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Physico-chemical changes of *Khasi* mandarin (*Citrus reticulata* Blanco) fruits as influenced by plant extracts, essential oils and natural coatings

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Abstract
An experiment was conducted during 2017-18 in the Post-harvest laboratory of the Department of Horticulture and Department of Plant Pathology, Assam Agricultural University, Jorhat to study the effect of physico-chemical changes of *Khasi* mandarin fruits as influenced by plant extracts, essential oils and natural coatings. *Khasi* mandarin fruits were treated with two best Plant extracts and essential oils (amongst 6 plant extracts and essential oils tried) alone or in combination with two natural coatings viz. *Aloe vera* gel and chitosan. After the treatment the fruits were wrapped in perforated 50 micron polyethylene bags and stored under ambient condition and various physico-chemical and sensory evaluations were taken up across the storage period. The results revealed that though Bavistin treatment recorded higher values with respect to physic-chemical and sensory evaluation; there was no significant difference between the Bavistin treatment and Neem extract treatment and also with the combination of *Aloe vera* gel (1%)+Neem extract(10%) (in some of the observations). Since plant extracts are environment friendly and do not leave any chemical residue as against use of chemical fungicides (like Bavistin), use of Neem leaf extract and combination of *Aloe vera* gel (0.1%) + Neem extract(10%) can be advocated for enhancing shelf life of *Khasi* mandarin fruits.

Keywords: *khasi* mandarin, *aloe vera* gel, neem extract, polyethylene bags

1. Introduction
Citrus is one of the important fruit crops in India next to mango and banana. Among citrus, *Khasi* mandarin (*Citrus reticulata* Blanco) is one of the most widely cultivated and important commercial fruit crop of North-East India. Fruits are depressed, globose to oblate, medium in size, loosed skinned, bright orange yellow in colour, surface smooth, glossy, rind thick to medium, rind and segment easily separable, segments moderate in numbers, juice abundant, with sour-sweet blend have short shelf life of 5-7 days at ambient storage condition (Ngachan *et al*., 2010) [15]. Treatment with basil oil controlled crown rot and anthracnose prolonging storage of bananas (Tzortzakis and Economakis, 2007) [22]. The composite edible coatings of GA combined with Lemon grass oil and Cinnamon oil showed the synergistic effects and great potential to control anthracnose in bananas and papayas and maintain quality for up to 33 days (Maqbool *et al.,* 2011) [14]. Some phototoxic effects were observed on banana and papaya fruit when Lemon grass oil and Cinnamon oil were used alone and fruit were spoiled earlier as compared with the fruit treated with GA combined with Lemon grass oil and cinnamon oil. It was reported that 80% control of anthracnose on banana and 71% on papaya is achieved with 10% gum Arabic combined with 0.4% cinnamon oil. This proves the effectiveness of this composite edible coating as an alternative to synthetic fungicides (Maqbool *et al.,* 2011) [14]. Thus, the study of natural antimicrobials is a promising area of research for maintaining the fruit quality by managing the post-harvest diseases (Cantrell *et al.,* 2005) [5]. There are many wild plants spp. available in nature especially in the north east part of India which have not been tested for their effect on enhancing shelf life of fruits. In view of these facts, an experiment was planned to study the effect of different plant extracts and essential oils on post-harvest shelf life of *Khasi* mandarin fruits.

2. Materials and Methods
Khasi mandarin fruits of uniform size and maturity (colour break stage) were harvested and brought to the laboratory on the same day during the month of December, 2017. A total of 500 fruits free from visual damage and diseases were considered for the study. The fruits were

initially washed with clean tap water and then with distilled water, dried off by keeping the fruits for 2 hours under fan inside the laboratory. These fruits were treated with different treatments as follows:

Treatments

Sl. No.	Treatments		Concentrations
1	T_0	Control(Distilled water)	1L
2	T_1	*Aloe vera* gel	1%
3	T_2	Chitosan	1%
4	T_3	*Azadirachta indica* (Plant extract 1)	10%
5	T_4	*Cinnamon cassia*(Plant extract 2)	10%
6	T_5	lemon grass oil (Essential oil 1)	4ml
7	T_6	Clove oil (Essential oil 2)	25µ
8	T_7	*Aloe vera* gel +Plant extract 1	1% + 10%
9	T_8	*Aloe vera* gel +Plant extract 2	1% + 10%
10	T_9	*Aloe vera* gel +Essential oil 1	1% + 4ml
11	T_{10}	*Aloe vera* gel +Essential oil 2	1% + 25µ
12	T_{11}	Chitosan + Plant extract 1	1% + 10%
13	T_{12}	Chitosan +Plant extract 2	1% + 10%
14	T_{13}	Chitosan +Essential oil 1	1% + 4ml
15	T_{14}	Chitosan +Essential oil 2	1% + 25µ
16	T_{15}	Fungicide (Bavistin 0.1%)	0.10%

Tepol was used as a surfactant in all the treatments. After treatments fruits were packed in perforated polyethylene bags. The packed fruits were stored up to a total period of 20 days at ambient condition. Various physico-chemical, Biochemical and organoleptic tests were undertaken at 5 days interval across storage.

3. Results and discussions

Acidity

Table 1: Acidity (%) of the fruits as influenced by different treatments

Treatments	Storage Period					
	0 Day	5 Day	10 Day	15 Day	20 Day	Mean
T_0	0.74	0.53	0.44	-	-	0.57
T_1	0.73	0.65	0.63	0.56	0.44	0.60
T_2	0.72	0.67	0.64	0.58	0.48	0.62
T_3	0.71	0.70	0.67	0.66	0.58	0.66
T_4	0.75	0.68	0.65	0.57	0.44	0.62
T_5	0.72	0.66	0.62	0.56	0.42	0.60
T_6	0.71	0.68	0.64	0.58	0.42	0.61
T_7	0.74	0.70	0.66	0.60	0.53	0.65
T_8	0.72	0.66	0.64	0.57	0.46	0.61
T_9	0.73	0.67	0.62	0.56	0.43	0.60
T_{10}	0.74	0.65	0.61	0.55	0.48	0.61
T_{11}	0.72	0.63	0.61	0.53	0.47	0.59
T_{12}	0.71	0.61	0.57	0.51	0.42	0.56
T_{13}	0.74	0.67	0.58	-	-	0.64
T_{14}	0.72	0.62	0.58	0.51	0.42	0.57
T_{15}	0.71	0.70	0.68	0.66	0.60	0.67
Mean	0.73	0.66	0.62	0.57	0.47	
SED	T=0.05		D=0.04			
CD at 5%	T=N.S		D=0.07			

The data on acidity of *Khasi* mandarin fruit are presented in Table 1. Various treatments, was found to be non-significant effect on acidity of *Khasi* mandarin fruit. But the acidity content of *Khasi* mandarin fruit due to period of storage was found to be significant. The maximum Acidity content was recorded in zero day (0.73) and minimum was recorded on 20th day (0.47) of storage. It was observed that titra table acidity of fruits showed decreasing trend with the advancement in storage period. The decrease in acidity during storage could be attributed to the use of organic acids as respiratory substrate during storage (Echeverria and Valich, 1989) [8]. However, fruits treated with Bavistin, Neem extract and combination *Aloe vera* gel + Neem extract recorded higher amount of acidity. It might be due to lesser utilization of the acids in the respiration process during the storage. The untreated fruits had minimum acids due to faster utilization of the acids in the respiration process during storage. The results are in conformity with the findings reported by Sonkar *et al.* (2009) [21] in *kinnow* mandarin, Jholgiker and Reddy (2007) [10] in Annona, Sidhu *et al*. (2006) [20] in pear, and Deka *et al.* (2006) [7] in *Khasi* mandarin.

Table 2: Total sugar (%) of the fruits as influenced by different treatments

Treatments	Storage Period					
	0 Day	5 Day	10 Day	15 Day	20 Day	Mean
T_0	5.17	5.51	5.91	-	-	5.53
T_1	5.16	5.41	5.69	6.38	6.93	5.91
T_2	5.24	5.51	5.83	6.39	6.96	5.99
T_3	5.28	5.50	5.98	6.63	6.96	6.07
T_4	5.18	5.50	5.91	6.37	6.91	5.97
T_5	5.24	5.51	5.91	6.40	6.93	6.00
T_6	5.04	5.49	5.90	6.39	6.95	5.95
T_7	5.23	5.50	5.98	6.58	6.98	6.05
T_8	5.21	5.49	5.90	6.40	6.96	5.99
T_9	5.04	5.49	5.82	6.37	6.94	5.93
T_{10}	5.14	5.51	5.82	6.40	6.93	5.96
T_{11}	5.22	5.51	5.79	6.37	6.92	5.96
T_{12}	5.06	5.50	5.90	6.39	6.94	5.96
T_{13}	5.14	6.33	5.96	-	-	5.95
T_{14}	5.24	5.51	5.91	6.40	6.96	6.00
T_{15}	5.34	5.29	5.90	6.43	7.73	6.14
Mean	5.18	5.54	5.94	6.42	7.00	
SED	T=0.30		D=0.30			
CD at 5%	T=N.S		D=0.60			

Total sugar

The data on Total sugar of *Khasi* mandarin fruit is presented in Table 2.The total sugar percentage of *Khasi* mandarin fruits due to various treatments was found to be non-significant. But among the storage period total sugar was found to be significant. Total sugar was found to be the lowest (5.18%) on the 0 day while it was the highest (7.00%) on 20th day of storage. The total sugar content of the fruits showed an increasing trend throughout the storage period. The probable reason for this increase might be due to the hydrolysis of polysaccharides by hydrolytic enzymes resulting in formation and accumulation of sugar (Barua and Yamdagni, 1996 and Abdur *et al*., 2011) [3, 1]. The decline in the sugar content at the later stages of storage may be attributed to the fact that after the completion of hydrolysis of polysaccharides, no further increase in sugars occurred and subsequently a decline in these parameters is predictable as they along with other organic acids are primary substrate for respiration (Wills *et al.*, 1980) [23]. This finding is in conformity with the findings of Bal *et al*. (1978) [2] in Ber and Keditsu *et al. (*2003) [11] in *Khasi* mandarin. The total sugar content of Nagpur mandarin increased with the advancement of storage period, but it was observed that the fruits treated with Neem leaf extract had minimum increase in total sugar content (Bhardwaj and Sen, 2003) [4]. Sharma and Dashora (2001) [19] also supported the view and they observed that the total sugar content of guava fruit increased during storage.

Table 3: Ascorbic acid content (mg/100g) of the fruits as influenced by different treatments

Treatments	Storage Period					
	0 Day	5 Day	10 Day	15 Day	20 Day	Mean
T_0	33.48	27.85	26.83	-	-	29.39
T_1	34.60	33.40	32.51	31.61	30.08	32.44
T_2	35.50	34.42	33.52	32.82	30.41	33.33
T_3	36.78	35.69	34.84	33.91	32.79	34.80
T_4	35.68	34.50	33.58	32.58	30.47	33.36
T_5	36.59	35.49	34.94	33.94	31.35	34.46
T_6	35.51	34.38	33.68	32.67	30.32	33.31
T_7	36.58	35.37	34.85	33.85	32.51	34.63
T_8	35.52	34.40	33.49	32.49	29.97	33.17
T_9	37.50	36.37	35.53	34.49	32.35	35.25
T_{10}	35.54	34.38	33.54	32.54	30.13	33.23
T_{11}	35.52	34.42	33.55	32.56	29.71	33.15
T_{12}	36.77	35.67	34.45	33.87	30.73	34.30
T_{13}	35.49	33.36	32.82	-	-	33.89
T_{14}	35.82	34.92	34.14	32.72	30.45	33.61
T_{15}	36.81	35.93	35.85	35.62	35.11	35.86
Mean	35.86	34.41	33.63	29.10	27.27	
SED	T=2.57		D=1.44			
CD at 5%	T=5.08		D=2.40			

Ascorbic acid

Observation on the changes of ascorbic acid content of *Khasi* mandarin fruit due to various treatments during storage are presented in Table 3. The various treatments and period of storage showed a significant effect on the ascorbic acid content of *Khasi* mandarin fruit. With an ascorbic acid content of 35.86mg/100g, the Bavistin treatment (T15) recorded the highest value. The Bavistin treatment was closely followed by Neem treatment (T3) which recorded 34.80mg/100g and *Aloe vera* gel + Neem extract treatment (T7)that recorded 34.63 mg/100g as compared to control with ascorbic acid content value of 29.39mg/100g (T0). The maximum ascorbic acid content recorded was on zero day (35.86) and minimum recorded was on 20th day (27.27). The decrease in ascorbic acid content might be due to the process of oxidation of ascorbic acid to de hydro ascorbic acid by the enzyme ascorbinase (Das and Desh, 1967; Mapson, 1970 and Gimnez *et al*., 2003) [6, 13, 9]. The difference in the ascorbic acid content of *Khasi* mandarin due to various treatments and storage conditions was found to be significant. Fruit treated with Bavistin and Neem extract followed by combination of *Aloe vera* gel + Neem extract showed the maximum retention of ascorbic acid while the lowest was recorded in control. There are various reports of retention of ascorbic acid by the use of chemicals. Ojha (1987) [16] has reported a 10% loss in ascorbic acid content after 10 days of storage of Aonla fruit treated with 1% calcium chloride + 0.1% Bavistin, whereas Pathak (1988) [17] also recorded 7% loss in ascorbic acid after 6 days of storage of Aonla fruit treated with the same treatment. This might be attributed to rapid loss of moisture and fast hydrolysis of polysaccharides to soluble forms of sugars under higher temperature and low humidity conditions. The present finding is in conformity with the findings of Bal *et al*. (1978) [2] in Ber and Keditsu *et al.* (2003) [11] in *Khasi* mandarin. Other workers have also reported that calcium nitrate protects the loss in ascorbic in *Kinnow* mandarin (Kumar and Chauhan, 1989) [12] and oranges (Rana *et al.*, 1992) [18].

4. Conclusion

During storage, the acidity content of *Khasi* mandarin fruits showed a pronounced decreasing trend with the increase in storage period. Fruits treated with Bavistin (T15),Neem extract (T3) and combination of *Aloe vera* gel+ Neem extract (T7) were very much effective in retaining acidity. However, maximum loss of acidity was noticed in untreated fruits (control) under ambient condition. The ascorbic acid content of the fruits under study decreased with advancement of storage period irrespective of treatments. Fruits treated with Bavistin (T15) and Neem extract (T3) followed by combination of *Aloe vera* gel+ Neem extract (T7) treatments showed the maximum retention of ascorbic acid. The untreated fruits (control) had the lowest value. Since the plant extracts are devoid of any chemical residue and are safe for human consumption the use of Neem extract (10%) can be advocated for retaining quality of *khasi* mandarin fruits during storage.

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