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ORIGINAL ARTICLE

Effect of juice extraction methods and processing temperature-time on juice quality of Nagpur mandarin (*Citrus reticulata* Blanco) during storage

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Abstract Influence of juice extraction methods and pasteurization temperature and time on quality of mandarin (*Citrus reticulata* Blanco) juice was studied. The experiment consisted of 65 °C pasteurization temperature with 15, 25 and 35 min holding time; 75 °C with 10, 20 and 30 min and 85 °C with 5, 10 and 15 min holding times and two types of juice extraction methods. The experiment was laid out in factorial completely randomized Design with three replications. Juice extracted with screw type juice extractor and processed at 65 °C for 15 min maintained better qualitative characteristics like total soluble solids, acidity, ascorbic acid, sugars and non-enzymatic browning during 6 months storage. Naringin and limonin contents were minimum with the screw extractor and 65 °C processing temperature for 15 min.

Keywords Mandarin · Juice · Pasteurization · Juice extraction method · Limonin · Naringin

Introduction

Citriculture is the third largest fruit industry in India next to mango and banana. It accounts for 10.8% of total fruit production and occupies 9.4% of total area under fruits in the country (Anon 2007). In India the area under citrus is 7.49 lakh ha, which produces 63.3 lakh tons of fruits (Anon 2007). The mandarin having largest area and maximum production constitutes about 41% of total area under citrus. The area under Nagpur mandarin alone in India is 193.7 thousand ha, which yields 13.13 lakh tons of fruits (Anon 2007). About 95% of the fruits are essentially sold fresh because after processing of fruits, bitterness develops in the products which is not preferred by consumers. The shelf life of fruit is very short at room temperature (Jawanda and Singh 1973). In view of its limited shelf-life, it must be processed to assure availability of its produce and also to minimize the glut in the market in its peak season of production (Sandhu and Singh 2001). At present, its widespread use in citrus industry is handicapped because of development of bitterness (Lotha and Khurdiya 1994). Few methods have been in use for the extraction of citrus juice. Among them only screw type juice extractor is used to extract the juice from mandarins (Ramteke and Eipeson 1990). Reports have also been published on the thermal processing of juice and its shelf-life (Ranote et al. 1993) but detailed investigation has not been conducted on the effects of different extraction methods and thermal processing on quality of juice (Lotha and Khurdiya 1994). Therefore, it is necessary to develop suitable technology for standardization of extraction of mandarin juice and its quality evaluation.

Materials and methods

The experiment was conducted in the Post-harvest Technology Laboratory, Department of Horticulture, SKN College of Agriculture, Jobner, Rajasthan, India. Jobner is situated at 26°05′ N latitude and 75°20′ E longitude at an elevation of 427 meters above mean sea level. Fully

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matured, well-developed and uniform sized fruits of mandarin (*Citrus reticulata* Blanco) cv. 'Nagpur' were purchased from Lal Kothi fruit market, Jaipur and brought to the Post-harvest Technology Laboratory of the Department on the same day.

Fruits were inspected thoroughly for any damage and spoilage. Selected fruits were thoroughly washed in tap water to remove dirt, dust particles and insecticidal residues. Juice was extracted after manually peeling. Screw type hand operated juice extractor (J_1) and power operated commercial juice extractor (J_2) were used in the study. The peeled fruits were fed into J_1 and J_2, separately. In the extractor, the juice and the pomace were separated and both were collected separately. The juice was filtered through a clean muslin cloth and kept for 24 h in refrigerator (4 °C) for sedimentation. Then the clear juice was divided into three lots. One lot was heat processed separately at 65 °C for 15, 25 and 35 min. Then, at that temperature juice was filled in the pre-sterilized bottles and sealed with crown cork. Similarly, other two lots were heat processed separately at 75 °C for 10, 20 and 30 min and at 85 °C for 5, 10 and 15 min. Therefore, total 18 treatment combinations were used for the study. The juice bottles were air cooled under fan. Then all bottled juices were stored at 3–4 °C and juices were used for physico-chemical analysis at 1 month interval for 6 months.

Quality evaluation The total soluble solids (TSS) content of the fruit juice was determined by using 'Zeiss-Hand' refractometer of 0–32% range. The values obtained were corrected at 20 °C with the help of temperature correction chart and expressed as per cent TSS of fruit juices (AOAC 1980). For acidity, a known volume of clean juice was diluted with distilled water and titrated against 0.1N NaOH using phenolphthalein as indicator. The ascorbic acid content was determined by diluting known volume of juice with 3% metaphosphoric acid as buffer and titrating it against 2,6-dichlorophenol indophenol dye solution (AOAC 1980) until the stable faint pink color was obtained. The results were expressed as mg ascorbic acid/100 ml of fruit juice. Total soluble sugars content was determined by using anthrone reagent method (Dubois et al. 1956). To 1 ml of diluted (100 times) fruit juice, 4 ml of Anthrone reagent was added, heated for 10 min in a water bath, cooled to room temperature (28.4 °C) and absorbance was measured at 630 nm on Spectrophotometer (GS 5700A, Electronics Corporation of India Ltd, Hyderabad, India). The amount of sugars present in the juice was plotted against standard curve prepared from glucose. The content was expressed on per cent basis. Reducing sugar content was measured by following 'Nelsons' modification of 'Somogyi method' (Somogyi 1952). Limonin of the juice was estimated using the modified Burnham reagent (Vaks and Litshitz 1981). Naringin of the juice was estimated colorimetrically as suggested by Davis (1947). Non-enzymatic browning of the juice was determined by alcohol extraction method (Klim and Nagy 1988).

Statistical analysis The experiment was laid out in a factorial with completely randomized design (CRD). Total number of treatment combinations was 18 with three replications and each treatment combination has three units. To test the significance of variation in the data, analysis of variance technique was adopted as suggested by Gomez and Gomez (1984). Significance of the difference due to the treatment effect was tested through 'F' test.

Results and discussion

Effect of juice extraction methods The increase in TSS from 9.1 to 10.6^{0}B was recorded in the juice obtained from screw type extraction (J_1) while it increased from 9.2 to 10.8^{0}B in the juice obtained from electrical juice extraction (J_2) from 1 month to 6 months of storage (Table 1). The higher TSS was recorded in J_2 treatment at the end of storage. This might be due to the more squeezing of juice sacs in power operated extractor than screw type extractor. The acidity was in decreasing order, which ranged from 0.91% in 1 month to 0.36% after 6 months of storage in the juice obtained from screw type juice extraction (J_1). However, slightly lower percentage of acidity (0.33%) was recorded in juice obtained from power operated juice extractor (J_2) on 6 months of storage (Table 1). At the end of storage, the higher ascorbic acid content of 22.3 mg/100 ml was recorded in J_1 treatment. There was decrease in ascorbic acid content to the extent of 29.4% in J_1 and 30.7% in J_2 from 1 month to 6 months of storage (Table 2).

On 6 month of storage, juice from J_2 had higher reducing sugar content of 6.5% than the juice from J_1 (6.1%) (Table 3). Reducing sugar content progressively increased during storage in both the treatments. The total sugars content increased during storage under both the treatments. Total sugars content was higher (10.1%) in the juice from J_2 than J_1 extractor (9.8%) at the end of storage period (Table 3). The rate of increase in limonin content in juice was significantly lesser in J_1 as compared to J_2 during storage (Table 4). However, on 6 months storage limonin content of 0.143 mg/ml juice was recorded in juice obtained by J_1 while higher limonin content (0.181 mg/ml) in juice was obtained in juice extracted from J_2. This might be due to the some crushing of seed and more extractor pressure exerted in J_2. Fellers (1989) is of the opinion that the extractor pressure and extractor type affect the limonin content of the juice. The naringin content was significantly

Table 1 Effect of juice extraction methods and processing temperature-time on total soluble solids (TSS) and acidity of juice during storage

	TSS, ^{0}B						Acidity,%					
	Storage period, months						Storage period, months					
	1	2	3	4	5	6	1	2	3	4	5	6
Extraction method												
J_1- Screw type	9.1	9.3	9.5	9.8	10.3	10.6	0.91	0.79	0.66	0.59	0.45	0.36
J_2- Power operated	9.2	9.5	9.6	10.0	10.4	10.8	0.88	0.76	0.64	0.56	0.43	0.33
SEm±	0.04	0.04	0.04	0.04	0.05	0.06	0.005	0.005	0.004	0.003	0.002	0.002
CD (p=0.05) (n=3)	0.13	0.12	0.12	0.13	0.15	0.16	0.014	0.013	0.012	0.010	0.007	0.005
Processing temperature -time												
P_1 t_{15} - 65 °C-15 min	8.8	9.0	9.2	9.5	10.0	10.3	0.93	0.82	0.69	0.60	0.47	0.38
P_1 t_{25} - 65 °C-25 min	8.9	9.1	9.4	9.7	10.1	10.5	0.92	0.82	0.69	0.61	0.47	0.38
P_1 t_{35} - 65 °C-35 min	9.0	9.3	9.5	9.8	10.2	10.6	0.92	0.80	0.66	0.58	0.44	0.35
P_2 t_{10} - 75 °C-10 min	9.0	9.2	9.4	9.6	10.2	10.6	0.91	0.79	0.66	0.59	0.45	0.35
P_2 t_{20} - 75 °C-20 min	9.1	9.4	9.6	9.9	10.3	10.7	0.90	0.78	0.65	0.58	0.44	0.34
P_2 t_{30} - 75 °C-30 min	9.3	9.5	9.7	10.1	10.5	10.9	0.89	0.76	0.65	0.57	0.44	0.33
P_3 t_5 - 85 °C-5 min	9.2	9.5	9.7	10.1	10.5	10.9	0.88	0.76	0.64	0.57	0.43	0.33
P_3 t_{10} - 85 °C-10 min	9.5	9.7	9.8	10.2	10.6	10.7	0.87	0.74	0.63	0.56	0.44	0.33
P_3 t_{15} - 85 °C-15 min	9.6	9.8	10.0	10.3	10.8	11.0	0.86	0.74	0.62	0.55	0.42	0.32
SEm±	0.09	0.08	0.08	0.09	0.11	0.12	0.010	0.009	0.012	0.007	0.004	0.004
CD (p=0.05) (n=3)	0.26	0.25	0.24	0.27	0.31	0.34	0.030	0.028	0.026	0.021	0.011	0.012

Table 2 Effect of juice extraction methods and processing temperature-time on ascorbic acid and non-enzymatic browning of juice during storage

	Ascorbic acid, mg/100 ml						Non-enzymatic browning, O.D. at 440 nm					
	Storage period, months						Storage period, months					
	1	2	3	4	5	6	1	2	3	4	5	6
Extraction method												
J_1- Screw type	31.6	29.9	27.7	26.0	24.0	22.3	0.13	0.16	0.18	0.21	0.24	0.30
J_2- Power operated	31.0	29.3	27.1	25.4	23.7	21.5	0.13	0.16	0.18	0.21	0.24	0.31
SEm±	0.142	0.158	0.138	0.134	0.069	0.135	0.001	0.001	0.001	0.002	0.002	0.002
CD (p=0.05) (n=3)	0.406	0.453	0.424	0.382	0.198	0.385	NS	NS	NS	NS	NS	NS
Treatments												
P_1 t_{15}	34.1	32.4	30.1	28.5	26.7	23.8	0.11	0.13	0.16	0.19	0.22	0.28
P_1 t_{25}	33.0	31.3	29.2	27.3	25.6	23.6	0.12	0.14	0.16	0.19	0.23	0.29
P_1 t_{35}	31.8	30.1	27.9	26.2	24.5	22.5	0.13	0.15	0.17	0.20	0.23	0.29
P_2 t_{10}	32.6	30.8	28.6	27.0	23.7	22.3	0.13	0.15	0.18	0.20	0.24	0.29
P_2 t_{20}	30.9	29.2	27.0	25.3	23.5	21.6	0.13	0.15	0.18	0.21	0.24	0.30
P_2 t_{30}	29.8	28.1	25.8	24.2	22.4	20.5	0.14	0.16	0.19	0.21	0.25	0.31
P_3 t_5	31.2	29.5	27.3	25.6	23.9	21.9	0.15	0.17	0.19	0.22	0.25	0.32
P_3 t_{10}	30.0	28.2	26.0	24.3	22.6	20.7	0.15	0.17	0.19	0.22	0.26	0.32
P_3 t_{15}	28.6	26.8	24.6	23.0	21.3	19.4	0.16	0.18	0.20	0.23	0.27	0.33
SEm±	0.301	0.335	0.314	0.283	0.147	0.286	0.002	0.002	0.003	0.003	0.004	0.005
CD (p=0.05) (n=3)	0.863	0.963	0.902	0.810	0.421	0.818	0.006	0.007	0.008	0.009	0.011	0.014

p_1t_{15} – p_3t_{15}: As in Table 1

Table 3 Effect of juice extraction methods and processing temperature-time on reducing sugar and total sugar of juice during storage

	Reducing sugar,%						Total sugar,%					
	Storage period, months						Storage period, months					
	1	2	3	4	5	6	1	2	3	4	5	6
Extraction method												
J_1- Screw type	3.7	4.1	4.7	5.6	5.9	6.1	8.3	8.4	9.1	9.4	9.6	9.8
J_2- Power operated	4.1	4.5	5.1	5.9	6.2	6.5	8.6	8.7	9.4	9.7	9.9	10.1
SEm±	0.021	0.022	0.026	0.033	0.031	0.035	0.048	0.049	0.055	0.058	0.062	0.064
CD (p=0.05) (n=3)	0.060	0.062	0.073	0.095	0.089	0.099	0.137	0.141	0.157	0.166	0.176	0.184
Treatments												
P_1 t_{15}	3.4	3.8	4.4	5.3	5.6	5.9	8.0	8.1	8.9	9.1	9.4	9.5
P_1 t_{25}	3.5	3.9	4.5	5.3	5.6	5.9	8.1	8.2	8.9	9.2	9.4	9.6
P_1 t_{35}	3.7	4.1	4.7	5.5	5.8	6.0	8.2	8.3	9.1	9.3	9.5	9.8
P_2 t_{10}	3.7	4.1	4.7	5.5	5.8	6.1	8.3	8.4	9.1	9.4	9.6	9.8
P_2 t_{20}	3.8	4.3	4.9	5.8	6.1	6.4	8.4	8.5	9.2	9.4	9.7	9.8
P_2 t_{30}	4.0	4.4	5.0	5.8	6.1	6.4	8.5	8.6	9.3	9.6	9.8	10.0
P_3 t_5	4.1	4.6	5.2	6.0	6.3	6.5	8.6	8.8	9.5	9.8	10.0	10.2
P_3 t_{10}	4.3	4.7	5.3	6.1	6.4	6.7	8.8	8.9	9.6	9.9	10.2	10.3
P_3 t_{15}	4.5	5.0	5.6	6.4	6.7	6.9	8.9	9.0	9.8	10.1	10.3	10.5
SEm±	0.044	0.046	0.054	0.070	0.066	0.073	0.101	0.104	0.116	0.123	0.131	0.136
CD (p=0.05) (n=3)	0.128	0.132	0.155	0.202	0.189	0.211	0.291	0.299	0.334	0.353	0.374	0.391

p_1t_{15} – p_3t_{15}: As in Table 1

Table 4 Effect of juice extraction methods and processing temperature-time on limonin and naringin of juice during storage

	Limonin, mg/ml						Naringin, mg/ml					
	Storage period, months						Storage period, months					
	1	2	3	4	5	6	1	2	3	4	5	6
Extraction method												
J_1- Screw type	0.078	0.090	0.104	0.120	0.132	0.143	0.32	0.32	0.34	0.38	0.40	0.44
J_2- Power operated	0.117	0.129	0.143	0.159	0.169	0.181	0.41	0.43	0.44	0.46	0.52	0.54
SEm±	0.024	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.003	0.002	0.003	0.003
CD (p=0.05) (n=3)	0.069	0.002	0.002	0.003	0.003	0.004	0.006	0.007	0.009	0.007	0.009	0.009
Treatments												
P_1 t_{15}	0.045	0.057	0.071	0.087	0.099	0.114	0.34	0.34	0.36	0.40	0.43	0.46
P_1 t_{25}	0.062	0.074	0.089	0.105	0.116	0.127	0.34	0.35	0.36	0.40	0.43	0.46
P_1 t_{35}	0.077	0.088	0.102	0.118	0.124	0.135	0.34	0.35	0.37	0.41	0.44	0.47
P_2 t_{10}	0.095	0.107	0.121	0.137	0.149	0.159	0.35	0.36	0.38	0.42	0.45	0.47
P_2 t_{20}	0.113	0.125	0.139	0.155	0.166	0.176	0.36	0.37	0.39	0.42	0.46	0.48
P_2 t_{30}	0.119	0.131	0.145	0.161	0.172	0.183	0.38	0.38	0.40	0.43	0.47	0.49
P_3 t_5	0.121	0.133	0.147	0.164	0.175	0.184	0.33	0.39	0.41	0.43	0.48	0.51
P_3 t_{10}	0.123	0.135	0.148	0.164	0.176	0.187	0.40	0.41	0.42	0.44	0.50	0.52
P_3 t_{15}	0.124	0.136	0.150	0.166	0.177	0.188	0.42	0.43	0.45	0.45	0.50	0.54
SEm±	0.051	0.001	0.002	0.002	0.002	0.003	0.004	0.005	0.007	0.005	0.007	0.007
CD (p=0.05) (n=3)	0.147	0.004	0.004	0.006	0.007	0.008	0.013	0.015	0.019	0.015	0.020	0.019

p_1t_{15} – p_3t_{15}: As in Table 1

increased by the juice extraction methods from 1 month to 6 months of storage (Table 4). At the end of storage naringin content of 0.54 mg/ml juice was recorded with J_2 as compared to lower naringin content of 0.44 mg/ml juice with J_1. The effect of juice extraction methods on non-enzymatic browning was found to be non-significant during the entire period of storage (Table 2). However, non-enzymatic browning increased during storage period.

Effect of processing temperature-time The TSS of juice increased during storage. The maximum TSS at the end of experimentation was recorded in P_3t_{15} treatment (11.0^0B) while minimum in P_1t_{15} treatment (10.3^0B). TSS content in P_3t_{15} treatments was found to be higher over other treatments except P_3t_{10}, P_2t_{10}, P_1t_{25}, P_1t_{35} and P_1t_{15} treatments which were at par (Table 1). This might be due to the evaporation of water which causes concentration of juice to some extent by heat processing. Similar opinions were put forth by Dar et al. (1992) in apple juice. Increase of TSS in storage was due to hydrolysis of polysaccharides (starch) into monosaccharides (sugars), increase in concentration of juice due to dehydration and degradation of pectic substances of juice in soluble solids. A similar increase in TSS content with the increase in storage period was observed in juice of mandarin, Sweet orange and lemon by Mehta and Bajaj (1983). The acidity content of fruit juice was decreased during storage. The minimum decrease in acidity from 0.86% to 0.32% was recorded in juice processed at 85 °C with 15 min of holding time (P_3t_{15}), while maximum decrease from 0.92% to 0.35% was recorded in juice processed at 65 °C with 35 min of holding time (P_1t_{35}) from 1 month to 6 months of storage. But the maximum acidity was retained in P_1t_{15} and P_1t_{25} treatments, and minimum in P_3t_{15} treatment at the end of storage. However, P_3t_{15} treatment was statistically at par with P_2t_{30}, P_3t_5 and P_3t_{10} treatments (Table 1). The decrease in acidity during storage could be attributed to the chemical interaction between the organic constituents of the juice induced by temperature and action of enzymes. The high acidity levels in high temperature processing might be due to the inactivation of enzymes and other reactions responsible for decrease in acidity. Singh et al. (2005) observed decrease in acidity of *bael* RTS throughout the storage period of 6 months. A slight decrease in titratable acidity was observed in Kinnow juice during 74 days of storage (Singh et al. 2009).

The ascorbic acid content decreased in all the treatments during storage (Table 2). At the end of storage the minimum ascorbic acid content was found in P_3t_{15} (19.4 mg/100 ml), whereas, it was maximum in P_1t_{15} (23.8 mg/100 ml), however, it was at par in P_1t_{25}. The maximum per cent loss in ascorbic acid was recorded under P_3t_{15} (32.2%), while minimum in P_1t_{25} (28.5%) during 6 months of storage. This loss of ascorbic acid might be due to heat processing and the presence of air at the headspace of glass bottles during storage. Besides that, enzymes like, cytochrome oxidase, ascorbic acid oxidase, and peroxidase are also responsible for oxidation of ascorbic acid and subsequent loss of vitamins C potency (Nagy 1980). Loss of ascorbic acid potency in processed products is due to aerobic and anaerobic reaction of non-enzymatic nature also. The incorporation of air into the juice during extraction, finishing and bottle filling have long been recognized by investigators (Farnworth et al. 2001) as causing ascorbic acid loss. After 6 months of storage 74% loss in vitamin C was observed in cucumber-litchi-lemon blended juice (Majumdar et al. 2009). The results are also in conformity with the findings of Jain and Khurdiya (2009). They observed the loss in vitamin C during storage of aonla juice and also found that low temperature pasteurization, sulphitation and low temperature storage minimize the loss in ascorbic acid.

The reducing sugar content increased during storage and the maximum value was recorded in P_3t_{15} treatment, while minimum recorded in P_1t_{15} treatment on 6 month of storage (Table 3). Total sugars content increased in all the treatments during storage. However, the minimum per cent total sugars content was recorded in P_1t_{15} treatment from 1 month to 6 months storage period and maximum under P_3t_{15} treatment at the end of storage. Treatment P_3t_{15}, had maximum total sugars content but remained at par with P_3t_5 and P_3t_{10} treatments and proved superior to other treatments (Table 3). The increase in total sugars might be due to the hydrolysis of polysaccharides like pectin, cellulose and starch and its conversion into simple sugars. Singh and Mathur (1983) observed that total sugars increased during storage in cashew apple juice. An increase in reducing sugar with the increasing period of storage in all the treatments could be attributed to gradual inversion of non-reducing sugar and acids into reducing sugars in acidic medium. The substantial increase in sugars levels in heat processed juices during storage might be due to the inactivation of enzymes, which might play an important part in the reactions responsible for decreasing acidity and conversion of polysaccharides into simple sugars (Ghorai and Khurdiya 1998). Garg et al. (2008) also observed the increase in reducing and total sugar content during storage in blended aonla juices.

The limonin content in juice increased during storage with higher temperature and longer holding time. At the end of storage, lowest limonin content of 0.114 mg/ml juice was recorded in P_1t_{15} while highest in P_3t_{15} (0.188 mg/ml juice) (Table 4). This might be due to the conversion of limonoate-α-ring lactone into limonin in the juice. The present findings are in conformity with the study of Premi et al. (1994). The increase in limonin was more at higher processing temperature which could be probably due in part to its low solubility in water; hence heating increased its

concentration (Kefford 1959) and accelerated conversion of non-bitter precursor, α-limonin monolactone to limonin (Maier and Beverly 1968). The low limonin content at low processing temperature might be due to inhibition of oxidation of D-ring lactone into limonin. Table 4 indicates that naringin content increased in all the treatments during storage. At the end of storage, maximum naringin content of 0.54 mg/ml juice was recorded under P_3t_{15}, which was higher compared to all other treatments but at par with P_3t_{10}. Lowest naringin content was in P_1t_{15} and P_2t_{15} at the end of storage (0.46 mg/ml juice).

Non-enzymatic browning of juice increased during storage. At the end of storage, minimum non-enzymatic browning was in the juice processed at 65 °C for 15 min holding time (P_1t_{15}), but it was at par with P_1t_{25}, P_1t_{35} and P_2t_{10} treatments. Maximum non-enzymatic browning was observed in juice processed at 85 °C for 15 min (P_3t_{15}), and it was at par with P_3t_5 and P_3t_{10} treatments (Table 2). Khurdiya and Anand (1981) reported a gradual increase in browning and formulation of hydroxy methyl furfural was noted in *Phalsa* beverage with increasing storage period. This might be due to the formation of hydroxy methyl furfural and other dark pigments. Ranote and Bains (1982) viewed that there was increased browning in heat processed Kinnow juice after 8 weeks of storage as compared to the juice preserved with sulphur dioxide. Further, Kacem et al. (1987) proved that ascorbic and dehydroascorbic acids may enter into the browning scheme as highly reactive α-dicarbonyls. They also observed that the effect of amino acids on browning of single strength orange juice was linear with concentration and found to be more pronounced in the presence of high levels of ascorbic acid. Jain and Khurdiya (2009) noticed the non-enzymatic browning in aonla juice during 6 months storage and also reported that it was minimized with sulphitation and low temperature storage. Total phenolic contents and oxidation reactions were increased in apple juice stored for 30 days which was responsible for non-enzymatic browning (Zhang et al. 2008).

Conclusion

The shelf life of mandarin juice is very short and also quality deteriorated during storage. In this study juice extraction method and processing temperature—time was optimized. Nagpur mandarin juice extracted with screw type extractor and processed at 65 °C for 15 min maintained better quality measured in terms of total soluble solids, ascorbic acid, sugars and non-enzymatic browning during 6 months storage at 3–4 °C. Limonin and naringin are responsible for the delayed bitterness in storage of mandarin juice and both were found lowest in the same treatment.

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