International Scholars Journals

African Journal of Wood Science and Forestry ISSN 2375-0979 Vol. 9 (3), pp. 001-011, March, 2021. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Botanical formulation and extracts based on plant leaves and flower, a substitute for toxic chemical and waxes for shelf life extension and quality retention of apple cv Starking Delicious in India

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Accepted 19 August, 2020

Pre-harvest treatments consisted of nimbecidine, neem azal, neem gold, with Bavistin, as control. The plant leaves/flowers used as coatings were neem leaf extract, drake leaf extract, spearmint leaf extract, marigold flower extract, and semperfresh. Neem, melia, mentha, walnut, banna, basooti, and camphor were used as cushioning materials in packages. Freshly harvested fruits were subjected to the above treatments and were kept under refrigerated storage (1±1°C) for analysis at a monthly interval up to 6 months. Nimbecidine (1.5%) was found better in reducing physiological loss in weight (PLW) and retaining fruit firmness, whereas, neem azal (2.0%) was found effective in retaining maximum total soluble solids (TSS) content, starch iodine rating and pectin content at the end of 6 months storage period. Among the treatments of extracts of plant leaves/flowers, fruits treated with 20% drake leaf extract proved to be most effective in reducing weight loss, whereas, maximum retention of firmness was recorded in fruits treated with 20% neem leaf extracts. Drake and neem leaf extracts also retained maximum TSS content. Minimum decrease in starch content maximum pectin content in the fruits and were recorded with 20% neem leaf extract. Leaf extract was highly effective in reducing spoilage as no spoilage was recorded under this treatment. Fruits cushioned with camphor leaves were superior over non-cushioned fruits in retaining most of quality characteristics.

Key words: Neem (*Azadirachta indica*), plant extract, drake (*Melia azedarach*), spearmint, marigold, banna (*Vitex negundu*), basooti (*Adhatoda vasica*), camphor, apple.

INTRODUCTION

In India apple is the most important fruit of Himalayan region. Despite spectacular progress made in the area and production, it is estimated that 20 to 30% of the total production is lost during the post-harvest handling period due to lack of proper handling and storage facilities. With the ever-increasing demand for good quality fruits, which are free from fungicides and pesticides residues, the growers are forced to produce quality fruit, especially after the removal of restrictions on international trade. In the absence of highly capital intensive handling infrastructure like precooling, refrigerated transport and controlled atmospheric storage, growers will have to depend upon on alternative, simple and low cost technique till such facilities are created.

From the last few fears the use of various chemicals and waxing material at the pre and post harvest stages is becoming popular among growers in order to enhance the shelf life of fruits. However, the use of these substances has their own limitations, as some of them are believed to be ecologically unsafe and economically not viable beside leaving their residue on the fruit surface,

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which may have the direct effect on human health. Additionally some of them may be associated with the changes of aroma of the fruit. In order to overcome these short comings there is a urgent need of substances which are of biological origin with 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 plants like neem, melia, mentha ,lantana are under active investigation for use as a plant protection agents. Already neem based formulations are available in the market. 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 undertaken with the objective to study the effect of pre- harvest treatment of apple cv starking delicious, with three neem based formulations, fresh leaves and their extracts on the storage quality of apples.

MATERIALS AND METHODS

Neem based formulations were tried in 2003/2004 and 2004/2005 and the experiment was laid out in well maintained commercial orchard situated 2100 m above msl in villages of Khaneti (Kotgarh) district, Shimla, Himachal Pradesh, India. Thirty well grown, uniform and 15 - 20 years old " starking delicious " apple trees raised on seedling rootstocks were selected. The trees were maintained under a uniform schedule of cultural operations and subjected to pre-harvest treatments of 3 commercial neem based formulations viz., nimbecidine, neem azal and neem Gold, 20 - 25 days harvest. Each treatment was replicated 3 times with each replication being applied individually to separate trees. The treatments were nimbecidine (0.5, 1.0, 1.5%), neem azal (1.0, 1.5, 2.0%), neem gold (0.5, 1.0, 1.5%), and bavistin (0.05%) was used as control. The entire fruits from individual trees were harvested manually and only sound, medium sized fruits were selected. The fruits were directly packed in corrugated fibre boxes (CFB) carton with paper moulded trays and were immediately transported to the laboratory for observing changes in fruit quality stored under refrigerated (1±1°C) conditions. While in second experiment coating materials were prepared from extracts of leaves and flowers which have been used traditionally for preventing spoilage in different crops. Aqueous extracts of plant materials were prepared as per the method described by Gakhukar (1996) and Sharma et al. (1997). The method consisted of collection of fresh leaves/flowers, shade drying and grinding to powder form in an electric blender. The powdered material was stored in HDPE bottles till use. Aqueous solutions were prepared by soaking a known weight of the powdered material in an equal quantity of water and keeping it overnight. The extract was separated with the help of muslin cloth and it was considered to be of 100% strength, which was diluted by adding appropriate quantity of distilled water to make up the desired concentration. Guar gum was also added to all the coating solutions at the rate of 2.0%. Semperfresh, a waxing material generally used commercially for waxing of apples, was used to compare the effectiveness of leaf and flower extracts. The aqueous extracts prepared and used were neem leaf (*Azadirachta indica*) extract 10, 20% drake (*Melia azedarach*) leaf extract 10, 20%, spearmint leaf (*Mentha spicata*) extract 10, 20%, marigold flowers (*Tagetes erecta*) extract 10, 20% and 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 the above extracts by dipping them for 5 min. The coated fruits 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 were kept with respect to their treatments under refrigerated (1±1°C) storage.

In third experiment fresh leaves of plants known to posses antimicrobial properties were collected from different parts of Himachal Pradesh during the fruit season 2003/2004 and 2004/2005. 25 g of fresh leaves were placed in CFB cartons (32 x 18 × 16 cm) of 3.5 kg capacities uniformly distributed from top to bottom of the trays along with the freshly harvested fruit and kept immediately after treatments under refrigerated storage (1±1°C). The leaves used were neem/camphor (*Cinnamomum camphora*), Banna/China/caste tree (*Vitex negundu*), basooti (*Adhatoda vasica*) leaves and control (uncushioned). Observations regarding PLW, firmness, TSS, starch -iodine rating, pectin and spoilage of fruits were recorded at monthly interval during the storage period of 6 months. PLW were weighed on a physical balance, fruit firmness were measured with an Effigi Penetrometer, TSS with the help of Erma hand refrectrometer, pectin was measured by Carra and Haynis methods as described by Ranganna (1986), starch iodine rating was measured by as described by Phillips and Poapst (1959), whereas fruit spoilage was calculated on percentage basis.

RESULTS

Experiment 1: Effect of neem based formulations

Increase in PLW during storage duration was observed under all neem based treatments though it was relatively less than that observed in control fruits (Table 1). Nimbecidine (1.5%) was most effective in reducing PLW in comparison to other treatments.

Loss in flesh firmness (Table 1) was lowest in 1.5% nimbecidine followed by 1.0% nimbecidine and 2.0% neem azal. Better firmness observed in nimbecidine treated fruit could be due to the direct effect of azadirachtin present in neem formulation on pectin molecules.

TSS in general increased as the storage period advanced upto 120 days, registering a gradual decline thereafter (Table 2). Although, definite treatment effects were not discernible, yet the treatments 2.0% neem azal and 1.5% nimbecidine demonstrated superiority by recording higher TSS at the end of 6 months storage.

Starch iodine rating (Table 2) indicated decline trend in the starch content of fruits with an increase in storage duration under all the treatments. 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.

It was observed that pectin content (Table 2) showed a gradual decline with an advancement of storage duration under all treatments. Among various formulation 2.0% neem azal retained maximum pectin content.

Spoilage (Table 3) is one of the most important criteria

Table 1. Effect of pre harvest treatments of commercial neem based formulations on the physiological loss in weight (PLW) and fruit firmness (N) of Starking Delicious apples 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%)	1.56 (1.12)	2.60 (1.61)	3.73 (1.93)	4.83 (2.19)	6.06 (2.46)	6.62 (2.57)	4.23 (2.05)	74.99	71.52	67.61	65.30	58.62	48.31	64.41
T_2 : Nimbecidine (1.0%)	1.50 (1.22)	2.52 (1.58)	3.69 (1.92)	4.78 (2.18)	5.88 (2.42)	6.46 (2.54)	4.13 (2.03)	75.26	71.88	68.28	65.79	58.94	48.79	64.81
T_3: Nimbecidine (1.5%)	1.4 (1.20)	2.43 (1.55)	3.59 (1.89)	4.66 (2.15)	5.79 (2.40)	6.24 (2.49)	4.03 (2.01)	75.62	72.41	68.50	66.19	59.43	49.24	65.21
T_4: Neem Azal (1.0%)	1.5 (1.24)	2.82 (1.67)	3.74 (1.93)	4.89 (2.21)	6.13 (2.47)	6.72 (2.59)	4.31 (2.07)	74.73	71.43	67.30	65.03	58.09	48.53	64.18
T_5: Neem Azal (1.5%)	1.50 (1.22)	2.71 (1.64)	3.68 (1.91)	4.78 (2.18)	6.08 (2.46)	6.61 (2.57)	4.22 (2.05)	74.90	71.75	67.74	65.39	58.22	48.71	64.45
T_6: Neem Azal (2.0%)	1.44 (1.20)	2.61 (1.61)	3.59 (1.89)	4.68 (2.16)	6.04 (2.45)	6.48 (2.54)	4.15 (2.03)	75.35	72.10	68.01	65.65	58.76	49.11	64.81
T_7: Neem Gold (0.5%)	1.75 (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%)	1.67 (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%)	1.60 (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%)	1.69 (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	1.57 (1.25)	2.68 (1.63)	3.74 (1.93)	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**						
$CD_{0.05}$														
T				0.02							0.04			
I				0.01							0.03			
TXI				0.05							0.09			

Figures in parenthesis are square root transformed values.

in determining the effect of neem formulations in retaining the storage quality of apple and spoilage was reduced significantly under all treatments. There was no spoilage up to 3 months of storage in treated fapples. Apple spoilage was (0.4%) in Neem gold and 3.6% in Bavistin treated fruit in 4th month. Among treatments 1.5% Nimbecidine and 2.0% Neem Azal decreased the spoilage considerably.

Experiment 2: Effect of leaf extracts

Various plant leaf/flower extract treatments caused significant reductions in PLW (Table 4) and the most effective treatment in this regard was coating with 20%. Drake leaf extract (T_4) where minimum physiological loss in weight (3.50%) was recorded, although it was statistically at par with T_6 (3.52%) and T_3 (3.56%), respect-tively. However, the maximum mean physiological loss in weight (3.89%) was recorded in fruits treated with 10% Marigold flower extract (T_7), which was closely followed by the treatment of 1.5% Semperfresh (T_9) and 20% Marigold flower extract (T_8).

Among various plant leaf/flower extracts, 20% Neem leaf extract (T_2) was the most effective in (Table 4) retaining higher mean fruit firmness (67.16 N) and it was followed by T_1 (66.76 N) and T_8 (66.50 N), respectively, whereas, minimum and significantly lower fruit firmness (65.07 N) was recorded under 1.5% Semperfresh (T_9) which also served as a control treatment for the experiment.

From the data, TSS (Table 5) contents, in general increased as the storage period progressed up to 120 days and thereafter, it followed a declining pattern during subsequent storage. Among various coating treatments with plant extracts maximum mean TSS (12.65^{o}B) was recorded when 20% Drake leaf extract (T_4), was applied, although it was statistically at par with the treatments T_2 (12.62^{o}B) and T_6 (12.60^{o}B), respectively. The lowest mean value (12.32^{o}B) for

Table 2. Effect of pre harvest treatments of commercial neem based formulations on the total soluble solids* (^{O}Brix), starch iodine rating and pectin content of Starking Delicious apples during storage at 1±1°C.

Treatment (T)	Storage interval in days																			
	Total soluble solids (oBrix)							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
T1: Nimbecidine (0.5%)	10.73	12.64	13.13	14.26	13.09	12.4	12.7	4.13	4.44	5.07	5.25	6.37	0.745	5.45	1.7	1.61	1.51	1.36	0.89	0.72	1.29
T2 : Nimbecidine (1.0%)	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	1.4	1.02	0.8	1.35
T3: Nimbecidine (1.5%)	10.61	12.46	13.02	14.13	13.77	12.99	12.83	4.04	4.29	4.9	5.1	6.29	7.39	5.33	1.74	1.67	1.57	1.42	1.05	0.85	1.38
T4: Neem Azal (1.0%)	10.76	12.7	13.18	14.29	13.1	12.35	12.73	4.1	4.41	5.06	5.22	6.32	7.4	5.42	1.74	1.7	1.61	1.45	1	0.85	1.39
T5: Neem Azal (1.5%)	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
T6: Neem Azal (2.0%)	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
T7: Neem Gold (0.5%)	10.75	12.74	13.11	14.3	13.1	11.96	12.66	4.24	4.43	5.19	5.35	6.42	7.59	5.53	1.69	1.63	1.6	1.36	0.99	0.87	1.35
T8: Neem Gold (1.0%)	10.68	12.62	13.09	14.2	13.69	12.06	12.72	4.21	4.4	5.14	5.29	6.36	7.5	5.48	1.71	1.66	1.63	1.38	1	0.91	1.38
T9: Neem Gold (1.5%)	10.65	12.54	13.03	14.16	13.84	12.37	12.76	4.18	4.36	5.11	5.23	6.29	7.4	5.42	1.73	1.69	1.65	1.45	1.03	0.93	1.41
T10: Bavistin (0.05%)	10.73	12.65	13.21	14.29	13.1	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
Mean	10.69	12.61	13.1	14.23	13.43	12.31		4.14	4.37	5.06	5.22	6.34	7.44		1.73	1.66	1.6	1.42	1.01	0.83	
***Initial value**	10.22							4.08							1.86						
CD0.05																					
T				0.05							0.01							0.02			
I				0.04							0.01							0.01			
TxI				0.13							0.03							0.05			

*, Rating on the basis of starch test guide; **, As % calcium pectate.

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

Treatment (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)	

$CD_{0.05}$: T = 0.26; I = 0.20; TxI = 0.66; Figures in parenthesis are square root transformed values.

Table 4. Effect of post harvest treatments of various plant extracts on the physiological loss in weight (PLW) and fruit firmness (N) of Starking Delicious apples during storage at 1±1°C.

Treatment (T)	Storage interval in days (2003-04)													
	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 extracts (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 extracts (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 extracts (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 extracts (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 extracts (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 extracts (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						
$CD_{0.05}$														
T				0.06							0.04			
I				0.04							0.03			
TxI				0.13							0.09			

Figures in parenthesis are transformed values

TSS content was recorded in 1.5% Semperfresh treated fruits and it was significantly lower in comparison to all other treatments.

Data reveal that there was a gradual and continuous decline in starch content (Table 5) of fruits with a progressive increase in storage duration. Amongst treatments maximum reduction in starch content of fruit was recorded as a result of the application of 1.5% Semperfresh (T_9), although it was statistically at par with the results of the treatment with 10% Marigold flower extract (T_7). At the same time minimum reduction in starch content was recorded when 20% Neem leaf extract (T_2) was applied and it was followed by the treatments T_6 and T_4, respectively.

In retaining pectin(Table 5) the most effective treatment in this regard was coating with 20% Neem leaf extract (T_2) as it retained maximum mean pectin content (1.45%) in fruits and it was closely followed by T_4 (1.42%) and T_6 (1.41%), with the differences among them being non-significant. The lowest mean pectin content (1.34%) was recorded in 1.5% Semperfresh (T_9)

Spoilage (Table 6) 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 (T_6) 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 (T_2) On the other hand, maximum mean fruit spoilage (1.42%) was recorded with coating 1.5% Semperfresh (T_9).

Experiment 3: Effect of cushioning by leaves in packages

From the data (Table 7) it is evident that non-cushioned control fruits (T_8) exhibited maximum mean PLW (4.39%). which was significantly higher than that recorded in all other treatments. It was reduced to varying extents by the use of different cushioning treatments. The most effective treatment in minimizing moisture loss was camphor leaves (T_5) in which only 3.97% PLW was recorded and it was followed jointly by the treatments T_2 and T_6 (4.01%), although there

Table 5. Effect of post harvest treatments of various plant extracts on the total soluble solids* (^{O}Brix), starch iodine rating and pectin content of Starking Delicious apples during storage at 1±1°C.

Treatment (T)	Storage interval in days (2004-05)																				
	Total soluble solids (oBrix)							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
T1 Neem leaf extract (10%)	10.46	12.1	13.09	14.13	13.48	12.07	12.55	4.26	4.91	5.22	6.19	6.3	7.39	5.71	1.71	1.62	1.53	1.42	1.08	0.97	1.39
T2 Neem leaf extract (20%)	10.4	12.04	13.06	14.11	13.71	12.39	12.62	4.23	4.82	5.16	6.18	6.26	7.3	5.65	1.78	1.65	1.58	1.5	1.12	1.07	1.45
T3 Drake leaf extract (10%)	10.46	12.1	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
T4 Drake leaf extract (20%)	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	5.7	1.76	1.71	1.59	1.47	1.08	0.98	1.42
T5 Spearmint leaf extract (10%)	10.43	12.08	13.08	14.14	13.37	11.83	12.49	4.33	4.93	5.18	6.22	6.31	7.4	5.73	1.76	1.64	1.55	1.42	1.06	0.87	1.38
T6 Spearmint leaf extract (20%)	10.4	12.05	13.04	14.1	13.59	12.38	12.6	4.26	4.89	5.14	6.18	6.28	7.35	5.68	1.78	1.68	1.57	1.46	1.08	0.9	1.41
T7 Marigold flower extract (10%)	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	1.7	1.63	1.51	1.39	1.03	0.83	1.35
T8 Marigold flower extract (20%)	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
T9 Semper fresh (1.5%)	10.16	12.12	13.08	14.16	13.23	10.91	12.32	4.29	4.95	5.33	6.32	6.5	7.68	5.84	1.73	1.67	1.54	1.43	1.06	0.59	1.34
Mean	10.44	12.08	13.1	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	
***Initial value**	10.11							4.07							1.82						
CD0.05																					
T				0.05							0.04							0.04			
I				0.04							0.03							0.03			
TxI				0.11							0.1							0.09			

*, Rating on the basis of starch test guide; **. As % calcim pectate.

Table 6. Effect of post harvest treatments of various plant extracts on the fruit spoilage (%) of Starking Delicious apples during storage at 1±1^{O}C

Treatment (T)	Fruit spoilage (%)						
	30	60	90	120	150	180	Mean
T_1 Neem leaves extract (10%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.40 (0.63)	1.20 (1.09)	0.26 (0.50)
T_2 Neem leaves extract (20%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.40 (0.63)	0.06 (0.03)
T_3 Drake leaves extract (10%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.80 (0.89)	2.00 (1.41)	0.46 (0.06)
T_4 Drake leaves extract (20%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.60 (1.26)	0.26 (0.05)
T_5 Spearmint leaves extract (10%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.40 (0.63)	2.00 (1.41)	0.39 (0.06)
T_6 Spearmint leaves extract (20%)	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 Marigold flower extract (10%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.00 (1.41)	3.27 (1.80)	0.87 (0.90)
T_8 Marigold flower extract (20%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.60 (1.26)	3.25 (1.60)	0.80 (0.89)
T_9 Semper fresh (1.5%)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.20 (1.78)	5.37 (2.31)	1.42 (1.13)
Mean	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.84 (0.91)	2.12 (1.45)	

$CD_{0.05;}$ T=0.01; I=0.01; TxI= 0.2; figures in parenthesis are square root transformed values.

Table 7. Effect of fresh leaves as cushioning material in packages on the physiological loss in weight (PLW) and fruit firmness* (N) of Starking Delicious apples during storage at 1±1°C

Treatment (T)	Storage Intrervals in days													
	Physiological loss weight (PLW)							Fruit firmness (N)						
	30	60	90	120	150	180	Mean	30	60	90	120	150	180	Mean
T_1 Neem leaves*(Azadirachta indica)*	1.59 (1.26)	2.64 (1.62)	3.66 (1.91)	4.22 (2.05)	5.92 (2.43)	6.22 (2.49)	4.04 (2.01)	74.01	70.59	67.12	62.98	58.00	48.97	63.61
T_2 Spearmint leaves*(Mentha spicata)*	1.57 (1.25)	2.62 (1.61)	3.62 (1.90)	4.19 (2.04)	5.87 (2.42)	6.18 (2.48)	4.00 (2.00)	73.44	70.68	67.08	63.21	57.74	48.84	63.47
T_3 Drake leaves*(Melia azedarach)*	1.58 (1.26)	2.64 (1.62)	3.65 (1.91)	4.23 (2.05)	5.94 (2.43)	6.14 (2.47)	4.03 (2.01)	73.39	70.41	66.99	63.12	58.05	49.37	63.56
T_4 Walnut leaves *(Juglans regia)*	1.56 (1.25)	2.63 (1.62)	3.64 (1.90)	4.22 (2.05)	5.92 (2.43)	6.28 (2.50)	4.04 (2.01)	73.57	70.68	67.12	63.16	58.00	49.11	63.61
T_5 Camphor leaves*(cinnamomum camphora)*	1.64 (1.28)	2.66 (1.63)	3.67 (1.91)	4.28 (2.06)	5.76 (2.40)	5.90 (2.42)	3.98 (1.99)	73.21	70.55	67.79	63.52	58.49	50.57	64.05
T_6 Banna leaves *(Vitex negundu)*	1.62 (1.25)	2.66 (1.63)	3.58 (1.89)	4.21 (2.05)	5.93 (2.43)	6.22 (2.49)	4.04 (2.01)	72.95	69.79	67.08	63.87	58.18	49.55	63.56
T_7 Vasaka leaves*(Adhatoda vasika)*	1.67 (1.29)	2.62 (1.61)	3.63 (1.90)	4.23 (2.05)	6.11 (2.47)	6.19 (2.48)	4.07 (2.02)	73.13	69.97	68.01	63.21	58.58	49.68	63.74
T_8 Control	1.71 (1.30)	2.74 (1.65)	3.85 (1.96)	4.84 (2.20)	6.12 (2.50)	6.28 (2.59)	4.35 (2.08)	73.57	69.88	67.21	62.85	47.50	40.52	60.23
Mean	1.61 (1.25)	2.65 (1.63)	3.65 (1.91)	4.30 (2.07)	6.01 (5.97)	6.17 (6.23)		73.39	70.32	67.30	63.25	56.85	48.35	
***Initial value**								76.33						
$CD_{0.05}$														
T	0.01										0.06			
I	0.01										0.05			
TxI	0.03										0.15			

Figures in parenthesis are square root transformed values.

were no significant difference among any of the treatments in which cushioning material was used.It is clear that among various treatments use of camphor leaves (T_5) exhibited the lowest decline in fruit firmness (Table 7) thereby, resulting in significantly higher mean fruit firmness (64.05 N) and it was followed by T_7 (63.74) and then jointly by T_1 and T_4 (63.61 N). However, the lowest mean value of (60.23 N) was recorded in fruit that were kept un-cushioned (T_8).

Among fresh leaves significantly higher mean TSS (Table 8) contents (13.09°B) were recorded in response to cushioning with Camphor leaves (T_5) which was followed jointly by T_1 and T_2 (12.95°B) and then by T_6 (12.91°B). After the 90 days storage period there was a faster decline in TSS contents of non- cushioned control fruits (T_9) as a results of which they exhibited the lowest value after 180 days of storage (9.42°B) and also the lowest mean value (12.20°B) over this period.

There was a gradual and continuous decline in the starch content (Table 8) of fruits under all the treatments as the starch content is inversely proportional to the numerical value for starch-iodine rating. However, the decline was slower in fruits packed with various fresh leaves as cushioning material. The decrease was relatively faster in untreated control fruits (T_8) and as such these fruits exhibited maximum reduction in starch content by the last sampling date and also the maximum mean reduction in starch content. At the same time, minimum reduction in starch content was recorded in fruits cushioned with Drake leaves (T_3) and it was followed by T_7 and T_1 and jointly by T_2 and T_6, respectively.

It was observed that there was a gradual decline in pectin content (Table 8) of fruit during the entire storage duration, the decline being more pronounced in control fruits (T_8) as compared to that in fruits cushioned with leaves, where it was relatively slow and more gradual. It was observed that cushioning with fresh leaves decreased the rate of pectin degradation and therefore, enabled the fruits to retain higher pectin content. Among fresh leaves, maximum pectin (1.29%) was recorded in fruits cushioned with Spearmint leaves (T_2) and it was followed by T_7 (1.28%) and T_3 (1.27%) and then jointly by T_1 and T_5 (1.26%) in that order. The lowest mean pectin content (1.06%) was recorded in non-cushioned control fruits (T_8). The control fruits also exhibited the lowest pectin content (0.50%) on the last sampling date.

A perusal of the pooled data reveals that during

Table 8. Effect of fresh leaves as cushioning material in packages on the total soluble solids* (^{O}Brix) of Starking Delicious apples during storage at 1±1^{O}C

Treatment (T)	Storage Intervals in days																				
	Total soluble solids (TSS)							Starch iodine rating*							Pectin content**						
	30	60	90	120	150	180	Mean	30	60	90	120	150	180	Mean	30	60	90	120	150	180	Mean
T1 Neem leaves(Azadirachta indica)	11.23	12.66	13.74	14.83	13.12	12.12	12.95	4.11	4.23	4.75	5.62	6.37	7.22	5.38	1.64	1.57	1.41	1.18	0.95	0.84	1.26
T2 Spearmint leaves(Mentha spicata)	11.27	12.78	13.89	14.87	12.89	12.02	12.95	4.18	4.24	4.62	5.59	6.45	7.3	5.39	1.67	1.61	1.38	1.3	0.91	0.78	1.29
T3 Drake leaves(Melia azedarach)	11.18	12.54	13.69	14.69	12.63	11.9	12.77	4.11	4.32	4.69	5.76	5.9	7.02	5.3	1.66	1.63	1.37	1.29	0.87	0.81	1.27
T4 Walnut leaves (Juglans regia)	11.29	12.54	13.68	14.57	12.65	12.07	12.8	4.08	4.26	4.6	5.71	6.32	7.84	5.46	1.63	1.54	1.37	1.32	0.85	0.76	1.25
T5 Camphor leaves(cinnamomum camphora)	11.34	12.62	13.93	14.91	13.45	12.25	13.09	4.12	4.29	4.66	5.68	6.42	7.54	5.45	1.65	1.56	1.33	1.31	0.87	0.79	1.26
T6 Banna leaves (Vitex negundu)	11.29	12.74	13.94	14.97	12.66	11.88	12.91	4.12	4.24	4.59	5.63	6.32	7.46	5.39	1.64	1.51	1.33	1.23	0.84	0.71	1.21
T7 Vasaka leaves(Adhatoda vasika)	11.21	12.77	13.92	14.93	12.73	11.85	12.9	4.07	4.2	4.49	5.73	6.38	7.05	5.32	1.62	1.52	1.4	1.3	1.03	0.83	1.28
T8 Control	11.41	12.98	14.91	13.81	10.7	9.42	12.2	4.53	4.88	6.11	6.28	6.52	8.77	6.18	1.54	1.39	1.22	1.13	0.61	0.5	1.06
Mean	11.28	12.7	13.96	14.7	12.61	11.69		4.16	4.33	4.81	5.75	6.33	7.52		1.64	1.54	1.36	1.25	0.86	0.75	

*,Rating on the basis of starch test guide; **, As % calcim pectate.

Table 9. Effect of fresh leaves as cushioning material in packages on the fruit spoilage (%) of Starking delicious apples during storage at 1±1°C.

Treatment (T)	Storage interval in days (2003-04)						
	Fruit spoilage (%)						
	30	60	90	120	150	180	Mean
T_1 Neem leaves*(Azadirachta indica)*	0.00 (0.00)	0.00 (0.00)	1.25 (1.11)	3.14 (1.77)	5.22 (2.28)	6.89 (2.62)	2.75 (1.65)
T_2 Spearmint leaves*(Mentha spicata)*	0.00 (0.00)	0.00 (0.00)	1.87 (1.36)	3.18 (1.78)	5.27 (2.29)	6.98 (2.64)	2.88 (1.09)
T_3 Drake leaves*(Melia azedarach)*	0.00 (0.00)	0.00 (0.00)	1.25 (1.11)	3.16 (1.77)	5.22 (2.28)	7.58 (2.75)	2.86 (1.69)
T_4 Walnut leaves *(Juglans regia)*	0.00 (0.00)	0.00 (0.00)	2.50 (1.58)	4.48 (2.12)	6.04 (2.45)	8.57 (2.92)	3.59 (1.89)
T_5 Camphor leaves*(Cinnamomum camphora)*	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.25 (1.11)	2.51 (1.58)	4.54 (2.13)	1.38 (1.17)
T_6 Banna leaves *(Vitex negundu)*	0.00 (0.00)	0.00 (0.00)	1.25 (1.11)	3.16 (1.77)	5.22 (2.28)	8.31 (2.88)	2.99 (1.72)
T_7 Vasaka leaves*(Adhatoda vasika)*	0.00 (0.00)	0.00 (0.00)	2.50 (1.58)	3.84 (1.95)	5.99 (2.44)	8.51 (2.91)	3.47 (1.86)
T_8 Control	0.00 (0.00)	1.25 (1.11)	3.79 (1.94)	5.26 (2.29)	7.64 (2.76)	13.57 (3.68)	5.25 (2.29)
Mean	0.00 (0.00)	0.15 (0.39)	1.80 (1.34)	3.43 (1.85)	5.38 (2.31)	8.11 (2.84)	

CD0.05; T=0.09; I=0.07; TxI=0.19; figures in parenthesis are square root transformed values.

the first 30 days there was no spoilage (Table 9) of fruits under any treatment. However, thereafter a slight increase in spoilage was recorded under some treatments and after 120 days spoilage was observed under all the treatments. Among cushioning treatments with fresh leaves, Camphor leaves (T_5) delayed the appearance of spoilage symptoms till 120 days and exhibited the lowest mean fruit spoilage (1.38%) and therefore was the most effective treatment in controlling spoilage during the entire storage duration of 180 days. It was followed by the treatments T_1 (2.75%) and T_3 (2.86%), respectively. On the other hand maximum fruit spoilage (5.25%) was recorded in non-cushioned control (T_8) fruit and it was significantly

higher in comparison to all other treatments.

DISCUSSION

Experiment 1: Effect of neem based formulations

During the present investigations increase in physiological loss in weight (PLW) with an increase in storage duration was observed under all treatments consisting of neem based formulations though it was relatively less than that observed in control fruits. It is a well known fact that with an increase in storage duration the respiratory and transpiratory losses keeps on increasing which results in loss of metabolites and moisture ultimately resulting in lower fruit weight (Wilkinson, 1965; Wills et al., 1980; Singh and Rana, 1992).

The degree of flesh firmness has been reported to be a fairly good index of storability and stage of ripening in apple as in many other fruits. It is one of the most crucial factors in determining the post-harvest quality and physiology of apple (Burg, 1962). With a decrease in fruit firmness the tissue rigidity decreases as a result of hydrolysis of intercellular pectin and also due to a decrease in cell turgor pressure because of an increase in permeability of cell membrane to water. The decrease in both the components of fruit firmness appears to contribute to tissue softening (Pollard, 1975). Retention of better firmness in Nimbecidine treated fruit can be attributed to the direct effect of azadirchtin, a principle active compound presented in neem formulations, on pectin molecules which are believed to regulate the calcium and pectin integrity, thereby lowering chances of its breakdown during storage (Kleeberg, 1996). Softening of fruits is caused either by breakdown of insoluble protopectin into soluble pectin or by hydrolysis of starch (Mattoo et al., 1975). It may also be due to cellular disintegration and microbial attack leading to increased membrane permeability (Wills et al., 1980).

During the present study it was observed that in response to pre-harvest treatments the amount of total soluble solids (TSS), contents in general increased as the storage period advanced up to 120 days, registering a gradual decline thereafter. The increase in fruit soluble solids during storage may result from an increase in the concentration of organic solutes as a consequence of water loss (Ryall and Pentzer, 1982). It may possibly be also due to the numerous anabolic and catabolic processes taking place in the fruit, preparing it for senescence. Hydrolysis of starch yielding mono-disaccharides could be one of the reasons for the increase in TSS.

Starch-iodine rating indicated a declining trend in the starch content of fruits with an increase in storage duration under all the treatments. The loss of starch in apple fruit during storage may be due to its hydrolysis into sugars (Wills et al., 1980; Priest and Lougheed, 1981) and many workers have reported similar observations earlier (Kleeberg, 1996 and Singh et al., 2000). 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 present in neem formulations slowing down the changes in constituents of fruit as a results of slower ripening changes.

It was observed that pectin content showed a gradual decline with an advancement of storage duration under all treatments. The loss in pectin content may be due to the breakdown 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 action of pectin degrading enzymes present in fruit (Nara et al., 2001). Azadirchtin a principle compound in neem formulations is reported to retard the destrification of pectin thereby slowing down its breakdown, resulting in higher pectin content in such fruits (Gakhukar, 1996; Kleeberg, 1996; Ozdemir et al., 1996; Singh et al., 2000).

Spoilage of fruits due to rotting was decreased considerably with the use of various neem formulations especially 1.5% Nimbecidine and 2.0% Neem Azal. Similar observations have also been reported earlier by Chai et al. (1990) and Singh et al. (2000) in apple and mango fruits, respectively. Reduction in spoilage due to rotting with use of neem formulations may be attributed to the presence of the principle compound azadirchtin 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). Similar results were also revealed by Singh et al. (1993) who found effective control of microbe infestations in banana fruits by the use of formulation of neem.

Effect of leaf extracts

During the present investigation, an increase in physiological loss in weight (PLW) was observed in all treatments with an increase in storage duration. Singh and Rana (1992) reported that respiration and transpiration are the two important processes, which are mainly responsible for water loss from fruits and vegetables. 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. During thepresent studies treatments with different leaf/flower extracts was observed to retain higher pectin content in fruits which might explain retention of better firmness in such fruits. The present findings are in conformity with the findings of Ozdemir et al. (1996); Hwang et al. (1998) and Singh et al. (2000) who have also reported similar retention in firmness of fruits as a result of coating with waxes and plant leaf extracts at low temperature storage

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. Such changes are expected to be slower and more gradual when the metabolism, of the commodity is slowed down by the application of various treatments. With the decrease in metabolism the rate of utilization of stored metabolites is also slowed down thereby resulting in retention of higher levels of these constituents. Increase in TSS content in apple fruit during storage has previously been reported to be due to hydrolysis of polysaccharides and dehydration of fruit (Fidler et al., 1973; Gross and Sams' dehydration of fruit (Gross and Sams, 1984; Suni et al., 2000)

There was an increase in starch-iodine rating, 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 affect of coating treatments may be attributed to the slower ripening changes as the metabolism of fruits can be expected to be slower when the fruits are treated and stored in conditions which are not conducive to enhance ripening. Hardisty (1975) reported that starch-iodine test was best to indicate the quantity of starch is apple. Panovo (1975) considers the decrease in starch content to be a good indicator of the degree of maturation.

In general, the pectin content 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 breakdown 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 the result of pectic enzyme activity on natural pectin in the fruit. These findings are also supported by the observations of Nara et al. (2001) who observed similar changes in the pectin content of stored apple fruit.

Spoilage is one of the most important criteria in determining the effect of extracts in retaining the storage quality of apple and it was observed that under all the treatment spoilage was reduced significantly. Among treatments 20% Spearmint leaf extract followed by Drake and Neem were found to be most effective in reducing spoilage. Similar findings on reduction of spoilage with botanical extracts have also been reported by various workers (Chai et al., 1990; Singh et al., 2000; Bhardwaj and Sen, 2003). Gakhukar (1996) reported that botanical extracts have the capability to act as antifeedent and antirepallent thereby inhibiting the pathogenicity of various microorganisms.

Effect of cushioning by leaves in packages

During the present study lower physiological loss in weight (PLW) of fruits was observed in response to cushioning with camphor and spearmint leaves. Reduction in weight loss due to these treatments might be therefore due to their effect on slowing down of physiological processes responsible for weight loss (Sharples and Johnson, 1977). Favorable effects of fresh leaves on lowering down the water vapour losses in fruits have also reported by Samanta and Prasad (1996).

During the present study, decrease in fruit firmness during storage was observed to be lower in fruits that were cushioned with camphor and vasaka leaves. Tzoutzoukou and Bourances (1997) reported a direct correlation between fruit firmness and calcium content in apple fruit as calcium is an integral part of the cell wall and combines with pectic acid to form calcium pectate and thus helps is maintaining the cellular integrity of fruit. It was observed that with use of fresh leaves as cushioning material in packages, the total soluble solids (TSS), total sugars and reducing sugar contents increased during the initial storage period up to 120 days whereas, in non-cushioned fruit this increase was observed only up to 90 days. After these periods a decline was observed in the constituents during the remaining storage period. The initial increase might be due to the fact that during storage starch get hydrolyzed into mono and disaccharides which leads to an increase in TSS and sugars contents (Aly et al., 1981) and after complete hydrolysis of starch no further increase in these constituents occur but subsequently a decline due to utilization as primary substrates for respiration (Wills et al., 1980). Among the treatments cushioning of camphor leaves (T_5) in general retained higher amount of these constituents during storage as compared to control fruits.

Decrease in starch-iodine rating was observed with an increase in storage duration. Drake leaves retained maximum starch content in apple fruits during 180 days of storage. Such an effect may be attributed to ability of menthol to act as an antisenscent agent (Grainge et al., 1984). The loss of starch in apple fruit during storage may also be predicted due to its hydrolysis to sugars (Wills et al., 1980; Priest and Lougheed, 1981) which acts an intermediatory substrate for catabolic and anabolic pathway.

Pectin content in general showed a decline with an increase in storage duration under all the treatments. However, fruits treated with Spearmint leaves retained higher pectin contents throughout storage. The decrease in pectin levels during storage may be due to its breakdown during storage as claimed by Sandhu et al. (1990). The slower and gradual decrease in pectin content of fruits cushioned with spearmint leaves during storage may be attributed to lower respiration rates, proteolysis and tissue breakdown in such fruits, as menthol is believed to deactivate the removal of galacturonic acid residues from the pectin molecule (Jazzar and Hammad, 2003) thereby retaining higher pectin content in fruits.

Apple fruits show considerable spoilage, even during storage at low temperature. Cushioning with camphor

leaves was found to be the most effective treatment in reducing spoilage during storage. Volatiles generated by these botanicals are reported to destroy incipient infection on fruit, which may cause rotting during storage (Saxena et al., 1981). Similar observations have also been reported by Gakhukar (1996), Singh et al. (2000); Bhardwaj and Sen (2003).

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