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RESEARCH PAPER

Effect of plant based organic treatments on the storage quality and management of diseases and disorders of oranges

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SUMMARY :

A study was conducted during 2010-11 on the pre and –post harvest treatment of neem (*Azadirachta indica* L.) based formulations of plant leaf extract on the storage quality,and management of diseases and post harvest disorders of oranges. The pre-harvest (20-25 days before harvest) treatments consisted of nimbecidine (0.5, 1.0, 1.5%), neem azal (1.0, 1.5, 2.0%) neem gold (0.5, 1.0, 1.5%) with bavistin (0.05%) as control (Table 3). Plant leaves/flower used as coatings were neem (*Azadirachta indica* L.) leaf extracts (10, 20%), drake (*Melia azedarach*) leaf extracts (10, 20%), spearmint (*Mentha spicata*) leaf extract (10, 20%), marigold (*Tagetus erectus*) flower extract (10, 20%) and semperfresh (control 1.5%). Freshly harvested fruits were treated with above treatments and were kept under refrigerated storage ($1\pm1^{o}C$) for analysis at a month interval up to 180 days. Among neem based formulations, nimbecidine (1.5%) was found better in reducing physiological loss weight, retaining fruit firmness, whereas, neem azal (2.0%) were found effective in retaining maximum total soluble solids (TSS) content, starch iodine rating and pectin content at the end of 180 days storage period. Fruits treated with 20 % drake leaf extract proved to be most effective treatment in reducing weight loss, whereas, maximum retention of firmness was recorded in fruits treated with 20 % neem leaf extracts. Drake and neem leaf extracts were also capable to retain maximum total soluble solid (TSS) content. Minimum decrease in starch content was recorded with 20 % neem leaf extract, this treatment also retained maximum pectin content in the fruits at the end of 180 days storage. On the other hand 20 % spearmint leaf extract (T_6) proved to be highly effective in reducing spoilage as no spoilage was recorded under this treatment. Therefore, uses of botanicals significantly helped not only in enhancing storage quality but it also reduces storage diseases and disorders to a greater extent. All the rotting causing pathogens namely *Aspergillus, Penicillium* activities were totally suppressed. Among various studies and experiments it was observed that botanicals can be effectively substituted against chemicals for eliminating the resistance pattern of several pathogens and thereby marinating storage quality and plant health at pre and post harvest level.

KEY WORDS : Botanical formulation**,** Botanical extract, Physico-chemical characteristics, Storage, Orange, Post harvest diseases and disorders

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In the global context use of chemicals and waxing material at the pre- and post-harvest stages has gained tremendous popularity among growers ultimately to enhance the shelf life of fruits (Gakhukar, 1996) and reducing disease incidences. But these substances have their own drawbacks, as some of them are believed to be ecologically and

economically unsafe and unviable besides leaving their toxic residue on the fruit surface, which may have the direct effect on human health. Additionally some of them may be associated with the changes of aroma of the fruit and prolonging disease resistance for sufficient longer period of time. In order to lessen these shortcomings there is a utmost important of substances which are of plant origin having growth regulating, fungicidal, insecticidal properties (Dhaliwal and Arora, 1996). Grainge *et al.* (1984) have documented and classified a number of plants belonging to various families having growth regulating, fungicidal properties and therefore, neem, melia, mentha, pongamia, ricinus, jatropha are under active investigation for use as a plant protection agents all over the world. Owing to its various effects, azadirachtin is considered as the most active principal substance in neem which has growth regulating, fungicidal and insecticidal properties (Schmutters, 1990). The present study was, therefore, aimed to study the effect of botanical formulations, plant leaves extract on the storage quality, and management of diseases and post harvest disorders of oranges.

EXPERIMENTAL METHODS

The experiment pertaining to the pre-harvest treatment of neem -based formulations was conducted in 2010-11 and 2011-12 in collaboration with Fresh and Healthy Enterprises Limited (FHEL) Container Corporation of India , Ministry of Railways a largest cold chain organization under Government management and was laid out in well maintained commercial orchard situated at an elevation of 2100 m above msl in villages Raew (Paonta Sahib) district Sirmour Himachal Pradesh. Thirty well grown, uniform 6 -8 years old trees raised on seedling rootstocks and clonal rootstocks were selected for the experiment. The trees were maintained under a uniform schedule of cultural operations throughout the season and subjected to pre-harvest treatments of three commercial neem based formulations *viz.*, nimbecidine, neem azal and neem gold 20-25 days before the expected date of harvest of fruit. Each treatment was replicated thrice with each replication being applied individually to separate trees. The details of treatments under study were nimbecidine (0.5, 1.0, 1.5%), neem azal (1.0, 1.5%, 2.0%), neem gold (0.5, 1.0, 1.5%), with bavistin (0.05%) as control. The entire fruits from individual trees were harvested manually and only sound, medium sized fruits were selected for conducting the studies. The fruits were directly packed in corrugated fibre boxes carton with paper moulded trays and were immediately transported to the post-harvest physiology laboratory for observing changes in fruit quality during storage. While in second experiment coating materials were prepared from extracts of leaves and flowers of some locally available plants which have been used traditionally for preventing spoilage in different crops. Aqueous extracts of different plant materials were prepared under laboratory condition on per cent weight basis as per the method described by Gakhukar (1996) and Sharma *et al.* (1997). The details of treatments under study were neem leaf extract 10%, 20%, drake (*Melia azadirach*) leaf extract 10%, 20%, spearmint leaf (*Mentha spicata*) extract 10%, 20%, marigold flowers (*Tagetes erecta*) extract 10%, 20%, semperfresh (control, 1.5%). For the application of postharvest coating treatments uniform, unblemished medium sized fruits were selected and washed in clean tap water. After air-drying the fruits were coated with different extracts by dipping them for 5 minutes. The coated fruit were placed on newspaper sheet for drying in shade for half an hour at room temperature and also to remove excess coating materials. Immediately after drying the fruits, they were kept with respect to their treatments under refrigerated storage. Observations regarding physico-chemical characteristics, physiological loss weight, firmness, TSS, starch-iodine rating, pectin and spoilage of fruits were recorded at an interval of a month during the storage period of 180 days. The physiological loss weight were weighed on a physical balance, fruit firmness were measured with an Effigi Penetrometer, TSS with the help of Erma hand refrectrometer, pectin were measured by Carra and Haynis methods as described by Ranganna (1986), starch iodine rating were measured by from starch test guide as described by Philips and Poapst (1959), whereas fruit spoilage were calculated on per cent bases.

EXPERIMENTAL FINDINGS AND ANALYSIS

Various neem based formulations applied before harvest had significant effect on most of the parameters. Increase in physiological loss in weight (PLW) with an increase in storage duration was observed under all treatments consisting of neem-based formulation though it was relatively less than that observed in control fruits (Table 1). Among various formulations, nimbecidine (1.5%) was found most effective in reducing PLW, which could be due to its ability to retard moisture loss and senescence enhancing mechanism as reported by Gakhukar (1996). The reduction in PLW with neem based formulation can also be attributed to their ability to check the growth of microbes that were responsible for rotting and increasing the metabolic rate of commodities (Kumar, 2004), which cause loss in weight through respiration (Singh *et al.*, 2000).

During another investigation loss in flesh firmness (Table 1) was observed to be the lowest in response to 1.5 % nimbecidine followed by 1.0 % nimbecidine and 2.0 % neem azal. Retention of better firmness in nimbecidine treated fruit can be attributed to the direct effect of azadirachtin, a principle active compound present in neem formulation on pectin molecules which are believed to regulate the calcium and pectin

Table 1 : Effect of pre harvest treatments of commercial neem based formulations on the physiological loss in weight (PLW) fruit firmness (N), TSS, starch iodine rating and pectin of oranges during storage at 1+1°C

Treatment (T)	Storage interval in days													
	Physiological loss in weight (%)							Fruit Firmness (N)						
	30	60	90	120	150	180	Mean	30	60	90	120	150	180	Mean
T_1: Nimbecidine (0.5%)	1.06 (1.18)	2.58 (1.61)	4.73 (1.93)	4.88 (2.19)	6.16 (2.46)	6.72 (2.57)	4.28 (2.05)	73.99	71.52	67.61	65.30	58.62	48.31	64.41
T_2: Nimbecidine (1.0%)	1.40 (1.22)	2.52 (1.58)	3.69 (1.92)	4.78 (2.18)	5.88 (2.42)	6.46 (2.54)	4.19 (2.03)	74.26	71.88	68.28	65.79	58.94	48.79	64.81
T_3: Nimbecidine (1.5%)	1.66 (1.20)	2.43 (1.55)	3.59 (1.89)	4.66 (2.15)	5.79 (2.40)	6.24 (2.49)	4.13 (2.01)	75.62	72.41	68.50	66.19	59.43	49.24	65.21
T_4: Neem azal (1.0%)	1.75 (1.24)	2.82 (1.67)	3.74 (1.93)	4.89 (2.21)	6.13 (2.47)	6.72 (2.59)	4.38 (2.07)	74.73	71.43	67.30	65.03	58.09	48.53	64.18
T_5: Neem azal (1.5%)	1.50 (1.25)	2.71 (1.64)	3.68 (1.91)	4.78 (2.18)	6.08 (2.46)	6.61 (2.57)	4.32 (2.05)	74.90	71.75	67.74	65.39	58.22	48.71	64.45
T_6: Neem azal (2.0%)	1.54 (1.20)	2.61 (1.61)	3.59 (1.89)	4.68 (2.16)	6.04 (2.45)	6.48 (2.54)	4.35 (2.03)	75.35	72.10	68.01	65.65	58.76	49.11	64.81
T_7: Neem gold (0.5%)	1.85 (1.32)	2.79 (1.67)	3.89 (1.97)	4.91 (2.21)	6.12 (2.47)	6.71 (2.59)	4.36 (2.08)	74.55	71.48	67.12	63.65	58.05	47.86	63.78
T_8: Neem gold (1.0%)	1.77 (1.29)	2.75 (1.65)	3.86 (1.96)	4.83 (2.19)	6.09 (2.46)	6.67 (2.58)	4.31 (2.07)	74.90	71.70	67.43	64.01	58.49	48.71	64.18
T_9: Neem gold (1.5%)	1.70 (1.26)	2.66 (1.63)	3.77 (1.94)	4.60 (2.14)	5.94 (2.43)	6.61 (2.57)	4.20 (2.04)	75.17	71.88	67.79	64.18	60.45	49.06	64.72
T_{10}: Bavistin (0.05%)	1.79 (1.30)	2.87 (1.69)	3.85 (1.96)	4.83 (2.19)	6.35 (2.51)	7.03 (2.65)	4.44 (2.10)	75.17	72.15	69.26	64.41	58.31	47.95	64.54
Mean	1.67 (1.35)	2.78 (1.53)	3.74 (1.83)	4.77 (2.18)	6.05 (2.45)	6.62 (2.57)		75.08	71.84	67.92	64.94	58.71	48.71	
Initial value								76.86						
C.D. (P=0.05)														
T				0.02							0.04			
I				0.01							0.03			
TXI				0.05							0.09			

Figures in parenthesis are square root transformed values

Storage interval in days																				
Total soluble solids (°Brix)							Starch iodine rating*							Pectin**						
30	60	90	120	150	180	Mean	30	60	90	120	150	180	Mean	30	60	90	120	150	180	Mean
10.73	12.64	13.13	14.26	13.09	12.40	12.70	4.13	4.44	5.07	5.25	6.37	7.45	5.45	1.70	1.61	1.51	1.36	0.89	0.72	1.29
10.66	12.57	13.09	14.16	13.41	12.85	12.79	4.08	4.34	4.94	5.13	6.32	7.42	5.37	1.72	1.64	1.54	1.40	1.02	0.80	1.35
10.61	12.46	13.02	14.13	13.77	12.99	12.83	4.04	4.29	4.90	5.10	6.29	7.39	5.33	1.74	1.67	1.57	1.42	1.05	0.85	1.38
10.76	12.70	13.18	14.29	13.10	12.35	12.73	4.10	4.41	5.06	5.22	6.32	7.40	5.42	1.74	1.70	1.61	1.45	1.00	0.85	1.39
10.72	12.67	13.12	14.28	13.38	12.41	12.76	4.05	4.35	5.01	5.12	6.27	7.37	5.36	1.76	1.71	1.65	1.48	1.02	0.87	1.41
10.64	12.54	13.09	14.23	13.84	12.84	12.86	4.02	4.27	4.96	5.09	6.22	7.27	5.31	1.78	1.73	1.68	1.55	1.17	0.96	1.47
10.75	12.74	13.11	14.30	13.10	11.96	12.66	4.24	4.43	5.19	5.35	6.42	7.59	5.53	1.69	1.63	1.60	1.36	0.99	0.87	1.35
10.68	12.62	13.09	14.20	13.69	12.06	12.72	4.21	4.40	5.14	5.29	6.36	7.50	5.48	1.71	1.66	1.63	1.38	1.00	0.91	1.38
10.65	12.54	13.03	14.16	13.84	12.37	12.76	4.18	4.36	5.11	5.23	6.29	7.40	5.42	1.73	1.69	1.65	1.45	1.03	0.93	1.41
10.73	12.65	13.21	14.29	13.10	10.92	12.48	4.35	4.44	5.26	5.45	6.58	7.66	5.62	1.74	1.65	1.57	1.41	0.96	0.57	1.31
10.69	12.61	13.10	14.23	13.43	12.31		4.14	4.37	5.06	5.22	6.34	7.44		1.73	1.66	1.60	1.42	1.01	0.83	
10.22							4.08							1.86						
			0.05							0.01							0.02			
			0.04							0.01							0.01			
			0.13							0.03							0.05			

Table 2 : Effect of post harvest treatments of various plant extracts on the physiological loss in weight (PLW), fruit firmness (N), TSS, starch iodine rating and pectin of oranges during storage at 1±1°C

Treatments (T)	Storage interval in days													
	Physiological loss in weight (%)							Fruit firmness (N)						
	30	60	90	120	150	180	Mean	30	60	90	120	150	180	Mean
T_1 Neem leaf extract (10%)	1.73(1.31)	2.39 (1.54)	3.08 (1.75)	4.55 (2.13)	5.15 (2.26)	5.23 (2.28)	3.68 (1.91)	76.02	74.55	70.10	66.54	60.89	52.44	66.76
T_2 Neem leaf extract (20%)	1.63 (1.27)	2.32 (1.52)	3.03 (1.70)	4.36 (2.10)	5.03 (2.24)	5.12 (2.25)	3.59 (1.89)	77.31	74.68	70.55	66.72	60.98	52.75	67.16
T_3 Drake leaf extract (10%)	1.62 (1.26)	2.27 (1.53)	3.03 (1.74)	4.31 (2.07)	5.02 (2.24)	5.15 (2.26)	3.56 (1.88)	75.88	74.01	69.48	65.34	60.45	51.33	66.10
T_4 Drake leaf extract (20%)	1.58 (1.25)	2.17 (1.50)	2.99 (1.72)	4.24 (2.05)	4.99 (2.23)	5.04 (2.24)	3.50 (1.87)	76.15	74.10	69.57	65.61	60.67	51.60	66.28
T_5 Spearmint leaf extract (10%)	1.60 (1.26)	2.35 (1.53)	3.01 (1.73)	4.33 (2.08)	4.95 (2.24)	5.31 (2.30)	3.59 (1.89)	75.84	73.70	68.10	65.25	60.49	50.93	65.70
T_6 Spearmint leaf extract (20%)	1.63 (1.26)	2.31 (1.51)	2.95 (1.71)	4.26 (2.06)	4.85 (2.20)	5.16 (2.27)	3.52 (1.87)	76.02	74.10	69.66	65.47	60.63	51.29	66.19
T_7 Marigold flower extract (10%)	1.77 (1.33)	2.40 (1.54)	3.14 (1.77)	4.63 (2.15)	5.26 (2.29)	6.16 (2.48)	3.89 (1.97)	76.06	74.15	69.97	66.10	60.67	51.06	66.32
T_8 Marigold flower extract (20%)	1.72 (1.30)	2.37 (1.53)	3.07 (1.75)	4.53 (2.12)	5.17 (2.29)	6.07 (2.48)	3.82 (1.96)	76.24	74.73	70.14	66.23	60.45	51.24	66.50
T_9 Semper fresh (1.5%)	1.68 (1.29)	2.35 (1.53)	3.05 (1.74)	4.49 (2.11)	5.18 (2.27)	6.42 (2.53)	3.86 (1.96)	76.06	73.88	70.01	65.16	60.45	45.06	65.07
Mean	1.66 (1.28)	2.32 (1.52)	3.04 (1.74)	4.42 (2.10)	5.08 (2.25)	5.53 (2.35)		76.19	74.19	69.70	65.83	60.63	50.84	
Initial value									78.84					
C.D. (P=0.05)														
T					0.06					0.04				
I					0.04					0.03				
TxI					0.13					0.09				

Figures in parenthesis are square root transformed values

Storage interval in days																					
Total soluble solids (°Brix)							Starch iodine rating*							Pectin**							
30	60	90	120	150	180	Mean	30	60	90	120	150	180	Mean	30	60	90	120	150	180	Mean
10.46	12.10	13.09	14.13	13.48	12.07	12.55	4.26	4.91	5.22	6.19	6.30	7.39	5.71	1.71	1.62	1.53	1.42	1.08	0.97	1.39
10.40	12.04	13.06	14.11	13.71	12.39	12.62	4.23	4.82	5.16	6.18	6.26	7.30	5.65	1.78	1.65	1.58	1.50	1.12	1.07	1.45
10.46	12.10	13.09	14.12	13.47	12.06	12.55	4.31	4.93	5.26	6.26	6.36	7.43	5.75	1.73	1.67	1.56	1.44	1.06	0.94	1.39
10.38	12.04	13.05	14.14	13.74	12.56	12.65	4.29	4.88	5.24	6.23	6.28	7.31	5.70	1.76	1.71	1.59	1.47	1.08	0.98	1.42
10.43	12.08	13.08	14.14	13.37	11.83	12.49	4.33	4.93	5.18	6.22	6.31	7.40	5.73	1.76	1.64	1.55	1.42	1.06	0.87	1.38
10.40	12.05	13.04	14.10	13.59	12.38	12.60	4.26	4.89	5.14	6.18	6.28	7.35	5.68	1.78	1.68	1.57	1.46	1.08	0.90	1.41
10.52	12.13	13.21	14.19	13.38	11.89	12.56	4.36	4.96	5.32	6.37	6.45	7.53	5.83	1.70	1.63	1.51	1.39	1.03	0.83	1.35
10.45	12.08	13.15	14.13	13.79	11.93	12.59	4.31	4.91	5.26	6.24	6.38	7.42	5.75	1.74	1.66	1.55	1.42	1.09	0.87	1.39
10.16	12.12	13.08	14.16	13.23	10.91	12.32	4.29	4.95	5.33	6.32	6.50	7.68	5.84	1.73	1.67	1.54	1.43	1.06	0.59	1.34
10.44	12.08	13.10	14.13	13.53	11.99		4.29	4.91	5.23	6.24	6.34	7.42		1.74	1.66	1.55	1.44	1.07	0.89	
10.11							4.07							1.82						
			0.05							0.04							0.04			
			0.04							0.03							0.03			
			0.11							0.10							0.09			

* Rating on the basis of starch test guide

** As % calcium pectate

integrity, thereby lowering the chances of its breakdown during storage (Kleeberg, 1996) hence, better firmness was recorded.

It was observed that TSS in general increased as the storage period advanced up to 120 days, registering a gradual decline thereafter (Table 1). Although, definite treatments effects were not discernible, yet the treatments 2.0 % neem azal and 1.5 % nimbecidine demonstrated distinct superiority over the other treatments by recording higher value for TSS at the end of 180 days storage. Higher value for total soluble solid under these treatments could be due to the maintenance of cell wall integrity for longer duration, thereby retarding ripening and senescence-related processes (Singh *et al.*, 2000 and Rank 2002).

Starch iodine rating (Table 1) indicated decline trend in the starch content of fruits with an increase in storage duration under all the treatments. The loss of starch in oranges fruits during storage may be due to its hydrolysis into sugars (Wills *et al.*, 1980; Priest and Lougheed, 1981). However, 2.0 % neem azal and 1.5 % nimbecidine resulted in minimum loss of starch content in fruit, such an affect may be attributed to the effect of active substances especially azadirachtin present in neem formulation slowing down the changes in constituents of fruit as a result of slower ripening changes (Bhaskar *et al.*, 2002 and Walia *et al.*, 2003).

It was observed that pectin content (Table 1) showed a gradual decline with an advancement of storage duration under all treatments. Among various formulation 2.0 % neem azal was best in retaining maximum pectin content and it was followed by T_5 and T_9. The loss of pectin content may be due to breakdown of pectin during storage as claimed by Sandhu *et al.* (1990). Azadirachtin is reported to retard the de-estrification of pectin thereby slowing down its breakdown resulting in higher pectin content in such fruits (Gakhukar, 1996; Kleeberg, 1996; Ozdemir *et al.*, 1996 and Singh *et al.*, 2000).

It was observed under all the treatments spoilage was reduced significantly. Among treatments 1.5% nimbecidine and 2.0% neem azal decreased the spoilage considerably. Reduction in spoilage due to rotting with the use of neem formulations may be attributed to the presence of the principle compound azadirachtin which has the ability to check the growth of microbes that are responsible for causing rotting and also to its ability to reduce the rates of respiration and transpiration in fruits (Gakhukar, 1996; Chai *et al.*, 1990). Among various pre-harvest treatments of neem based formulations nimbecidine (1.5%) and neem azal (2.0%) retained the most of the quality characterstics of oranges when compared with bavistin. Beside this application of neem formulations totally reduce the incidence of post harvest fungal pathogen *viz.*, *Penicillium, Aspergillus, Alternaria* which generally causes various rotting in stored fruits.

Coating treatments with plant leaf/flower extracts caused significant reduction in PLW (Table 2) and the most effective treatments in this regard was 20 per cent drake leaf extract. Coating of plant leaf/flower extracts might form a thin film around each fruit, which can act as a semi-permeable membrane to regulate the diffusion of O_2 and CO_2 into and out of the fruit, thereby reducing the rate of metabolism and also prevents water loss (Smith and Stow, 1994; Alleyne and Hagenmaier, 2000).

Table 3 : Effect of pre harvest treatments of commercial neem based formulations on the fruit spoilage (%) of oranges during storage at 1±1°C

Treatments (T)	Storage interval in days						
	Fruit spoilage (%)						
	30	60	90	120	150	180	Mean
T_1 Nimbecidine 5%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.00 (1.41)	0.33 (0.57)
T_2 Nimbecidine 1.0%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.80 (0.89)	0.13 (0.36)
T_3 Nimbecidine 1.5%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T_4 Neem azal 1.0%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.40 (1.59)	4.10 (2.02)	1.08 (1.03)
T_5 Neem azal 1.5%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T_6 Neem azal 2.0%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
T_7 Neem gold 0.5%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.40 (0.60)	2.41 (1.55)	4.94 (2.22)	1.29 (1.13)
T_8 Neem gold 1.0%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.20 (1.09)	2.83 (1.68)	0.67 (0.81)
T_9 Neem gold 1.5%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.06 (0.03)
T_{10} Bavistin 0.05%	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.63 (1.90)	5.85 (2.42)	9.26 (3.04)	3.12 (1.76)
Mean	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.41 (0.63)	1.18 (1.08)	2.43 (1.55)	
C.D. (P=0.05)							
T				0.26			
I				0.20			
TxI				0.66			

Figures in parenthesis are square root transformed values

It has been observed that there was a gradual decline in fruit firmness (Table 2) under all the treatments with the progressive increase in storage durations. However, the application of 20 % neem leaf extract proved to be the most effective treatment in retention of fruit firmness during storage. Retention of relatively high firmness under this treatment could be due to slower metabolic activities leading to slower ripening changes and delayed senescence (Bhardwaj and Sen, 2003). The loss of pectin substances from the middle lamella of the cell wall is perhaps the key step in the ripening process that leads to the loss of cell wall integrity of fruits (Gross and Sams, 1984) and consequently leads to softening.

The TSS (Table 2) in general increased with the advancement of storage period up to 120 days and thereafter these constituents started declining during the remaining storage period. Among the treatments highest mean TSS contents were recorded in response to coating with 20 per cent neem leaf extract whereas, they were lowest in control fruits, which might be due to higher respiratory losses in these fruits as there was no barrier to restrict the movement of gases into and out of the fruit (Singh *et al.,* 2000). The increase in TSS and sugar contents during the earlier part of storage may be due to the hydrolysis of insoluble polysaccharides into simple sugar (Borthakar *et al.,* 2002).

There was an increase in starch iodine rating (Table 2) indicating disappearance or loss of starch in fruits under all the treatments during storage minimum reduction in starch content of fruit was recorded with 20 % neem leaf extract, whereas other coating materials were effective to a lesser extent in this regard. Such an effect of coating treatments may be attributed to the slower ripening changes on the metabolism of fruits and can be expected to be slower, when the fruits are treated and stored under conditions, which are not conducive to enhance ripening (Singh *et al.,* 2003).

In general, the pectin content (Table 2) in fruit exhibited a continuous decline with an increase in storage duration under all coating treatments with, 20 % neem leaf extract being the most effective in retaining higher pectin content. The subsequent loss in pectin content may be due to break down of pectin during storage as claimed by Sandhu *et al.* (1990). The gradual decrease in pectin content with the advancement of storage period might be due to the result of pectin enzyme activity on natural pectin in the fruit (Jazzar and Hammad, 2003).

Spoilage due to rotting did not occur under any of the treatments during the first four storage intervals. Thereafter, some spoilage was recorded under most of the treatments and a significant increase was observed as the storage period increased to 180 days. Among treatments, 20 % spearmint leaf extract proved to be highly effective in reducing fruit spoilage as no spoilage was recorded under this treatment. It was followed by the treatment consisting of coating with 20 % neem leaf extract. On the other hand, maximum mean fruit spoilage was recorded with coating 1.5 % semperfresh, which was the control treatment for the experiment.

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