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Effect of Pre- and post-harvest treatments of neem (*Azadirachta indica*)-based formulations, plant leaves and their extract on the storage quality of apple (*Malus domestica*)*

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From the last few years the use of various chemicals and waxing material at the pre- and post-harvest stages is becoming popular among growers to enhance the shelf-life of fruits (Gakhukar 1996). However the use of these substances have their own limitations, as some of them are believed to be ecologically unsafe and economically unviable, besides leaving their 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. To overcome these shortcomings there is an 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 therefore neem (*Azadirachta indica* L.), melia (*Melia azadrach* L.), menthe (*Mentha spicata* L.), lantana (*Lantana camera* L.) 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 pre- and post-harvest treatment of neem-based formulation, plant leaves extract on the storage quality of 'Starking Delicious' apple (*Malus domestica* Borkh).

The experiment pertaining to the pre-harvest treatment of neem-based formulations was conducted during 2003–04 and 2004–05 and was laid out in well maintained commercial orchard situated at an elevation of 2 100 m above mean sea level in villages Khaneti (Kotgarh) district Shimla, Himachal Pradesh. Thirty well grown, uniform 15–20-years-old 'Starking Delicious' apple trees raised on seedling 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 3 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 of 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). The details of treatments under study were neem leaf extract 10%, 20%, drake (*Melia azedarach*) 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 post-harvest 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 min. The coated fruit were placed on newspaper sheet for drying in shade for ½ hr at room temperature and also to remove excess coating materials.

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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 'Starking Delicious' apples during storage at 1±1°C

Treatment	Physiological loss in weight (%)	Fruit firmness (N)	Total soluble solids (°Brix)	Starch iodine rating	Pectin
			Mean values of 180 days		
T_1: Nimbecidine (0.5%)	4.23 (2.05)	64.41	12.70	5.45	1.29
T_2: Nimbecidine (1.0%)	4.13 (2.03)	64.81	12.79	5.37	1.35
T_3: Nimbecidine (1.5%)	4.03 (2.01)	65.21	12.83	5.33	1.38
T_4: Neem Azal (1.0%)	4.31 (2.07)	64.18	12.73	5.42	1.39
T_5: Neem Azal (1.5%)	4.22 (2.05)	64.45	12.76	5.36	1.41
T_6: Neem Azal (2.0%)	4.15 (2.03)	64.81	12.86	5.31	1.47
T_7: Neem Gold (0.5%)	4.36 (2.08)	63.78	12.66	5.53	1.35
T_8: Neem Gold (1.0%)	4.31 (2.07)	64.18	12.72	5.48	1.38
T_9: Neem Gold (1.5%)	4.20 (2.04)	64.72	12.76	5.42	1.41
T_{10}: Bavistin (0.05%)	4.44 (2.10)	64.54	12.48	5.62	1.31
Initial value		76.86	10.22	4.08	1.86
CD (P=0.05)					
T	0.02	0.04	0.05	0.01	0.02
I	0.01	0.03	0.04	0.01	0.01
T×I	0.05	0.09	0.13	0.03	0.05

Figures in parentheses are square root transformed values

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 'Starking Delicious' apples during storage at 1±1°C

Treatment	Physiological loss in weight (%)	Fruit firmness (N)	Total soluble solids (°Brix)	Starch iodine rating	Pectin
			Mean values of 180 days		
T_1: Neem leaf extract (10%)	3.68 (1.91)	66.76	12.55	5.71	1.39
T_2: Neem leaf extract (20%)	3.59 (1.89)	67.16	12.62	5.65	1.45
T_3: Drake leaf extract (10%)	3.56 (1.88)	66.10	12.55	5.75	1.39
T_4: Drake leaf extract (20%)	3.50 (1.87)	66.28	12.65	5.70	1.42
T_5: Spearmint leaf extract (10%)	3.59 (1.89)	65.70	12.49	5.73	1.38
T_6: Spearmint leaf extract (20%)	3.52 (1.87)	66.19	12.60	5.68	1.41
T_7: Marigold flower extract (10%)	3.89 (1.97)	66.32	12.56	5.83	1.35
T_8: Marigold flower extract (20%)	3.82 (1.96)	66.50	12.59	5.75	1.39
T_9: Semper fresh (1.5%)	3.86 (1.96)	65.07	12.32	5.84	1.34
Initial value		78.84	10.11	4.07	1.82
CD (P=0.05)					
T	0.06	0.04	0.05	0.04	0.04
I	0.04	0.03	0.04	0.03	0.03
TXI	0.13	0.09	0.11	0.10	0.09

Figures in parenthesis are square rootTransformed values

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.

Various neem-based formulations applied before harvest had significant effect on most of the parameters. Increase in physiological loss in weight 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 physiological loss in weight that could be due to its ability to retard moisture loss and senescence enhancing mechanism as reported by Gakhukar (1996). The reduction in physiological loss in weight 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 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).

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 apple 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

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 deestrification 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 apple when compared with Bavistin.

Coating treatments with plant leaf/flower extracts caused reduction in physiological loss in weight (Table 2) and the most effective treatments in this regard was 20% 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).

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% 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 that 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 4 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.

SUMMARY

A study was conducted during 2003–05 on the pre- and post-harvest treatment of neem (*Azadirachta indica* L. Juss.)-based formulations of plant leaf extract on the storage quality of 'Starking Delicious' apple (*Malus domestica* Auyh). 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 the control. Plant leaves/flower used as coatings were neem 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±1°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 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 proved to be highly effective in reducing spoilage as no spoilage was recorded under this treatment.

REFERENCES

Alleyne X and Hagenmaier R D. 2000. An alternative formulation for coating apples. *Hort Science* **35** (4): 691–3.

Bhardwaj R L and Sen N Z. 2003. Zero energy cool chamber storage of Mandarin (*Citrus reticulata* cv. Nagpur Santra). *Journal of Food Science and Technology* **40** (6): 669–72.

Borthakar P K, Ranjit Kumar and Kumar R. 2002. Effect of plant extracts on size and rind thickness of Baramasi lemon fruits (*Citrus lemon*) during storage. *Journal of Agricultural Science Society of North – East India* **15** (1): 98–103.

Chai Y L, Dana B O and Deery N C. 1990. Shelf- life extension of Michigan apples using sucrose polyester. *Journal of Food Processing and Preservation* **15**: 197–214

Dhaliwal G S and Arora R. 1996. *Principle of insect Pest Management,* 374 pp. National Agriculture Technology Centre, Ludhiana.

Gakhukar R T. 1996. Commercial and industrial aspects of neem based pesticide. *Pestology* **22** (10): 15–32

Grainge M, Ahmed S, Mitchell W C and Hylen L W. 1984. Plant species reportedly possessing pest control properties, an EWC/ UN data base. Resource System Institute, EWC Honoly College of Tropical Agriculture and Human Resources, UWV of Hawali

Gross K C and Sams C E. 1984. Changes in the cell wall neutral sugar composition during fruit ripening. A special survey. *Phytochemistry* **23**: 2457–61.

Jazzar C and Hammad E A F. 2003. The efficiency of enhanced aqueous extract of *Melia azadirach* leaves and fruits integrated with the *Camptoyles reuteri* releases against sweet potato white fly nymphs. *Bulletin of Insectology* **56** (2): 269–75.

Kleeberg H. 1996. The Neem Azal conception: Future possibilities of the use of neem in biological and integrated pest management. (*in*) *Neem and Environment,* pp 875–82. Singh R P, Chavi M S, Raheja R K (Eds). Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Kumar A. 2004. Effect of neem based pesticides on germination of okra. *Shaspha* **11** (1): 83–5.

Ozdemir A E, Kaskan N, Ayar I T and Dumdar O. 1996. Effect of Semperfresh treatments on the post-harvest physiology of cold stored apples II Golden Delicious. *Turkey Journal of Agriculture and Forestry* **19**: 11–5

Phillips W R and Poapst P A. 1959. Storage of apple. *Bulletin Canadian Department of Agriculture.*

Priest K L and Lougheed E C. 1981. Evaluation of apple maturity using the starch-iodine test. *Factsheet No. 81.*625, Ministry of Agriculture and Food, Ontario, Canada.

Ranganna S. 1986. *Handbook of Analysis and Quality, Control of Fruit and Vegetable Products.* 2nd edn. Tata McGraw Hill Publications Co, New Delhi

Sandhu K S, Bhatia B S and Shukla F C. 1990. Effect of lye treatment on the quality of Kinnow juice. *Indian Journal of Horticulture* **47**: 55–9

Schmutters H. 1990. Properties and potential of natural pesticides from neem tree *Azadirachta indica. Annual Review of Entomology* **35**: 271–9.

Singh Dinesh, Thakur R K and Singh D. 2003. Effect of pre-harvest sprays of fungicides and calcium nitrate on post-harvest rot of Kinnow in low temperature storage. *Plant Disease Research* **18** (1): 9–11.

Singh J N, Acharya P and Singh B B. 2000. Effect of GA_3 and plant extracts on storage behaviour of mango (*Manifera indica*) cv. Langra. *Haryana Journal of Hortiulture Science* **29** (3–4): 121–9.

Smith S M and Stow J R. 1994. Potential of a sucrose ester coating material for improving the storage and shelf life qualities of Cox's Orange Pippin. Annals of *Applied Ecology* **104**: 383–87.

Wills R B H, Bembridge P A and Scott K J. 1980. Use of flesh firmness and other objective tests to determine consumer acceptability of Delicious apple. *Australian Journal of Experimental Agriculture and Animal Husbandry* **20**: 252–6.