.72^0B total soluble solids, 0.621 per cent acidity, 3.89 pH, 43.46 mg/100 mL ascorbic acid, 9.68 per cent total sugars and 3.89 per cent reducing sugars. Similar results were also recorded by Verma *et al* (2012) in Nagpur mandarin.

Chemical composition of Nagpur mandarin juice during storage

1. Total soluble solids (TSS) (˚B)

The Total soluble solids (TSS) content of Nagpur mandarin juice were found to be increased significantly in all treatment combinations (Table 1). The minimum TSS was recorded in S2P3B1 (10.72 to11.73°B) followed by S2P3B2 (10.72 to 11.87°B) during 180d of storage. The TSS content of juice increased might be due to reduction of moisture content, conversion of insoluble carbohydrates into soluble sugars and hydrolysis of polysaccharides into monosaccharide and oligosaccharides during storage. The results were in agreement with the research work carried out by Obenland *et al* (2011) on mandarin juice; Pareek *et al* (2011) on Nagpur mandarin juice.

2. Acidity (%)

The acidity of Nagpur mandarin juice was found to be statistically not significant up to 90d of storage period afterward found to be significant (Table 1). The minimum acidity was recorded in S2P3B1 (0.62 to 0.73 %) followed by S2P3B2 (0.62 to 0.74%) during 180 days of storage. The acidity increased during storage might be due to decrease in pH, degradation of pectic substances into soluble solids and release of acid from juice particles. The results were in agreement with the research work carried out by Pareek *et al* (2011) on Nagpur mandarin juice.

3. Ascorbic acid (mg per 100 mL)

The ascorbic acid of Nagpur mandarin juice was found to be statistically significant. The maximum ascorbic acid was recorded in S2P3B1 (from 43.46 to 35.21 mg/100mL) followed by S2P3B2 (from 43.46 to 34.23 mg/100mL) during 180 days of storage. The decrease in ascorbic acid content might be due to oxidation of ascorbic acid, oxidation of ascorbic acid by enzymes and various treatments applied, conversion of L-ascorbic acid into dihydro ascorbic acid oxidase (ascorbinase) because of heat processing and the presence of air at the head space of packaging materials. Similar results were also reported by Bhardwaj and Mukherjee (2011) in kinnow mandarin juice and Bhardwaj and Lal (2013) in kinnow mandarin juice.

4 . Total sugars (%)

The total sugars content of juice was increased significantly with advancement of storage (Table 1). The minimum increase in total sugars was recorded in S2P3B1 from 9.68 to 11.17 per cent followed by S2P3B2 from 9.68 to 11.30 per cent during 180d of storage. The maximum total sugars were recorded in S1P1B3 from 9.68 to 11.69 per cent

followed by S1P1B2 from 9.68 to 11.55 per cent during 90d of storage period and afterward spoiled. The total sugars during storage were found to be increased which might be due to loss of moisture or due to conversion of starch and carbohydrates into sugars, hydrolysis of polysaccharides (like pectin, cellulose and starch) into monosaccharide and oligosaccharides, inactivation of enzymes which are responsible for decreasing acidity and conversion of polysaccharides into simple sugars. The results were in agreement with the research work carried out by Bhardwaj and Mukherjee (2011) in kinnow mandarin juice; Pareek *et al* (2011) on Nagpur mandarin juice.

Sensory evaluation of Nagpur mandarin juice during storage

The colour, flavor, taste and overall acceptability score of Nagpur mandarin juice was found to be decreased statistically during 180d of storage which might be due to oxidation, storage time, temperature, oxygen content, light exposure, packaging materials sorption or chemical contamination and changes in volatile compounds of beverages. (Table 2). The highest scores in overall acceptability was recorded in S2P3B1 from 8.12 to 7.57 followed by S2P3B2 from 8.02 to 7.44 during 180d of storage. The similar results were also observed by Bhardwaj and Mukherjee (2011) in kinnow mandarin juice and Obenland *et al* (2011) in mandarin juice.

Microbial quality (yeast and mould) of Nagpur mandarin juice during storage

The microbial detection was within the acceptable level (less than 2.00 colony forming unit per mL) in all treatment combinations at ambient storage up to 90d and at cold storage up to 180d in juice. The microbial growth was found to be within acceptable level in the juice which might be due to acid environment, chemical preservative, packaging materials maintained the juice at a safe level and has prevented microbial growth. Similar results reported by Ogodo *et al* (2016) on different fruit juices grown in Nigeria.

CONCLUSION

The storage behavior of juice extracted by screw type pulper using different preservative levels packed in different packaging materials and stored at ambient and cold storage was studied. The data regarding chemical composition revealed that, there was increase in TSS, acidity, total sugars, reducing sugars while pH, ascorbic acid decreased in all treatment combination of juice during 180d of storage. During sensory evaluation, decrease was observed in colour, flavour, taste, overall acceptability score of juice during 180d of storage. The microbial quality *viz*. yeast and mould count were found to be increased during 180d of storage. The microbial growth was observed within acceptable level in all treatment combination of juice in cold storage and T7at ambient condition treatment. The treatment T16 (S2P3B1) was found to be superior in respect of chemical composition, sensory evolution and microbial quality followed by T17 (S2P3B2). The cost of preparation for 1litre juice from Nagpur mandarin fruits was found to be Rs. 104.92 for best treatment combination of S2P3B1 i.e. juice could be stored at cold storage using 350 ppm preservative and packed in glass bottles.

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Table 1. Chemical composition of Nagpur mandarin Juice during 180 days of storage.

Particulars	Storage period (days)	Treatment																				
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	SE. m(±)	CD @ 5%	CD @ 1%
Total Soluble Solid ^{0}B																						
	30	11.93	12.03	12.15	11.58	11.62	11.86	11.50	11.54	11.79	11.33	11.41	11.42	11.02	11.16	11.31	10.75	10.89	11.22	0.0115	0.0331	0.0444
	60	12.00	12.10	12.22	11.65	11.69	11.93	11.57	11.61	11.86	11.40	11.48	11.49	11.09	11.23	11.38	10.82	10.96	11.29	0.0133	0.0381	0.0511
	90	12.19	12.29	12.41	11.78	11.87	12.11	11.70	11.74	12.04	11.56	11.61	11.62	11.25	11.39	11.54	10.98	11.12	11.45	0.0150	0.0431	0.0579
	120	12.21	*	*	11.89	11.90	12.12	11.83	11.83	12.06	11.67	11.73	11.76	11.42	11.54	11.66	11.20	11.32	11.60	0.0169	0.0484	0.0649
	150	*	*	*	12.30	*	*	12.22	12.26	*	12.05	12.13	12.14	11.73	11.87	12.03	11.46	11.60	11.94	0.0160	0.0460	0.0616
	180	*	*	*	*	*	*	12.48	*	*	12.31	12.39	12.40	12.00	12.14	12.29	11.73	11.87	12.20	0.0168	0.0481	0.0645
Acidity %																						
	30	0.65	0.65	0.66	0.64	0.64	0.65	0.64	0.64	0.64	0.63	0.63	0.63	0.62	0.63	0.63	0.62	0.62	0.63	0.0116	NS	NS
	60	0.75	0.76	0.77	0.71	0.73	0.74	0.70	0.71	0.73	0.69	0.69	0.70	0.66	0.67	0.68	0.63	0.65	0.68	0.0162	NS	NS
	90	0.77	0.78	0.79	0.73	0.74	0.76	0.72	0.73	0.75	0.71	0.72	0.72	0.68	0.69	0.71	0.65	0.66	0.70	0.0167	NS	NS
	120	0.79	*	*	0.75	0.76	0.78	0.74	0.75	0.77	0.73	0.74	0.74	0.70	0.71	0.73	0.67	0.68	0.72	0.0174	0.0500	0.0670
	150	*	*	*	0.78	*	*	0.77	0.77	*	0.75	0.76	0.76	0.72	0.74	0.75	0.70	0.71	0.74	0.0174	0.0500	0.0671
	180	*	*	*	*	*	*	0.80	*	*	0.79	0.80	0.80	0.76	0.77	0.79	0.73	0.74	0.78	0.0168	0.0481	0.0646
Ascorbic Acid mg/100mL																						
	30	28.25	27.30	26.34	31.98	31.08	29.16	33.78	32.88	30.07	36.55	35.63	34.70	40.28	39.30	37.47	42.24	41.26	38.40	0.0167	0.0480	0.0644
	60	27.95	26.00	25.04	30.68	29.78	27.86	32.48	31.58	28.77	35.25	34.33	33.40	38.98	38.00	36.17	40.94	39.96	36.10	0.0219	0.0629	0.0844
	90	24.60	24.65	23.69	29.33	28.43	26.51	31.13	30.23	27.42	33.90	32.98	32.05	37.63	36.65	34.82	39.59	38.61	35.30	0.0248	0.0712	0.0955
	120	24.20	*	*	27.93	27.03	25.11	29.73	28.83	26.02	32.50	31.58	30.65	36.23	35.25	33.42	38.19	37.21	34.35	0.0267	0.0765	0.1026
	150	*	*	*	26.48	*	*	28.28	27.38	*	31.05	30.13	29.20	34.78	33.80	31.97	36.74	35.76	32.90	0.0264	0.0757	0.1015
	180	*	*	*	*	*	*	26.75	*	*	29.52	28.60	27.67	33.25	32.27	30.44	35.21	34.23	31.37	0.0271	0.0778	0.1043
Total Sugars %																						
	30	11.01	11.11	11.25	10.66	10.70	10.94	10.59	10.63	10.87	10.42	10.50	10.51	10.11	10.25	10.40	9.86	9.99	10.31	0.0125	0.0358	0.0480
	60	11.22	11.32	11.46	10.87	10.91	11.15	10.80	10.84	11.08	10.63	10.71	10.72	10.32	10.46	10.61	10.07	10.20	10.52	0.0162	0.0464	0.0622
	90	11.55	11.55	11.69	11.10	11.14	11.38	11.03	11.07	11.31	10.86	10.94	10.95	10.55	10.69	10.84	10.30	10.43	10.84	0.0214	0.0613	0.0822
	120	11.71	*	*	11.36	11.40	11.64	11.29	11.33	11.57	11.12	11.20	11.21	10.81	10.95	11.10	10.56	10.69	11.01	0.0234	0.0671	0.0900
	150	*	*	*	11.64	*	*	11.57	11.61	*	11.40	11.48	11.49	11.09	11.23	11.38	10.84	10.97	11.29	0.0226	0.0649	0.0870
	180	*	*	*	*	*	*	11.90	*	*	11.73	11.81	11.82	11.42	11.56	11.71	11.17	11.30	11.62	0.0232	0.0666	0.0894

Table 2. Sensory parameters of Nagpur mandarin Juice during 180 days of storage.

Particulars	Storage period (days)	Treatment																				
		T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18	SE. m(±)	CD @ 5%	CD @ 1%
Color																						
	0	5.29	5.17	5.07	5.89	5.82	5.38	6.57	6.11	5.54	6.87	6.73	6.64	7.66	7.53	6.98	7.98	7.85	7.23	0.0470	0.1340	NS
	30	4.20	3.92	3.91	4.85	4.81	4.55	5.72	4.90	4.78	6.15	5.87	5.74	7.60	7.47	6.50	7.92	7.79	6.63	0.0510	0.1470	0.1980
	60	3.40	3.05	2.90	4.69	4.50	3.53	5.63	4.82	4.37	6.06	5.78	5.65	7.51	7.38	6.41	7.83	7.70	6.54	0.0550	0.1590	0.2130
	90	3.38	3.03	2.88	4.67	4.48	3.51	5.57	4.80	4.35	6.00	5.72	5.59	7.45	7.32	6.35	7.77	7.64	6.48	0.0690	0.1990	0.2660
	120	2.85	*	*	3.74	3.61	2.98	5.50	4.58	3.26	5.93	5.65	5.52	7.38	7.25	6.28	7.70	7.57	6.41	0.0870	0.2500	0.3350
	150	*	*	*	2.83	*	*	5.42	3.85	*	5.85	5.57	5.44	7.30	7.17	6.20	7.62	7.49	6.33	0.0990	0.2840	0.3810
	180	*	*	*	*	*	*	5.36	*	*	5.79	5.51	5.38	7.24	7.11	6.14	7.56	7.43	6.27	0.1200	0.3460	0.4630
Flavor																						
	0	5.81	6.53	6.37	6.73	6.69	6.36	6.91	6.84	6.48	7.67	7.39	6.93	8.03	7.90	7.73	8.35	8.22	7.82	0.0468	0.1341	0.1799
	30	5.19	4.91	4.90	5.84	5.80	5.54	6.06	5.89	5.77	6.49	6.21	6.08	7.94	7.81	6.84	8.26	8.13	6.97	0.0514	0.1474	0.1976
	60	4.39	4.04	3.89	5.68	5.49	4.52	5.98	5.81	5.36	6.41	6.13	6.00	7.86	7.73	6.76	8.18	8.05	6.89	0.0554	0.1590	0.2132
	90	4.37	2.79	2.67	5.66	5.47	4.50	5.87	5.79	5.34	6.30	6.02	5.89	7.75	7.62	6.65	8.07	7.94	6.78	0.0693	0.1987	0.2665
	120	2.84	*	*	4.73	3.60	2.97	5.83	4.79	3.25	6.26	5.98	5.85	7.71	7.58	6.61	8.03	7.90	6.74	0.0871	0.2498	0.3350
	150	*	*	*	3.82	*	*	5.73	3.96	*	6.16	5.88	5.75	7.61	7.48	6.51	7.93	7.80	6.64	0.0990	0.2839	0.3807
	180	*	*	*	*	*	*	5.59	*	*	6.02	5.74	5.61	7.47	7.34	6.37	7.79	7.66	6.50	0.1205	0.3456	0.4634
Taste																						
	0	5.82	5.60	5.53	6.86	6.79	6.26	7.14	6.91	6.63	7.49	7.43	7.38	7.96	7.90	7.78	8.03	8.00	7.81	0.0470	NS	NS
	30	3.91	3.63	3.62	4.56	4.52	4.26	5.76	4.61	4.49	6.19	5.91	5.78	7.64	7.51	6.54	7.96	7.83	6.67	0.0510	0.1470	0.1980
	60	3.11	2.76	2.61	4.40	4.21	3.24	5.67	4.53	4.08	6.10	5.82	5.69	7.55	7.42	6.45	7.87	7.74	6.58	0.0550	0.1590	0.2130
	90	3.09	2.74	2.59	4.38	4.19	3.22	5.57	4.51	4.06	6.00	5.72	5.59	7.45	7.32	6.35	7.77	7.64	6.48	0.0690	0.1990	0.2660
	120	2.56	*	*	3.45	3.32	2.69	5.53	4.29	2.97	5.96	5.68	5.55	7.41	7.28	6.31	7.73	7.60	6.44	0.0870	0.2500	0.3350
	150	*	*	*	2.54	*	*	5.34	3.56	*	5.77	5.49	5.36	7.22	7.09	6.12	7.54	7.41	6.25	0.0990	0.2840	0.3810
	180	*	*	*	*	*	*	5.17	*	*	5.60	5.32	5.19	7.05	6.92	5.95	7.37	7.24	6.08	0.1200	0.3460	0.4630

Overall Acceptability																						
	0	5.83	5.77	5.66	6.49	6.43	6.00	6.87	6.62	6.22	7.34	7.18	6.98	7.88	7.78	7.50	8.12	8.02	7.62	0.502	NS	NS
	30	4.43	4.15	4.14	5.08	5.04	4.78	5.85	5.13	5.01	6.28	6.00	5.87	7.73	7.60	6.63	8.05	7.92	6.76	0.0510	0.1470	0.1980
	60	3.63	3.28	3.13	4.92	4.73	3.76	5.76	5.05	4.60	6.19	5.91	5.78	7.64	7.51	6.54	7.96	7.83	6.67	0.0550	0.1590	0.2130
	90	3.61	2.85	2.71	4.90	4.71	3.74	5.67	5.03	4.58	6.10	5.82	5.69	7.55	7.42	6.45	7.87	7.74	6.58	0.0690	0.1990	0.2660
	120	2.75	*	*	3.97	3.51	2.88	5.62	4.55	3.16	6.05	5.77	5.64	7.50	7.37	6.40	7.82	7.69	6.53	0.0870	0.2500	0.3350
	150	*	*	*	3.06	*	*	5.50	3.79	*	5.93	5.65	5.52	7.38	7.25	6.28	7.70	7.57	6.41	0.0990	0.2840	0.3810
	180	*	*	*	*	*	*	5.37	*	*	5.80	5.52	5.39	7.25	7.12	6.15	7.57	7.44	6.28	0.1200	0.3460	0.4630

*= spoiled treatment

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