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Original Research Article

Studies on the Physico–Chemical Changes in Minimally Processed Nagpur Mandarin Fruits during Storage

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A B S T R A C T

An investigation involving the use of different chemicals (citric acid, ascorbic acid and chitosan) and two type of packaging material (polyethylene film 38µ and75µ) and their combinations to enhance the storage life of minimally processed Nagpur mandarin fruits was carried out at the department of Post-Harvest Technology, College of Horticulture and Forestry, Jhalarapatan, Jhalawar (Rajasthan) in the month of Feruary, 2017. The minimally processed fruits were treated with 3 concentrations of chemicals viz. citric acid and ascorbic acid (0.5%, 1.0% and 1.5%) and 0.1%, 0.2% and 0.3% concentration of chitosan, placed in polystyrene trays and were packed in 38 micron or 75 micron polyethylene film and stored in refrigerated condition at 4±1^{0}C and 85-90 per cent relative humidity. On the basis of sensory attribute, physico-chemical characteristics and microbial activity the minimally processed fruits treated with various chemicals such as citric acid, ascorbic acid, and chitosan were acceptable up to 8th day of storage however untreated fruits were not acceptable. The treatment of Chitosan 0.3% with 75 micron polyethylene gave encouraging results. At the 8th of the storage period minimum TSS (10.67^{0}brix), minimum total sugars (5.98 %), minimum Reducing sugars (3.40%) were found in fruits treated with Chitosan 0.3% and packed in 75 micron polyethylene. Maximum acidity (0.94%), and minimum pH (3.68), was observed in Citric acid 1.5% with 75 micron polyethylene film and maximum ascorbic acid content (35.44mg/100g) was noticed Ascorbic acid 1.5% with 75 micron polyethylene packing fruits at the end of the 8 days of storage period as compared to the control.

Keywords

Minimal processed, Physico- chemical, Chitosan, Polyethylene film, Mandarin

Introduction

Mandarin (*citrus reticulata* Blanco) belongs to family Rutaceae. Nagpur mandarin is considered to be one of the most important cultivated species among citrus and is being commercially grown in specific region of the country like Nagpur mandarin in Central India, Khasi mandarin in North Eastern regions and Coorg mandarin in Southern regions. Post-harvest losses of a fruits in India is reported to be as high as 30 percent (Verma and Joshi, 2001). Though, it is grown in every state, certain belts/pockets have emerged as the leading producers. Nagpur mandarin is chiefly grown in Satpura hills (Vidarbha region) of central India. Hilly slopes of Darjeeling (West Bengal) and Coorg (Karnataka) are other major belts of mandarin production. In north-western India, Jhalawar (Rajasthan) is major growing belt of Nagpur mandarin.

Citrus fruit are very important agricultural products in many countries where sometimes there is an over-production. In this case the presentation of minimally processed ready – to- eat fruit will diversify and add value to the product, and avoid any decrease in prices. The minimally processed fruit market continues to expand both for the food service and retail markets. Changing life styles dictate the need for food that offers convenience to the consumer in a myriad of ways such as minimizing preparation time while also offering high quality though an extended shelf life (Blakistone,1999). As a result, consumers are increasingly demanding convenient, ready to use and ready to eat fruits with a fresh like quality, containing only natural ingredients (Lund, 1989; Rocha and Morais, 2007). In response to these needs, one of the most important recent developments in the food industry has been development of minimal processing technologies designed to limit the impact of processing on the nutritional and sensory quality and to preserve food without the use synthetic additives.

While there is considerable interest in minimally processed ready- to- eat fruits especially in metro cities, restaurants and food markets. There are very few published studies on minimally processed citrus products and to the best of my knowledge none on minimally processed mandarin fruits.

Materials and Methods

Freshly harvested, uniform maturity size and quality fruits of Mandarin var. 'Nagpur' free from insect pest and microbial infection were procured from the local farmers with prior arrangement. These were brought to the laboratory and sorted out. Bruised, off types and misshaped fruits were removed. Fruits were dipped in three concentrations of Citric acid, Ascorbic acid (0.5%, 1.0% and 1.5%) and Chitosan (0.1%, 0.2% and 0. 3%) for 5 minutes followed by placing them on cellphone sheet for drying in shade for 30 minutes. After treatment the fruits of each lot were packed in polypropylene (punnet) sealed with two types of polyethylene films (38 and 75 micron) with the help of polyethylene sealing machine. The fruits were stored in refrigerated condition at 4 ± 1^{0}c and 85-90 per cent Relative humidity.

Storage Studies

First, observations of chemical components recorded before treating the fruits. The changes studied during the storage period included:

Chemical changes

Changes in total soluble solids (T.S.S.), acidity, pH, ascorbic acid, total sugar, reducing sugar content.

Methods of Analysis

For chemical analysis, one healthy fruit was selected randomly from each unit. Pulp from the fruit was scooped out and grinded in a mortar and pestle. The pulp was filtrated through filter paper and the clear extract was used for different chemical analysis. Total soluble solids measured by the "Erma" Hand Refractometer (0-30) and value obtained was corrected at 20ºC (A.O.A.C, 1995). Titratable acidity was determined by titrating the juice against standard alkali solution (0.1N NaOH) and end point reached with disappearance of pink colour. pH of the sample was determined by a glass electrode pH meter (Martini) after calibrating with a buffer (pH 4.0) at ± 20˚C, ascorbic acid content of the sample was determined by method as described by

Ranganna (1997). Total sugar content was determined by using anthrone reagents method (Dubois *et al.,* 1951). Reducing sugar content was measured by following Nelson's modification of Somogy's method (Nelson, 1944)

Statistical Analysis

The data obtained in the present investigation were subjected to the analysis of variance by 'F' test for Factorial completely randomized design (Gomez and Gomez, 1984) with 20 treatment combinations and 3 replicates.

Results and Discussion

Total soluble solids (°Brix)

The TSS content of the fruits first increased (Table 1) from an initial value of 8.5°Brix up to 8th day of storage and there after decreased on 12th day, irrespective of the treatments, packaging material and their interactions..On 8th day of storage Among, the various interactions, significantly highest TSS was seen in untreated fruits packed in 38 micron polyethylene film (12.10° Brix), while the lowest TSS was recorded in fruits treated with chitosan 0.3% + packed in 75 micron polyethylene film (10.67° Brix). The better retention of TSS in minimally processed fruits might be due to slow rate of respiration and consequently less oxidative breakdown of polysaccharides and sugars in coated fruits packed in thicker polyethylene. These results were in confirmation with the results obtained in minimally processed papaya (Alam *et. al.,* 2013); cherry fruits (Okan *et al.,* 2011).

Acidity (%)

It is evident from the (Table 2) that the acidity content of the minimally processed fruits decreased throughout the storage period, irrespective of the treatments, packaging material and their interactions from an initial value of 1.12 per cent. At 8th day of storage the acidity content decreased irrespective of the treatments, packaging material and their interactions.

Among, the various interactions, significantly highest acidity was seen in citric acid 1.5% treated fruits packed in 75 micron polyethylene film (0.94 per cent), while the lowest acidity was recorded in untreated fruits and packed in 38 micron PE (0.78 per cent).

The decrease in acidity could be attributed to the fruit ripening process during storage, and enhancement in enzymatic depolymerisation as well as the conversion of organic acids in to starch and sugar through the process of gluconeogenesis (Saxena *et al.,* 2008).

pH

The pH (active acidity) of stored fruits increased during the entire period of storage (Table 3) irrespective of the treatments, packaging material and their interactions from an initial value of 3.05.

At 8th day of storage the pH content increased irrespective of the treatments, packaging material and their interactions. Among, the various interactions, significantly highest pH was seen in untreated fruits packed in 38 micron polyethylene film (4.85), while the lowest pH was recorded in fruits treated with citric acid 1.5% + packed in 75 micron polyethylene film (3.68). The increase in pH might be due to the corresponding breakdown of organic acids due to respiration process during storage (Pesis *et al.,* 1999).

Table.1 Effect of pretreatment and packaging material on the total soluble solids (^{0}Brix) of minimally processed Nagpur mandarin during storage (Initial value at 0 days = 8.5)

	4th day			8th day			12th day		
Treatment	Packaging Material			Packaging Material			Packaging Material		
	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean
Control	9.60	9.40	9.50	12.10	11.90	12.00	11.10	10.90	11.00
Citric acid 0.5%	9.36	9.34	9.35	11.93	11.27	11.60	11.02	10.90	10.96
Citric acid 1.0%	9.36	9.29	9.32	11.50	11.20	11.35	10.91	10.83	10.87
Citric acid 1.5%	9.32	9.27	9.30	11.36	11.15	11.25	10.86	10.69	10.78
Ascorbicacid0.5%	9.30	9.26	9.28	11.20	11.10	11.15	10.63	10.47	10.55
Ascorbicacid1.0%	9.30	9.24	9.27	11.15	11.00	11.07	10.58	10.38	10.48
Ascorbicacid1.5%	9.28	9.24	9.26	11.05	10.95	11.00	10.46	10.38	10.42
Chitosan 0.1%	9.22	9.17	9.19	11.00	10.80	10.90	10.45	10.25	10.35
Chitosan 0.2%	9.17	9.13	9.15	10.90	10.76	10.83	10.30	10.15	10.22
Chitosan 0.3%	9.12	9.08	9.10	10.84	10.67	10.75	10.20	10.10	10.15
Mean	9.30	9.24		11.30	11.08		10.65	10.50	
	S.Em±	C.D.at 5%		S.Em±	C.D.at 5%		S.Em±	C.D.at 5%	
Treatment (T)	0.05	0.11		0.12	0.24		0.05	0.10	
Packaging (P)	0.02	0.05		0.05	0.10		0.02	0.04	
T × P	0.08	0.16		0.17	0.34		0.07	0.14	

Table.2 Effect of pretreatment and packaging material on the acidity content (%) of minimally processed Nagpur mandarin during storage (Initial value at 0 day = 1.12)

	4th day			8th day			12th day		
Treatment	Packaging Material			Packaging Material			Packaging Material		
	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean
Control	0.98	1.00	0.99	0.78	0.79	0.79	0.60	0.73	0.66
Citric acid 0.5%	1.01	1.03	1.02	0.80	0.88	0.84	0.68	0.83	0.75
Citric acid 1.0%	1.03	1.04	1.03	0.83	0.90	0.87	0.72	0.85	0.78
Citric acid 1.5%	1.03	1.07	1.05	0.84	0.94	0.89	0.74	0.86	0.80
Ascorbicacid0.5%	0.99	1.05	1.02	0.78	0.85	0.81	0.69	0.68	0.69
Ascorbicacid1.0%	1.02	1.06	1.04	0.80	0.86	0.83	0.71	0.72	0.71
Ascorbic acid1.5%	1.03	1.06	1.04	0.84	0.88	0.86	0.72	0.73	0.73
Chitosan 0.1%	1.00	1.01	1.00	0.83	0.80	0.81	0.70	0.68	0.69
Chitosan 0.2%	1.01	1.02	1.02	0.85	0.85	0.85	0.76	0.72	0.74
Chitosan 0.3%	1.02	1.03	1.02	0.85	0.89	0.87	0.83	0.76	0.79
Mean	1.01	1.03		0.82	0.86		0.71	0.76	
	S.Em±	C.D.at 5%		S.Em±	C.D.at 5%		S.Em±	C.D.at 5%	
Treatment (T)	0.018	0.037		0.022	0.044		0.028	0.056	
Packaging (P)	0.008	0.016		0.009	0.019		0.012	0.025	
T × P	0.025	0.052		0.031	0.063		0.039	0.080	

Table.3 Effect of pretreatment and packaging material on the $_{P}^{H}$ content of minimally processed Nagpur mandarin during storage (Initial value at 0 day = 3.05)

	4th day			8th day			12th day		
Treatment	Packaging Material			Packaging Material			Packaging Material		
	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean
Control	4.01	3.97	3.99	4.85	4.64	4.74	5.33	5.30	5.31
Citric acid 0.5%	3.51	3.49	3.50	3.77	3.79	3.78	4.65	4.50	4.57
Citric acid 1.0%	3.46	3.35	3.41	3.74	3.79	3.76	4.57	4.45	4.51
Citric acid 1.5%	3.38	3.34	3.36	3.70	3.68	3.69	4.48	4.39	4.43
Ascorbic acid0.5%	3.72	3.70	3.71	4.02	4.00	4.01	4.94	4.88	4.91
Ascorbic acid1.0%	3.67	3.64	3.66	3.94	3.94	3.94	4.84	4.78	4.81
Ascorbic acid1.5%	3.64	3.61	3.62	3.85	3.83	3.84	4.73	4.71	4.72
Chitosan 0.1%	3.90	3.86	3.88	4.31	4.24	4.27	4.96	4.90	4.93
Chitosan 0.2%	3.84	3.81	3.83	4.21	4.17	4.19	4.90	4.86	4.88
Chitosan 0.3%	3.80	3.78	3.79	4.06	4.07	4.06	4.84	4.80	4.82
Mean	3.69	3.65		4.04	4.01		4.82	4.75	
	S.Em±	C.D.at 5%		S.Em±	C.D.at 5%		S.Em±	C.D.at 5%	
Treatment (T)	0.21	0.043		0.037	0.075		0.047	0.096	
Packaging (P)	0.09	0.019		0.016	0.033		0.020	0.042	
T × P	0.030	0.061		0.052	0.106		0.067	0.138	

Table.4 Effect of pretreatment and packaging material on the vitamin C (mg/100g) content of minimally processed Nagpur mandarin oranges during storage (Initial value at 0 day = 40.25)

	4th day			8th day			12th day		
Treatment	Packaging material			Packaging material			Packaging material		
	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean
Control	37.97	38.01	37.99	33.16	33.79	33.47	27.71	28.73	28.22
Citric acid 0.5%	37.93	38.45	38.19	34.89	34.67	34.78	30.69	30.28	30.48
Citric acid 1.0%	38.67	38.48	38.57	34.98	34.69	34.83	30.79	30.78	30.78
Citric acid 1.5%	38.70	38.67	38.69	34.99	34.85	34.92	30.91	31.03	30.97
Ascorbic acid0.5%	39.08	39.03	39.05	35.13	35.08	35.10	31.10	31.06	31.08
Ascorbic acid1.0%	39.28	39.23	39.25	35.27	35.22	35.25	31.26	31.22	31.24
Ascorbic acid1.5%	39.38	39.42	39.40	35.32	35.44	35.38	31.32	31.40	31.36.
Chitosan 0.1%	38.18	38.12	38.15	34.07	34.20	34.13	30.05	30.12	30.08
Chitosan 0.2%	38.48	38.19	38.34	34.27	34.88	34.57	30.36	30.21	30.28
Chitosan 0.3%	38.57	38.29	38.43	34.55	34.41	34.98	30.48	30.45	30.47
Mean	38.58	38.63		34.67	34.71		30.47	30.52	
	S.E±	C.D. at 5%		S.Em±	C.D.at 5%		S.Em±	C.D.at 5%	
Treatment (T)	0.19	0.40		0.34	0.69		0.31	0.60	
Packaging (P)	0.09	0.17		0.15	0.30		0.13	0.27	
T × P	0.28	0.57		0.49	0.99		0.44	0.87	

Table.5 Effect of pretreatment and packaging material on the total sugar content (%) of minimally processed Nagpur mandarin during storage (Initial value at 0 day = 6.10)

	4th day			8th day			12th day		
	Packaging material			Packaging material			Packaging material		
Treatment	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean
Control	7.03	6.98	7.00	8.06	7.92	7.99	6.90	6.67	6.79
Citric acid 0.5%	6.85	6.74	6.79	7.39	7.32	7.36	6.73	6.61	6.67
Citric acid 1.0%	6.71	6.61	6.66	7.28	7.25	7.26	6.57	6.58	6.57
Citric acid 1.5%	6.58	6.44	6.51	7.19	7.24	7.21	6.51	6.48	6.49
Ascorbicacid0.5%	6.43	6.39	6.41	7.16	7.14	7.15	6.41	6.39	6.40
Ascorbicacid1.0%	6.37	6.24	6.31	7.10	7.11	7.10	6.34	6.28	6.31
Ascorbicacid1.5%	6.30	6.21	6.25	7.06	7.06	7.06	6.23	6.20	6.21
Chitosan 0.1%	6.23	6.15	6.19	6.98	6.96	6.97	6.17	6.12	6.14
Chitosan 0.2%	6.15	6.12	6.13	6.92	6.90	6.91	6.08	6.05	6.06
Chitosan 0.3%	6.10	6.08	6.09	6.87	6.83	6.85	6.00	5.98	5.99
Mean	6.47	6.39		7.20	7.17		6.39	6.33	
	S.Em ±	C.D.at 5%		S.Em±	C.D.at 5%		S.Em±	C.D.at 5%	
Treatment (T)	0.32	0.065		0.031	0.063		0.032	0.066	
Packaging (P)	0.014	0.029		0.014	0.028		0.014	0.029	
T × P	0.045	0.92		0.044	0.090		0.046	0.93	

Table.6 Effect of pretreatment and packaging material on the reducing sugar content (%) of minimally processed Nagpur mandarin during storage (Initial value at 0 day =3.50)

	4th day			8th day			12th day		
Treatment	Packaging material			Packaging material			Packaging material		
	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean	PE38µ	PE75µ	Mean
Control	4.32	4.27	4.29	5.31	5.29	5.30	4.22	4.17	4.20
Citric acid 0.5%	4.15	4.07	4.11	4.87	4.84	4.85	4.10	4.06	4.08
Citric acid 1.0%	4.08	4.06	4.07	4.80	4.78	4.79	4.04	3.98	4.01
Citric acid 1.5%	3.97	3.99	3.98	4.74	4.70	4.72	3.94	3.94	3.94
Ascorbic acid0.5%	3.88	3.82	3.85	4.67	4.68	4.68	3.84	3.87	3.85
Ascorbic acid1.0%	3.81	3.77	3.79	4.63	4.60	4.62	3.74	3.70	3.72
Ascorbic acid1.5%	3.74	3.75	3.75	4.60	4.57	4.58	3.65	3.64	3.64
Chitosan 0.1%	3.69	3.68	3.69	4.53	4.50	4.51	3.57	3.58	3.57
Chitosan 0.2%	3.66	3.63	3.64	4.47	4.46	4.47	3.50	3.47	3.48
Chitosan 0.3%	3.62	3.60	3.61	4.43	4.39	4.41	3.45	3.40	3.43
Mean	3.89	3.87		4.70	4.68		3.80	3.78	
	S.Em±	C.D.at 5%		S.Em±	C.D.at 5%		S.Em±	C.D.at 5%	
Treatment (T)	0.018	0.037		0.015	0.031		0.007	0.034	
Packaging (P)	0.008	0.16		0.006	0.014		0.016	0.015	
T × P	0.026	0.53		0.021	0.044		0.024	0.048	

Ascorbic acid (mg/100 g)

Ascorbic acid content of the minimal processed mandarin fruits decreased throughout the storage period (Table 4). All the treatments, packaging material and interactions had significant effect on the ascorbic acid content of the fruit. On the 8th day of storage among, the various interactions, significantly highest ascorbic acid was seen in ascorbic acid 1.5 per cent treated fruits packed in 75 micron polyethylene film (35.44 mg/100 g), while the lowest ascorbic acid was recorded in untreated fruits and packed in 38 micron PE (33.16 mg/100 g). The rate of decrease in

ascorbic acid was significantly higher in untreated fruits as compared to treated fruits. This might be due to rapid loss of L-ascorbic acid by oxidation because of greater availability of oxygen. Another reason might be due to rapid conversion of L-ascorbic acid into dehydro-ascorbic acid in the presence of enzyme ascorbinase (Atress *et al.,* 2010).

Total sugars (%)

It is evident from the (Table 5) that the total sugar content of the fruits first increased from an initial value of 6.10 per cent up to 8th day of storage and thereafter decreased on 12th day, irrespective of the treatments, packaging material and their interactions. However, on the 8rd day of storage, Among, the various interactions, significantly highest total sugar was seen in untreated fruits packed in 38 micron polyethylene film (8.06 per cent), while the lowest total sugar was recorded in fruits treated with chitosan 0.3% + packed in 75 micron polyethylene film (6.83 per cent).

Citrus fruits contain natural sugars mainly in the form of sucrose; glucose and fructose. These sugars are produced as a result of oxidative breakdown of polysaccharides in the process of respiration and ripening. The treatment involving Chitosan and packaging in 75 micron polyethylene reported the least increase in total sugar due to their ability to retard ripening process as compared to control. These results are in conformity with those Babsky *et al.,* 1986 and Ahemad *et al.,* (1979) and Ahmad and Khan (1987) in citrus fruit, and Ladaniya (2001) in sweet orange.

Reducing Sugar (%)

It is evident from the (Table 6) that the reducing sugar content of the fruits first increased from an initial value of 3.50 per cent up to 8th day of storage and thereafter decreased on 12th day, irrespective of the treatments, packaging material and their interactions. The variations due to different treatments were significant on all the days of storage, however, on the 8rd day of storage Among, the various interactions, significantly highest reducing sugar was seen in untreated fruits packed in 38 micron polyethylene film (5.31 per cent), while the lowest reducing sugar was recorded in fruits treated with chitosan 0.3% +packed in 75 micron polyethylene film (4.39 per cent).

A reducing sugar is any sugar that is capable of acting as a reducing agent because it has a free aldehyde group or a free ketone group. All monosaccharides such as glucose, fructose, galactose etc. are reducing sugars. These are produced during ripening of fruits as a result of depletion of starch and other polysaccharides (Chaimanee and Suntornwat, 2010).

The application of Chitosan 0.3% + 75 micron polyethylene film to the minimal processed mandarin fruits helped to maintained all the sensory characters attributing to quality. In addition, sensory perception indicated the superior quality of the chitosan-treated product compared with the non-treated product at the end of the storage period.

Further, this treatment also maintained the fruit quality in terms of total soluble solids (TSS), reducing sugars and total sugars content during storage on 8th day of storage.

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