EFFECT OF POLYETHYLENES AND PLANT EXTRACTS ON THE SHELF LIFE OF KINNOW

BY

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Affectionately Dedicated to my respectful Ma andDaddy

CERTIFICATE - I

This is to certify that this thesis entitled, **"Effect of polyethylenes and plant extracts on the shelf life of kinnow"**, submitted for the degree of Master of Science, inthe subject of Horticulture of the **Chaudhary Charan Singh Haryana Agricultural University, Hisar,** is a bonafide research work carried out by Miss. Pinky Yadav under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

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Major Advisor

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CERTIFICATE - II

This is to certify that this dissertation entitled, **"Effect of polyethylenes and plant extracts on the shelf life of kinnow"**, submitted by **Pinky Yadav to the Chaudhary Charan Singh Haryana Agricultural University, Hisar,** in partial fulfilment of the requirement for the degree of Master of Science in the subject of Horticulture, has been approved by the student's Advisory Committee after an oral examination.

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Hisar, 2000

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CONTENTS

LIST OF ABBREVIATIONS

cv.	Cultivar
cm	Centimeter
C. D.	Critical difference
^{0}C	Degree celsius
et al.	*et alii* (and others)
g	Gramme
ha	hectare
HDPE	High Density Polyethylene Film
i. e.	*id est* (that is)
$KMnO_4$	Potassium permagnate
kg	Kilogramme
L	Litre
LDPE	Low Density Polyethylene Film
mg	Milligramme
ml	Millilitre
N	Normal
No.	Number

PLW	Physiological loss in weight
pkg	package
pp.	pages
%	percent
R. H.	Relative humidity
STS	Sodium thiosulphate
TSS	Total soluble solids
temp.	Temperature

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CHAPTER - I

INTRODUCTION

Citrus is the third most important fruit crop in the world. It is a rich source of vitamin - C and minerals such as calcium, Magnesium, Iron and Phosphorus. It can be grown in tropical and sub-tropical regions of world. The total production of the citrus fruits in the world was 93.478 million tonnes with average yield of 8.3 metric tones per hectare (FAO,1997). India has total area of one lakh hectare under cultivation of citrus . While the Haryana state has got the total area of 4378 hectares with production of 37800 tonnes under citrus crop (Kartar Singh , 1998).

Among the different citrus crop, kinnow has gained importance because of its higher yields and incomes. However, its commercial cultivation is restricted to some districts in a particular belt comprising Punjab, Haryana and Rajasthan viz. Abohar and Bhatinda in Punjab, Sriganganagar in Rajasthan and Sirsa districts in Haryana. Kinnow is a hybrid mandarin (King X Willow leaf). It has a good yield potential and acceptance to the consumers. It cannot be stored on the tree for a long due to granulation. However, at room temperature it has a shelf life of hardly seven days. This shelf life is not sufficient for transportation of fruits to long distances. This, creates a glut in the local market and farmers cannot fetch better prices for their produce. Due to faulty handling and transportation, 20-25% of the fruits go waste. So, it is imperative to enhance the shelf life of this fruits so that these can be transported to the longer distances to fetch good market and better returns.

Use of polyethylene has been reported to enhance the shelf life of kinnow fruits (Bhullar et al. 1981) and Guava fruits (Siddiqui and Gupta, 1997). Polyethylene as a packaging material is helpful to decrease the respiration rate and transpiration as a result of which physiological loss of weight decreases and shelf life increases in kinnow fruits (Kumar *et al.*, 1991). However, in some cases polyethylene to be used for packing is very thick then it leads to decay of the fruits and growth of microflora inside the packing, thereby increasing the decay loss. So, thickness of the polyethylene to be used for the packaging material should be in such a way it should allows the proper diffusion of carbondioxide and oxygen in order to maintain the minimum respiration rate. However, in case of kinnow no such work has been undertaken to standardize the thickness of the polyethylene which is sufficient enough to enhance shelf life of kinnow.

Use of fungicides in fruits to enhance the shelf life and to reduce the decay loss are liable to cause pollution due to their residual effect. So, efforts are being made to reduce the decay loss by the use of bio products. Neem leaf extract and Bael leaf extract (Bioproducts) have been reported to reduce the decay loss in fruit (Singh et al., 1993) and to enhance the shelf life of fruits (Farooqi, 1988).

So in the present studies, i. e. the use of different thickness of polyethylene in combination with Bael and Neem leaf extract will be studied to enhance the shelf life of kinnow fruits with an objective :-

To a ssess the effect of plant extracts and polyethylene on the quality and shelf life of kinnow fruits.

CHAPTER - II

REVIEW OF LITERATURE

The available literature with regard to effect of polyethylene and plant extracts on the shelf-life of kinnow fruits has been collected and presented in the chapter under various appropriate headings.

2.1 Physiological parameters :-

1. Physiological loss in weight (PLW) :-

Moisture content of citrus fruits is high and weight loss during transportation and storage can be serious economic factor specially if fruit is sold by weight in the market. Physiological loss in weight is mainly due to water evapovation, respiration and various degradative process occurring during post-harvest handling of fruit (Hoard and Salunkhe, 1975). So, PLW increases gradually with the increase in the storage period in citrus fruits (Kumar *et al.*, 1990; Aworth *et al.*, 1991; Singh and Rana, 1992; Jain and Chauhan, 1994 and Sindhu and Singhrot, 1994), ber (Abbas *et al.*, 1990; Baviskar *et al.*, 1995), grapes (Lu and Ouyung, 1990) and in Aonla (Patel and Sachan, 1995). The physiological loss in weight is reduced by use of chemicals and fungicides during storage. Bhullar *et al.*, (1981) reported that minimum weight loss was observed in the kinnow fruits treated with benlate and captan than control. Dipping of guava fruits in calcium nitrate (1%) solution minimized the loss in weight during room temperature storage (Singh *et al.*, 1981 and Singh, 1988). Habibunnisa and Narsimhan (1988) observed reduction of weight loss in apple after treatment with bavistin @ 1000 ppm during ambient storage condition. Sindhu and Singhrot (1994) reported that minimum loss in weight was observed in Lemon fruits stored in modified storage with diphenyl treatment in zero energy chamber. Patel and Sachan (1995) reported that loss in weight was found minimum in Aonla fruits treated with calcium nitrate (1%) followed by CCC (400 ppm).

Similarly, post-harvest application of wax and oil alone or in combination with fungicides have been observed to reduce the physiological loss in weight in different fruits by different workers. Singhrot *et al.*, (1987) found that waxol (12%) + captan (1%); waxol (12%) + topsin-m (1%) and waxol (12%) alone were effective in reducing PLW in Baramasi lemon.

The weight loss of kinnow mandarin was least (6%) in polythene bags compared with 24% for waxed fruits and 48% for control (Jawanda *et al.*, 1978) The PLW was reduced significantly with modified

atmospheric storage of kinnow (Kumar *et al.*, 1991) Weight loss of litchi fruits was least in wax treated fruits packed in perforated polyethylene bags with paper cutting as cushioning material compared to control fruits (Kahlon and Bajwa, 1991). Singh *et al.*, (1993) reported that minimum weight loss was found in guava fruits packed in per-forated polythene bags followed by wax emulsion throughout the entire period of storage. Pal and Roy (1995) observed minimum weight loss in mango fruits treated with bavistin and packed in HMF film as compared to control fruits. Sonkar and Ladaniya (1998) reported that loss in weight was significantly reduced by heat-shrin kable and stretch cling polyethylene film. The losses in weight were decreased when perforated polythene bags were used for storage of kinnow (Bhullar *et al.*, 1985); Sweet orange or Mosambi (Ghosh and Sen, 1981), Guava (Dhoot *et al.*, 1984; Sharma *et al.*, 1994). Banana fruits treated with extracts of *A. indica* recorded minimum percentage loss in weight (Singh *et al.*, 1993).

Juice content :-

The decrease in extractable juice during storage of kinnow mandarin was probably due to continous dehydration (Bhullar *et al.*, 1980). The extractable juice decreased in general with the increase in storage period of Pineapple and Mandarin : (Bhullar, 1981). Kinnow (Bhullar *et al.*, 1985) and in mandarin (Angadi and Krishnamurthy, 1992).

Angadi and Krishnamurthy (1992) reported that at room temperature storage, juice content of Mandarin fruits packed in polyethylene bags decreased from 49.4 to 42.7 percent and at low temperature storage decreased to 36.1 percent. Singh and Rana (1992) reported that highest juice content (33.44%) of was retained in sweet orange fruits stored in wooden box with polythene bags as compared to wooden box alone (30.13%) and gunny bag (29.06%) after 80 days of storage.

Biochemical parameters :-

1. Total soluble solids (T. S. S.) :-

Generally fruits TSS contains 90 per cent sugar, 10 percent minerals and acid etc. An increased trend in TSS due to evaporational losses was reported in kinnow (Ahlawat *et al.*, 1984; Singhrot *et al.*, 1987; Singh *et al.*, 1989); in lime (Bhullar, 1983), Sweet orange

(Chattopadhyay and Ghosh, 1994) and mango (Chauhan *et al.*, 1987). There are reports that TSS first increase for few days and then start decreasing due to dehydration of fruits and hydrolysis of polysaccharides such as in ber (Bariskar *et al.*, 1995) and kinnow (Tewari *et al.*, 1992).

The total soluble solids retention of guava fruits improved with captan or calcium compound applied as pre or post-harvest treatments (Bhadu, 1983). Similar results were obtained in kinnow (Singh *et al.*, 1988) as post-harvest treatment with various fungicides. Singh and Singh (1992) reported maximum total soluble solids (21.4^{0} Brix) in 2000 ppm captan treated fruits under perforated polythene wrapping mango fruits after 13 days of storage.

Adsule and Tandon (1983) found that the guava fruits wrapped in low density polythylene films retained maximum total soluble solids as compared to control fruits. Dhoot et al., (1984) reported maximum TSS in polythene packed guava fruits compared to control fruits after 6 days of storage. Singh *et al.*, (1993) observed that polythene packed guava fruits retained maximum total soluble solids compared to control fruits after 10 days of storage. Venkatesha and Reddy (1994) recorded maximum total soluble solids in guava fruits wrapped in 300 guava polyethylene bags whereas minimum in control fruits after 9 days of storage. (Singh and Rana 1992) reported that sweet orange fruits packed in wooden box with polythene corering retained maximum total soluble solids upto 80 days in zero energy chember storage.

2. Acidity :-

Maturity and storage temperature are main factors which determine the changes

in acidity during storage. Increase in acidity during storage has been reported in guava (Siddiqui and Gupta, 1997), kinnow (Singh *et al.*, 1989; Tewari *et al.*, 1992) while decrease in acidity has been reported in ber (Abbas *et al.*, 1990; Baviskar *et al.*, 1995), kinnow (Angadi and Krishnamurthy, 1992; Sonkar and Ladaniya, 1998), Sweet orange (Chattopadhyay and Ghosh, 1994) and in mango (Tandon and Kalra, 1997).

Gupta *et al.*, (1979) reported that acidity in guava fruits increased for few days under roots temperature storage and decreased thereafter. Similar results were observed in kinnow (Gupta *et al.*, 1980; Singh *et al.*, 1988), Baramasi lemon (Singhrot *et al.*, 1987; Sharma *et al.*, 1989). This increased acidity during storage was due to water loss (Hifney and Abdel, 1977). Hawker (1968) reported conversion of acids into salts and sugars by invertase enzyme might be one of the factors for decreased level of acidity. Kapse *et al.*, (1977) explained that slow decrease in acidity in mango during low temperature storage might be due to the reduced respiration. Acidity decreased with the increase in the storage period in litchi and also observed that wax emulsion helps in preserving acidity in litchi fruits (Kahlon and Bajwa, 1991).

Minimum acidity was observed in guava fruits packed in perforated polyethylene bags (Singh *et al.*, 1976). Venkatesha and Reddy (1994) recorded more acidity in guava fruits packed in polyethylene bag (300 guage) where as less in control fruits after 9 days of storage. Sharma *et al.*, (1994) reported that acidity of guava fruits cv. L-49 was not affected by any of packaging materials. Similar observations were made by Khedkar *et al.*, (1982).

Wavhal and Athale (1988) reported higher acidity in mango fruits treated with $KMNO_4$ and wrapped in polyethylene whereas minimum in control fruit after 20 days of storage.

Ascorbic Acid :-

Nutritive value of the fruit is largely due to its high vitamin C content, specially ascorbic acid. The content of ascorbic acid during storage has been reported to decrease in mango cv. Langra (Mukherjee and Srivastava, 1979; Khader *et al.*, 1988) apple (Aggarwal and Bisen, 1976); citrus (Bhullar, 1983, Singh and Rana, 1992; Jain and Chauhan, 1995). Ascorbic acid increased upto certain period during storage in guava (Mowlahand Itoo, 1983); kinnow (Kumar *et al.*, 1991) and in ber (Siddiqui *et al.*, 1989). The loss in ascorbic acid on prolonged storage could be attributed to the rapid conversion of L-ascorbic acid into dehydro ascorbic acid in the presence of ascorbinase enzyme (Das and Dash, 1967 and Mapson, 1970). Ahmed *et al.*, (1980) found decreased ascorbic acid during room temperature storage in kinnow fruits. Similar results were also reported in citrus (Bhullar, 1983) and Mango (Mann and Singh, 1975). Singhrot *et al.*, (1987) found increased level of ascorbic acid with waxol + diphenyl lining.

Adsule and Tandon (1983) reported that the guava fruits retained higher vitamin C content when packed in 600 guage low density polyethylene bags. Sharma *et al.*, (1994) also reported that when guava cultivar L-49 fruits were packed in polythene bags there was maximum vitamin C content when compared with those packed in newspaper, typing paper, rice paper and rough filter paper. Venkatesha and Reddy (1994) also found that use of polyethylene bags had retention of ascorbic acid for long period as compared to control fruits.

Sugars :-

Sugars is an important factor in determining the palatability of fruits. A progressive increase in sugar during storage was observed in Mango (Upadhyay and Tripathi, 1985), Lime (Bhullar, 1983), Kinnow (Joshan *et al.*, 1983) and in ber (Bal *et al.*, 1978; Jawanda *et al.*, 1980). The increase in sugar contents during early days of storage and then decrease on subsequent days was observed in citrus (Tewari *et al.*, 1992) and in guava (Siddiqui and Gupta, 1997). This increase in early days and then decrease in sugar content during storage was mainly due to hydrolysis of polyaccharides and degradative process respectively (Roy and Singh, 1979). Increased sugar content was also observed due to conversion of starch into sugar. Garg and Ram (1973) observed higher sugar content in control fruits whereas low in wax coated mango fruits. Bhullar *et al.*, (1985) observed the high percentage of total sugar was maintained in kinnow with butter paper whereas, lowest level of it was in paddy straw wrapped fruits. Wavhale and Athale (1988) reported that mango fruits treated with $KMnO_4$ and packed in polyethylene bags had more total sugars compared to control fruits after 20 days of storage. Similar results were recorded by Venkatesha and Reddy (1994) in guava fruits wrapped in polyethylene bags (300 guage).

Organoleptic rating :-

The fruits are generally purchased on the basis of their organoleptic test which coincide with appearance, colour, taste, flavour and marketability of fruits. Gupta *et al.*, (1980) found decrease in organoleptic rating in kinnow fruits with storage period but observed maximum

rating in waxol treated fruits. Angadi and Krishnamurthy (1992) reported that manadarin fruits dipped in 3% waxol and packed in polythene bags results in better organoleptic rating.

Bal (1980) observed better organoleptic rating of ber fruits upto 7 days at ambient temperature and 20 days at zero energy chamber. The fruits of ber remained acceptable upto 3 days of storage at ambient temperature whereas upto 9 days in zero energy chambers (Siddiqui and Gupta, 1991). Khedkhar *et al.*, (1982) found higher organoleptic score and good marketability in guava fruits when packed in 300 gauge polythene bags after 10 days of storage. Similar observation were made by Dhoot *et al.*, (1984). Highest organoleptic score and good marketability upto 10 days has been reported in guava cv. Allahabad Safeda when packed in 600 gauge polyethylene bags (Adsule and Tandon, 1983). Venkatesha and Reddy (1994) reported that packaging of guava cv. L-49 in 300 gauge polythene bags showed highest organoleptic rating for long time as compared to control fruits. Sonkar and Ladaniya (1998) reported that mandarin fruits packed in stretch cling film had better acceptability as compared to non-wrapped fruit after 60 days.

Pathological parameters :-

Decay loss :-

A variety of microbes invade the fruits during storage. During storage there is decrease in pectic compounds and resultant decreased firmness ultimately make the fruits more susceptible to microbial infection. Microbial spoilage together with water loss and biochemical changes are

responsible for deterioration of fruits during storage (Dennis, 1977). Fruit rot increase during storage in fruits (Bhullar *et al.*, 1981).

The perforated polythene bags during storage reduced the decay loss in papaya (Thompson and Lee, 1971), in guava (Singh *et al.*, 1976) and in kinnow (Dhillon *et al.*, 1977). Perforated polythene bags reduced rotting and butter paper was also found equally effective (Bhullar *et al.*, 1985). Adsule and Tandon (1983) reported less decay loss in guava cv. L-49 when packed in low density polyethylene film (L. D. P. E.). *Singhrot et al.*, (1987) observed minimum decay loss in waxol coated kinnow fruits when packed in diphenyl impregnated papers as a cushioning material. Wavhal and Athale (1988) reported minimum (23.98%) spoilage in mango treated with $KMnO_4$ and packed in polythene whereas maximum (34.47%) in control after 20 days of storage. Reddy and Thimmaraju (1989) recorded less spoilage in mango cv Alphanso stored in polyethylene bags compared to control fruits. Sharma *et al.*, (1994) reported that when guava cultivar L-49 fruits were packed in polythene bags there was minimum decay loss compared to control fruits. Sonkar and Ladaniya (1998) reported that very low (2.2%) microbial spoilage was recorded in heat-shrinkable polyethylene film wrapped mandarin fruits.

Leaf extract of *Azadirachta indica* inhibited growth,sporulation, spore germination (Bhowmick and Vardhan, 1981), reduced hyphal dry weight and Sclerotia production (Singh and Dwivedi, 1987), inhibited mycelial growth (Eswaramurthy *et al.*, 1989) and radial mycelial growth (Shenoi *et al.*, 1993). Pandey *et al.*, (1983) reported an inhibition of germination of *Pestalotia psidii* of guava fruits using neem leaf extract. Singh *et al.*, (1993) reported an effective

control of infestation of banana fruits by the extracts of *A. indica* and *Ocimum sanctum*. Onion extracts has been reported to inhibit aflatoxin production (Bilgranu *et al.*, 1992) Garlic pulp extract was found to be effective against mango fruit anthracnose (Chauhan and Joshi, 1990). The antifungal properties of neem product were shown to be due to inhibition of indirect germination of sporongia (Achium and Schloser, 1992). Neem oil has been reported to be as effective as thiabendazole (Ali *et al.*, 1992) in checking growth of *P. italicum, Alternaria alternata, Aspergillus niger*. Arora and Pandey (1984) tested few oils against *P. italicum* in *citrus* reticulata. Among others Eucalyptus oil was also capable of controlling the fungus. It was also found to be effective against fruit rot of lemon (Babu and Reddy, 1986) fruit rot of guava (Madhukar and Reddy, 1998) and anthracnose of mango (Chauhan and Joshi, 1990). Raoof and Parkash Omprakash (19830 reported castor oil to possess antifungal properties. There are reports of controlling fruit rot of guava by using castor oil and sunflower oil (Madhukar and Reddy, 1988).

Decay organism :-

The importance of pathogens responsible for decay of fruits has been responsible for decay of fruits has been observed by many workers. The fungus which are responsible for decay losses during storage in several fruits viz. *Penicillium expansum* in apple (Spalding, 1969) *Aspergillus niger* in grapes (Popa and Giurea, 1979), *Cladosporium sphaerospermum* in oranges and potatoes (Gaur and Chenula, 1982), *Colletotrichum musae* in banana (Ram and Viv, 1982), *Fusarium moniliformae* in citrus and potatoes (Gaur and Chenula, 1982), *Rhizopus artocarpi* in jack fruit (Gupta and Pandey, 1985) and *Pencillium Spp.* in kinnow (Tewari *et al.*, 1992).

Govini *et al.*, (1985) observed that stored rots of pear fruits was caused by *Botrytis*, *Penicillium* and *Alternaria Spp.* Singh and Parashar (1985) reported that Rhizopus stolonifer caused losses in peach fruits during storage. Miller *et al.*, (1986) reported that mango fruits wrapped in plastic films had more serious decay caused by *Colletotrichum gloeosproides* and *Diplodia natalensis.*

CHAPTER - III

MATERIALS AND METHODS

The present investigations entitled " Effect of Polyethylene and Plant extracts on the shelf life of Kinnow" were carried out in the Post-harvest laboratory. Department of Horticulture, C.C.S. Haryana Agricultural University, Hisar during 1999-2000. The following experiment were conducted as per technical details given below :-

Experiment :-

To assess the effect of plants extracts and Polyethylene on shelf life of kinnow.

Fully mature fruits with well developed colour and uniform size with small pedicel were harvested during morning hours and were brought to the laboratory. Fruits were then subjected to different post-harvest plant extract treatments and packed in different thickness of polythene bags as mentioned below:

Treatments :-

1. Individual packing in 50 gauge polyethylene bags.
2. Individual packing in 100 gauge polyethylene bags.
3. Individual packing in 150 gauge polyethylene bags.
4. Individual packing in Newspaper.
5. Neem leaf extracts (2%) and packed in 50 gauge polyethylene bags individually.
6. Neem leaf extracts (2%) and packed in 100 gauge polyethylene bags individually.
7. Neem leaf extracts (2%) and packed in 150 gauge polyethylene bags individually.

8. Neem leaf extracts (2%) and packed in Newspaper individually.

9. Bael leaf extracts (2%) and packed in 50 gauge polyethylene bags individually.

10. Bael leaf extracts (2%) and packed in 100 gauge polyethylene bags individually.

11. Bael leaf extracts (2%) and packed in 150 gauge polyethylene bags individually.

12. Bael leaf extracts (2%) and packed in Newspaper individually.

50 gauge = 0·125 mm (thick), 100 gauge = 0·025 mm (thick), 150 gauge = 0·0375 mm (thick)

Fruits were dipped in (2%) extract of each Neem leaf and Bael leaf for 2 minutes. After dipping, the fruits were air dried before packing into different thickness of polyethylene bags, 4 kg fruits of each treatments were packed in cardboard boxes. Each box was treated as one replication. All treatments were replicated four times.

The plant extract used for the experiment was prepared by the following method:-

The healthy leaves of individual plants were collected from the field and were washed in running tap water to remove dust and other foreign materials from the surface of the leaf. Such leaves were pressed in between the sterile blotting paper to remove the water drops present on the leaf surface. Two gm of each leaf sample was *macerated* with 100 ml of water and leaf tissues were squeezed with the help of muslin cloth. The supernatant was filtered through whatman No. 1 filter paper. Neem leaf extract (2%) and Bael leaf extract (2%) thus obtained were utilized for the experiment.

The fruits were taken at 7 days interval for analysis of various physiological and biochemical parameters.

I Physical parameters :-

1. Physiological loss in weight (%)
2. Juice content (%)

II Biochemical parameters:-

1. Total soluble solids (T.S.S.) (%)
2. Acidity (%)
3. Ascorbic Acid (mg/100 mL)
4. Total sugars (%)
5. Reducing sugars (%)
6. Non-reducing Sugars (%)
7. Organoleptic rating

III Pathological parameters:-

1. Decay loss (%)
2. Disease incidence (%)
3. Decay organisms (%)

I. Physiological parameters :-

1. Physiological Loss in Weight (PLW):-

PLW was evaluated from Ist, IInd and IIIrd replications. In the beginning of the storage period , initial weight of fruits was recorded. On subsequent dates of observations during storage the fruit were again weighed and the weight was termed as final weight on the particulars date of observation. Percent loss in weight for each date of observations was calculated by using the following formula:-

$$\text{Percent loss in weight} = \frac{\text{(Initial wt. - final wt.)}}{\text{Initial wt.}}$$

2. Juice (%) :-

Juice (%) was evaluated from fruit of IVth replication. Juice was extracted from the fruit with the help of muslin cloth. The juice was measured with the help of graduated cylinder and percent juice was worked out by the following formula:-

$$\text{Percent juice (V/W)} = \frac{\text{Volume of juice extracted (ml)}}{\text{Weight of fruit (g)}} \times 100$$

II. Biochemical Parameter :-

Fruit of IVth replication were used for evaluating the following parameters:-

1. Total Soluble Solids (T.S.S.) :-

Total soluble solids of the fruits juice were determined by using a Abbe's hand refractometer of 0-32 percent range. The values were corrected to 25^{0}C with the help of a temperature correction chart and expressed as percent TSS of juice.

2. Acidity :-

The titrable acidity was determined by the method suggested by A.OA.C (1990). Five ml of freshly extracted juice were titrated against 0.1 N NaoH using one percent phenolphthalein solution as indicator. The appearance of light pink color was taken as the end point. The acidity of fruit was expressed as gram of citric acid per 100 ml of juice.

3. Ascorbic Acid :-

The method given by A.OA.C (1990) was followed. It was estimated by adding 5 ml of juice immediately after extraction in 3 percent metaphosphoric acid as buffer, 10 ml volume was made with distilled water and from it 5 ml aliquot was titrated against 2,6-dichlorophenol indophenol dye solution till the light pink colour appeared 50 mg ascorbic acid taken in 50 ml volumeric flask and volume was made with 3% MPA ml of standard ascorbic acid was taken and titrated against dye on each day of observation. The results were expressed as mg of ascorbic acid per 100 ml of juice.

4. Sugars :-

Sugars were estimated by the method suggested by Hulme and Narain (1931) and expressed in gram per 100ml of juice.

Reagents :-

a) Potassium ferricyanide solution :

i)	Potassium ferricyandie	8.25 g
ii)	Anhydrous Sodium Carbonate	10.6 g
iii)	Volume made to	1 litre

b) Potassium iodide solution :

i)	Potassium Iodide	12.5 g
ii)	Zinc Sulphate	25.0 g
iii)	Sodium Shloride	125 g
iv)	Volume made to	1 litre

c) Acetic acid solution (5%) v/v :

d) Sodium thiosulphate Solution

i)	Sodium thiosulphate	2.419 g
ii)	Volume made to	1 litre

e) Starch Solution (indicator) :

i)	Soluble Starch	1.0 g
ii)	Sodium Chloride	10.0 g
iii)	Volume made to	100 ml

Estimation :-

Reducing Sugars :-

The fresh juice was diluted 200 times. Five ml of diluted juice was taken in culture tube into which five ml of potassium ferricyanide solution was added. The covered tubes were kept in boiling water bath for 15 minutes. After cooling the tubes, 5 ml of potassium iodide solution was added, followed by 3 ml of acetic acid solution. The liberated iodine was titrated against sodium thiosulphate solution using starch indicator. The end point was marked with disappearance of blue colour and appearance of milky white colour. A blank with 5 ml of distilled water was carried out simultaneously.

Non- Reducing sugars :-

The amount of non-reducing sugars was calculated by subtracting the amount of reducing sugars from the total sugars and were expressed as per cent non-reducing sugars.

Total sugars :- The estimation of total sugars was done as follows:-

10 ml of diluted juice taken and plus 2.0 ml of hydrochloric acid (conc.) was added in a screw culture tube and kept at 68^{0}C for 15 minutes to hydrolyse sugars. Volume was made to 50 ml and the acidity was neutralized by adding anhydrous sodium carbonate till the effervescence stopped.

3. Organoleptic rating :-

Organoleptic rating was conducted at end of observation, by a panel of five judges who expressed their opinion on the basis of taste/ appearance/color/marketability. Each parameter was given maximum of 10 marks. Judges were requested to evaluate different fruits and score

for different parameters out of 10 and average fall was taken as final organoleptic rating as follows :-

Condition of the fruits	Marks
Excellent	10
Very good	09
Good	08
Fair	07
Acceptable	06
Just acceptable	05
Unacceptable	04
Rejected	03

III. Pathological observations :-

Decay loss :-

Fruits showing rotting due to over ripening and pathogenic infection were considered as decayed and were weighed on the day of each observation. The percent decay loss was estimated using the following formula:-

$$\text{Decay loss (\%)} = \frac{\text{weight of decayed fruits}}{\text{Initial weight of fruits at the time of packing}} \times 100$$

2. Disease Incidence :-

Number of fruits rotted due to pathogenic infection were considered as decayed ones and discarded on the day of each observation. The percent disease incidence was determined . The per cent disease incidence was determined by the following formula :-

$$\text{Percent disease incidence} = \frac{\text{No. of fruits affected}}{\text{Total No. of fruits}} \times 100$$

3. Casual organisms :-

The fruits in storage were inspected and fungal species present on the fruits responsible for rotting were identified by culturing them in Lab. in collaboration with the Department of plant pathology , Haryana Agricultural University, Hisar. The important fungus which were mainly responsible for decay losses during storage in citrus fruits were *Botryodiplodia theobromae, Penicillium digitatum* ; *Penicillium italicum Aspergillus niger.*

CHAPTER - IV

EXPERIMENTAL RESULTS

The results of the present investigation on effect of polyethylene, Neem and Bael leaf extracts during storage in kinnow fruits are presented and interpreted in this chapter. To study the effect of polyethylene, Neem and Bael leaf extracts on the shelf life and quality of fruit.

Physiological parameters :-

Physiological loss in weight :-

Results on physiological loss in weight in Kinnow during storage as affected by different thickness of polyethylene, Neem and Bael Leaf extracts have been presented in Table 1. Data in Table 1. reveals that PLW of fruits increased with increasing period of storage in all the treatments. Fruits packed in different thickness of polyethylene showed minimum physiological loss in weight on all periods of storage. Fruits packed in 100 gauge polyethylene and treated with Neem Leaf extracts (2%) had minimum PLW on all periods of storage followed by 50 gauge polyethylene and treated with Neem leaf extracts (2%). On seventh day of storage fruits packed in 50 gauge polyethylene showed minimum PLW (0.43%) which was at par with 100 and 150 gauge packed polyethylene fruits. Similar results were obtained from 14th day upto 63rd day of storage. On 70th day of storage minimum PLW (5.73%) was observed in 100 gauge polyethylene and treated with Neem leaf extracts (2%) followed by (6.09%) in 50 gauge polyethylene and treated with Neem leaf extracts (2%) although all the polyethylene were effective in checking the PLW as shown in fig. (i) and maximum PLW (27.66) was observed in Newspaper wrapped

TABLE 1. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on physiological loss of weight (%) during storage in kinnow fruits

Treatments	Days of storage									
	7	14	21	28	35	42	49	56	63	70
50 Gauge Polyethylene (unipack)	0.43	0.92	1.08	1.48	1.86	2.43	3.56	3.95	4.39	6.34
100 Gauge Polyethylene (unipack)	0.53	0.69	0.93	1.37	1.69	2.25	3.08	3.48	4.15	6.81
150 Gauge Polyethylene (unipack)	0.50	0.81	0.95	1.38	1.62	1.93	2.24	3.36	5.97	7.75
News paper (unipack)	2.98	6.29	7.78	9.72	13.74	15.30	17.77	22.48	24.72	27.66
50 Gauge+Neem leaf extracts (2%)	0.46	0.77	0.91	1.29	1.79	2.32	3.22	4.09	5.04	6.09
100 Gauge+Neem leaf extracts (2%)	0.45	0.79	0.94	1.27	1.58	1.95	2.14	3.16	3.96	5.73
150 Gauge+Neem leaf extracts (2%)	0.43	0.65	0.85	1.45	1.61	1.87	2.52	5.06	5.92	8.17
News Paper+Neem leaf extracts (2%)	2.68	5.76	8.25	10.44	12.94	12.99	16.20	19.36	22.43	25.59
50 Gauge+Bael leaf extracts (2%)	0.64	1.07	1.36	1.59	1.85	2.58	3.38	3.74	4.66	6.49
100 Gauge+Bael leaf extracts (2%)	1.62	2.13	2.39	2.68	2.96	3.04	3.96	4.64	5.78	7.03
150 Gauge+Bael leaf extracts (2%)	0.83	1.28	1.56	1.87	2.15	2.69	3.42	4.48	6.20	8.18
News Paper+Bael leaf extracts (2%)	2.94	6.08	8.5	10.68	12.80	14.50	16.26	18.67	21.61	24.57
C. D. at 5%	0.37	0.47	0.51	0.55	0.47	0.48	0.45	0.58	0.62	0.61

Fig. (i) Fruits packed in different thickness of polyethylene as compared with control after 70th day at room temperature showing minimum physiological loss of weight.

fruits followed by Newspaper wrapped fruits treated with Neem leaf extracts (2%) followed by (24.57%) in Newspaper wrapped and treated with Bael leaf extracts (2%).

Juice % :-

The results on juice % during storage in kinnow as affected by different treatment has been presented in Table 2. The decrease in juice content was recorded with the increase in period of storage in all the treatments. The highest juice content (55.22%) was recorded in the beginning of storage i. e. on 0 day of storage and lowest (31.63%) was at the end i. e. 70th day of storage in Newspaper packed fruits treated with Neem leaf extracts. On 7th day of storage maximum (56.43%) juice content was observed in 50 gauge polyethylene packed fruits and treated with Bael leaf extracts followed by (56.17%) in 50 gauge polyethylene packed fruits treated with Neem leaf extracts and minimum (52.86%) was observed in Newspaper packed fruits followed by (53.01%) in Newspaper packed fruits treated with Bael leaf extracts. This similar trend was observed on 14th day to 63rd day of storage. On 70th day of storage, maximum (50.60%) was observed in 50 gauge polyethylene packed fruits treated with Neem leaf extracts followed by (50.49%) in 50 gauge polyethylene packed fruits treated with Bael leaf extracts and minimum (31.63%) was observed in Newspaper packed fruits treated with Neem leaf extracts followed by (31.69%) in Newspaper packed fruits. All the polyethylene treatments were found effective in maintaining the juice content upto 70th day of storage.

TABLE 2. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on juice (%) during storage in kinnow fruits

Treatments	Days of storage											
	0	7	14	21	28	35	42	49	56	63	70	Mean
50 Gauge Polyethylene (unipack)	55.22	54.66	54.08	53.84	53.51	52.60	52.02	51.70	50.80	50.63	50.46	52.68
100 Gauge Polyethylene (unipack)	55.22	55.01	54.72	53.57	53.05	52.35	51.88	50.84	50.75	50.52	50.36	52.57
150 Gauge Polyethylene (unipack)	55.22	54.10	53.83	53.66	53.46	52.81	52.02	50.88	50.58	50.22	50.10	52.45
News paper (unipack)	55.22	52.86	50.40	48.37	46.76	44.28	41.56	38.17	35.94	34.13	31.69	45.58
50 Gauge+Neem leaf extracts (2%)	55.22	56.17	55.55	54.67	54.18	53.83	52.94	52.43	51.55	51.08	50.60	53.47
100 Gauge+Neem leaf extracts (2%)	55.22	55.62	55.41	54.50	53.61	52.57	52.04	51.55	50.98	50.75	50.40	52.97
150 Gauge+Neem leaf extracts (2%)	55.22	55.55	54.71	54.17	53.37	52.30	51.75	51.33	50.98	50.70	50.34	52.77
News Paper+Neem leaf extracts (2%)	55.22	53.24	50.50	48.30	46.45	44.58	41.59	38.91	36.64	34.92	31.63	43.82
50 Gauge+Bael leaf extracts (2%)	55.22	56.43	55.70	54.62	54.30	53.53	53.00	52.59	51.70	51.38	50.49	53.54
100 Gauge+Bael leaf extracts (2%)	55.22	56.02	54.62	53.67	53.21	52.82	52.59	51.31	50.78	50.48	50.26	52.81
150 Gauge+Bael leaf extracts (2%)	55.22	55.04	54.40	54.08	53.42	53.03	52.66	51.50	50.99	50.46	50.21	52.82
News Paper+Bael leaf extracts (2%)	55.22	53.01	54.09	47.65	46.29	44.09	41.49	39.53	36.49	34.60	32.12	43.70
Mean	55.22	54.81	53.67	52.59	51.80	50.73	49.63	48.40	47.35	46.54	45.73	

CD at 5% -Storage = 2.11

CD at 5% -Treatment = 2.41

CD at 5% - Storage x Treatments = 3.39

Biochemical parameters

Total soluble solids (TSS) :-

The data on total soluble solids (%) during storage in kinnow as affected by different treatments has been predicted in Table 3.

The data in Table 3 reveals that fruits at the initial stage i. e. at 0 day of storage had TSS of 9.8%. Total soluble solids content of fruits increased with increasing period of storage in all polyethylene treatments i. e. upto 70th day of storage. However, in Newspaper packed fruits treated with or without Neem and Bael leaf extracts the TSS content increased upto 35th day and decreased thereafter upto 70 th day of storage. On 7th day of storage maximum (9.9%) was observed in Newspaper packed fruits treated with or without bael leaf extracts and minimum (9.6%) was observed in 50 and 100 gauge polyethylene packed fruits treated with or without Neem leaf extracts (2%). Similar trend was observed from 14th to 63rd day of storage. On 70th day of storage fruits packed in 100 and 150 gauge polyethylenes with or without treatments with Neem or Bael leaf extracts had TSS value of 10.5% whereas fruits packed in Newspaper with or without Neem or Bael leaf extracts had TSS of 9.5% on 70th day of storage. TSS content of the fruits in Newspaper packed fruits increased from 9.8 on 7th day to 10.4% on 28th day of storage and was constant on 35th day of storage (10.4%) and decreased there after upto 70th day of storage.

TABLE 3. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on total soluble solids (%) during storage in kinnow fruits

Treatments	Days of storage											
	0	7	14	21	28	35	42	49	56	63	70	Mean
50 Gauge Polyethylene (unipack)	9.8	9.6	9.9	9.9	9.9	10.0	101	10.2	10.2	10.3	10.3	10.0
100 Gauge Polyethylene (unipack)	9.8	9.7	9.9	10.0	10.1	10.1	10.2	10.3	10.4	10.4	10.5	10.1
150 Gauge Polyethylene (unipack)	9.8	9.8	9.9	10.0	10.1	10.2	10.3	10.3	10.4	10.5	10.5	10.2
News paper (unipack)	9.8	9.9	10.0	10.2	10.4	10.4	10.1	9.9	9.8	9.8	9.5	10.0
50 Gauge+Neem leaf extracts (2%)	9.8	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.3	10.4	10.0
100 Gauge+Neem leaf extracts (2%)	9.8	9.6	9.7	9.9	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.0
150 Gauge+Neem leaf extracts (2%)	9.8	9.8	9.9	10.1	10.1	10.2	10.3	10.3	10.4	10.4	10.5	10.2
News Paper+Neem leaf extracts (2%)	9.8	9.8	10.0	10.1	10.3	10.4	10.1	9.9	9.8	9.7	9.5	10.0
50 Gauge+Bael leaf extracts (2%)	9.8	9.7	9.8	9.8	10.0	10.1	10.2	10.2	10.3	10.3	10.4	10.1
100 Gauge+Bael leaf extracts (2%)	9.8	9.8	9.8	9.8	10.1	10.2	10.0	10.0	10.3	10.4	10.5	10.1
150 Gauge+Bael leaf extracts (2%)	9.8	9.8	9.9	10.0	10.2	10.2	10.3	10.3	10.4	10.4	10.5	10.2
News Paper+Bael leaf extracts (2%)	9.8	9.9	10.0	10.1	10.3	10.4	10.1	10.0	9.8	9.7	9.4	10.0
Mean	9.8	9.7	9.9	10.0	10.1	10.2	10.2	10.2	10.2	10.2	10.2	

CD at 5% -Storage = 0.2

CD at 5% -Treatments = 0.3

CD at 5% - Storage x Treatments = 0.5

2. Acidity

Results on acidity during storage in kinnow as affected by different treatments has been presented in Table 4. There was slight increase in acidity on the 7th day of storage in different treatments whereas from 14th day onwards, the acidity content decreased upto the end of storage (70th day) in all the treatments except Newspaper packed fruits with or without Neem or Bael leaf extract. In Newspaper packed fruits without any treatment, the acidity content of the fruits increased from 0.52% in the beginning to 0.53% on 7th day of storage and started decreasing from 14th day upto 28th day and the value reached to 0.49% on 28th day of storage. From 35th day onward acidity content started increasing from 0.50% to 0.58% on 70th day of storage. The fruits treated with Bael and Neem leaf extracts and packed in newspaper also showed the similar trend upto the end of storage. Among the polyethylenes packed fruits value of acidity was almost same with similar trend in all thicknesses of polyethylene. On 70th day of storage, the acidity content was 0.47% in all polyethylene packing with or without Neem or Bael leaf extracts.

3. Ascorbic acid :-

The results on ascorbic acid content were collected and data are presented in Table 8. The perusal of the data indicates that ascorbic acid content of the juice increased with increasing period of storage, upto 28th day of storage and decreased thereafter upto 70th day of storage in all the treatments. On 7th day of storage, maximum ascorbic acid (27.10 mg/100 ml) was found

TABLE 4. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on acidity (%) during storage in kinnow fruits

Treatments	Days of storage											
	0	7	14	21	28	35	42	49	56	63	70	Mean
50 Gauge Polyethylene (unipack)	0.52	0.54	0.52	0.51	0.50	0.50	0.48	0.48	0.47	0.47	0.47	0.50
100 Gauge Polyethylene (unipack)	0.52	0.54	0.52	0.51	0.50	0.50	0.48	0.48	0.47	0.47	0.47	0.50
150 Gauge Polyethylene (unipack)	0.52	0.53	0.52	0.51	0.49	0.50	0.49	0.48	0.48	0.47	0.47	0.50
News paper (unipack)	0.52	0.53	0.51	0.50	0.49	0.50	0.52	0.53	0.54	0.55	0.58	0.52
50 Gauge+Neem leaf extracts (2%)	0.52	0.54	0.53	0.53	0.51	0.51	0.50	0.49	0.48	0.48	0.47	0.50
100 Gauge+Neem leaf extracts (2%)	0.52	0.54	0.53	0.51	0.50	0.51	0.50	0.49	0.48	0.48	0.47	0.50
150 Gauge+Neem leaf extracts (2%)	0.52	0.53	0.52	0.51	0.50	0.50	0.49	0.49	0.48	0.48	0.47	0.50
News Paper+Neem leaf extracts (2%)	0.52	0.52	0.51	0.50	0.49	0.50	0.51	0.52	0.54	0.55	0.57	0.52
50 Gauge+Bael leaf extracts (2%)	0.52	0.52	0.52	0.51	0.50	0.50	0.49	0.48	0.48	0.48	0.47	0.50
100 Gauge+Bael leaf extracts (2%)	0.52	0.52	0.52	0.50	0.49	0.50	0.48	0.48	0.47	0.47	0.47	0.49
150 Gauge+Bael leaf extracts (2%)	0.52	0.53	0.52	0.50	0.50	0.50	0.50	0.49	0.48	0.48	0.47	0.50
News Paper+Bael leaf extracts (2%)	0.52	0.53	0.52	0.51	0.49	0.51	0.52	0.53	0.54	0.55	0.57	0.53
Mean	0.52	0.53	0.52	0.50	0.50	0.50	0.50	0.49	0.49	0.49	0.50	

CD at 5% -Storage = 0.01

CD at 5% -Treatments = 0.01

CD at 5% - Storage x Treatments = 0.01

TABLE 5. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on ascorbic acid (mg/100ml) during storage in kinnow fruits

Treatments	Days of storage											
	0	7	14	21	28	35	42	49	56	63	70	Mean
50 Gauge Polyethylene (unipack)	25.57	26.97	27.70	29.13	30.53	30.30	30.03	29.47	29.13	28.70	28.13	28.70
100 Gauge Polyethylene (unipack)	25.57	26.73	28.03	29.43	30.50	30.33	29.93	29.53	29.20	28.70	28.10	28.73
150 Gauge Polyethylene (unipack)	25.57	27.00	27.70	29.07	30.30	30.13	29.93	29.47	29.13	28.57	28.00	29.62
News paper (unipack)	25.57	26.50	26.83	27.90	30.13	29.43	28.87	28.13	27.30	25.83	24.33	27.34
50 Gauge+Neem leaf extracts (2%)	25.57	26.87	27.70	28.70	30.53	30.37	29.90	29.57	29.20	28.67	28.07	28.65
100 Gauge+Neem leaf extracts (2%)	25.57	26.80	27.77	28.93	30.57	30.43	30.13	29.60	29.13	28.70	28.23	28.72
150 Gauge+Neem leaf extracts (2%)	25.57	24.33	27.40	28.70	30.53	30.40	30.03	29.53	29.10	28.63	28.20	28.40
News Paper+Neem leaf extracts (2%)	25.57	26.27	26.77	27.97	30.33	29.40	28.73	28.00	27.17	25.80	24.27	27.30
50 Gauge+Bael leaf extracts (2%)	25.57	27.00	27.97	28.83	30.33	30.27	30.00	29.70	29.17	28.73	28.33	28.72
100 Gauge+Bael leaf extracts (2%)	25.57	26.80	27.90	28.77	30.63	30.43	29.33	29.63	29.10	28.63	27.97	28.67
150 Gauge+Bael leaf extracts (2%)	25.57	27.10	27.90	28.63	30.70	30.40	30.03	29.63	29.17	28.57	28.07	28.71
News Paper+Bael leaf extracts (2%)	25.57	26.33	26.87	27.97	30.20	29.43	28.83	27.97	27.20	25.87	24.30	27.32
Mean	25.57	26.56	27.54	28.67	30.44	30.11	29.70	29.18	28.67	27.95	28.17	

CD at 5% -Storage = 1.16

CD at 5% -Treatments = 1.19

CD at 5% - Stroage x treatments =2.55

in 150 gauge polyethylene packed fruits treated with Bael leaf extracts closely followed by in 150 gauge polyethylene packed fruits (27.00 mg/ml) and 50 gauge polyethylene packed fruits treated with Bael leaf extracts (27.10 mg/100 ml) and there were par with each other. Minimum ascorbic acid (24.33 mg/100 ml) was observed in 150 gauge polyethylene packed fruits treated with Neem leaf extracts. Similar trend was observed from 14th to 63rd day of storage. On 70th day of storage maximum ascorbic acid content (28.33 mg/ 100 ml) was found in fruits packed in 50 gauge polyethylene and treated with Bael leaf extracts followed by 100 guage polyethylene packed fruits treated with Neem leaf extracts (28.23 mg/ 100 ml) and minimum (24.27 mg/ 100 ml) was found in Newspaper packed fruits treated with Neem leaf extracts followed by (24.30 mg/ 100 ml) in Newspaper packed fruits treated with Bael leaf extracts. All the polyethylenes alone or in combination with Neem and Bael leaf extracts were found effective in maintaining ascorbic acid content upto 70th day of storage.

4. Total sugars :-

The observations on total sugars during storage in kinnow as affected by different thickness of polyethylene, Neem and Bael leaf extracts has been collected and presented in Table 6. The data in Table 6 reveals that total sugars content of juice decreased on 7th day of storage in all the treatments and increased thereafter upto 70th day of storage in 50, 100 and 150

TABLE 6. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on total sugars (%) during storage in kinnow fruits

Treatments	Days of storage											
	0	7	14	21	28	35	42	49	56	63	70	Mean
50 Gauge Polyethylene (unipack)	6.09	6.06	6.17	6.28	6.45	6.46	6.47	6.51	6.55	6.57	6.60	6.38
100 Gauge Polyethylene (unipack)	6.09	6.02	6.11	6.24	6.42	6.47	6.48	6.50	6.52	6.55	6.58	6.36
150 Gauge Polyethylene (unipack)	6.09	6.06	6.16	6.26	6.45	6.48	6.49	6.55	6.57	6.60	6.62	6.39
News paper (unipack)	6.09	6.12	6.22	6.37	6.39	6.20	6.09	5.91	5.78	5.63	5.51	6.03
50 Gauge+Neem leaf extracts (2%)	6.09	5.97	6.05	6.16	6.31	6.40	6.40	6.49	6.52	6.57	6.58	6.32
100 Gauge+Neem leaf extracts (2%)	6.09	5.96	6.10	6.20	6.35	6.40	6.45	6.50	6.53	6.56	6.58	6.34
150 Gauge+Neem leaf extracts (2%)	6.09	6.04	6.14	6.26	6.40	6.45	6.49	6.52	6.55	6.60	6.62	6.38
News Paper+Neem leaf extracts (2%)	6.09	6.11	6.22	6.35	6.33	6.22	6.10	5.97	5.80	5.64	5.47	6.03
50 Gauge+Bael leaf extracts (2%)	6.09	6.05	6.12	6.24	6.40	6.44	6.43	6.51	6.52	6.56	6.57	6.36
100 Gauge+Bael leaf extracts (2%)	6.09	6.07	6.15	6.27	6.39	6.46	6.49	6.56	6.58	6.60	6.62	6.39
150 Gauge+Bael leaf extracts (2%)	6.09	6.06	6.15	6.26	6.41	6.46	6.49	6.56	6.58	6.60	6.62	6.39
News Paper+Bael leaf extracts (2%)	6.09	6.11	6.21	6.36	6.34	6.22	6.10	5.96	5.78	5.64	5.46	6.02
Mean	6.09	6.05	6.15	6.27	6.39	6.39	6.37	6.37	6.36	6.34	6.32	

CD at 5% -Storage = 0.02

CD at 5% -Treatments = 0.02

CD at 5% - Storage x Treatments =0.05

gauge polyethylene packed fruits treated with or without Neem and Bael leaf extracts. Total sugar content of fruits packed in Newspaper treated with or without Neem or Bael leaf extracts increased upto 28th day of storage and decreased thereafter upto 70th day of storage. On 7th day of storage, total sugars was maximum (6.12%) in Newspaper packed fruits and minimum (5.96%) was observed in 100 gauge polyethylene packed fruits treated with Neem leaf extracts. Similar trend was observed from 14th to 63rd day of storage. On 70th day of storage, maximum total sugar (6.62%) was observed in 150 gauge polyethylene packed fruits treated with or without Neem or Bael leaf extracts followed by 100 gauge polyethylene and both were at par with each other. Minimum (5.46%) in Newspaper packed fruit treated with Bael leaf extracts followed by (5.47%) in Newspaper packed fruits treated with Neem leaf extracts.

5. Reducing sugars :-

Observations on reducing sugars in kinnow during storage as affected by different treatments has been collected and presented in Table 7. The data in Table 7 reveals that reducing sugar increased with increasing period of storage upto 35th day of storage and decreased thereafter upto 70th day of storage in all polyethylenes packed fruits treated with or without Neem and Bael leaf extract. In newspaper packed fruits treated with or without Neem and Bael leaf extracts, reducing sugars increased upto 28th day and decreased thereafter upto 70th day of storage.. On

TABLE 7. Effect of different thickness of Polyethylene, Neem, Bael leaf extracts on reducing sugars (%) during storage in kinnow fruits

Treatments	Days of storage											
	0	7	14	21	28	35	42	49	56	63	70	Mean
50 Gauge Polyethylene (unipack)	3.41	342	3.46	3.50	3.62	3.72	3.69	3.65	3.60	3.56	3.54	3.56
100 Gauge Polyethylene (unipack)	3.41	3.40	3.44	3.52	3.61	3.71	3.66	3.63	3.59	3.57	3.54	3.55
150 Gauge Polyethylene (unipack)	3.41	3.42	3.45	3.51	3.64	3.72	3.66	3.64	3.61	3.59	3.55	3.54
News paper (unipack)	3.41	3.45	3.49	3.59	3.69	3.64	3.54	3.45	3.35	3.23	3.12	3.50
50 Gauge+Neem leaf extracts (2%)	3.41	3.39	3.42	3.48	3.60	3.67	3.64	3.61	3.59	3.55	3.54	3.53
100 Gauge+Neem leaf extracts (2%)	3.41	3.37	3.41	3.50	3.63	3.66	3.64	3.61	3.58	3.55	3.52	3.53
150 Gauge+Neem leaf extracts (2%)	3.41	3.40	3.44	3.52	3.63	3.69	3.66	3.61	3.60	3.56	3.54	3.55
News Paper+Neem leaf extracts (2%)	3.41	3.43	3.49	3.56	3.68	3.64	3.55	3.46	3.35	3.23	3.09	3.44
50 Gauge+Bael leaf extracts (2%)	3.41	3.40	3.43	3.51	3.63	3.70	3.65	3.62	3.60	3.57	3.55	3.55
100 Gauge+Bael leaf extracts (2%)	3.41	3.43	3.45	3.52	3.63	3.70	3.63	3.61	3.59	3.56	3.53	3.55
150 Gauge+Bael leaf extracts (2%)	3.41	3.43	3.45	3.53	3.65	3.70	3.66	3.63	3.62	3.58	3.57	3.57
News Paper+Bael leaf extracts (2%)	3.41	3.44	3.49	3.57	3.69	3.63	3.56	3.47	3.34	3.21	3.11	3.44
Mean	3.41	3.42	3.45	3.53	3.64	3.68	3.63	3.58	3.53	3.48	3.43	

CD at 5% -Storage = 0.01

CD at 5% -Treatments = 0.01

CD at 5% - Storage x Treatments =0.04

7th day of storage maximum (3.45%) reducing sugars was found in Newspaper packed fruits followed by (3.44%) in Newspaper packed fruits treated with Bael leaf extracts and minimum (3.37%) was found in 100 gauge polyethylene packed fruits treated with Neem leaf extracts followed by (3.39%) in 50 gauge polyethylene packed fruits treated with Neem leaf extracts. These trend was followed from 14 to 63rd days.

On 70th day of storage, maximum (3.57%) reducing sugar was observed in 150 gauge polyethylene packed fruits treated with Bael leaf extracts closely followed by (3.55%) in 150 gauge polyethylene packed fruits and in 50 gauge polyethylene packed fruits treated with Bael leaf extracts which were at par with each other. Minimum reducing sugar was (3.09%) found in Newspaper packed fruits treated with Neem leaf extracts followed by (3.11%) in Newspaper packed fruits treated with Bael leaf extracts followed by (3.12%) in Newspaper packed fruits.

6. Non-Reducing sugar :-

The results on non-reducing sugars during storage in kinnow were presented in Table 8. The perusal of the data indicates that non-reducing sugars decreased in the beginning from 0 to 7th day of storage in all fruit packed in polyethylenes with or without Neem or Bael leaf extracts. However from 14th day onward non-reducing sugars increased upto 28th day in all polyethylene

TABLE 8. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on non-reducing sugars (%) during storage in kinnow fruits

Treatments	Days of storage											
	0	7	14	21	28	35	42	49	56	63	70	Mean
50 Gauge Polyethylene (unipack)	2.69	2.64	2.71	2.77	2.83	2.73	2.78	2.86	2.95	3.02	3.06	2.82
100 Gauge Polyethylene (unipack)	2.69	2.61	2.68	2.72	2.81	2.76	2.82	2.88	2.93	2.98	3.04	2.81
150 Gauge Polyethylene (unipack)	2.69	2.64	2.72	2.75	2.81	2.75	2.82	2.90	2.96	3.01	3.08	2.83
News paper (unipack)	2.69	2.70	2.73	2.78	2.70	2.59	2.54	2.46	2.44	2.40	2.39	2.58
50 Gauge+Neem leaf extracts (2%)	2.69	2.58	2.63	2.69	2.72	2.71	2.76	2.88	2.94	3.01	3.05	2.79
100 Gauge+Neem leaf extracts (2%)	2.69	2.59	2.69	2.71	2.75	2.72	2.81	2.89	2.95	3.00	3.07	2.81
150 Gauge+Neem leaf extracts (2%)	2.69	2.64	2.70	2.73	2.79	2.77	2.83	2.91	2.95	3.03	3.08	2.83
News Paper+Neem leaf extracts (2%)	2.69	2.67	2.72	2.79	2.65	2.58	2.55	2.51	2.45	2.38	2.38	2.58
50 Gauge+Bael leaf extracts (2%)	2.69	2.65	2.69	2.73	2.77	2.74	2.78	2.89	2.92	3.03	3.03	2.80
100 Gauge+Bael leaf extracts (2%)	2.69	2.63	2.70	2.74	2.77	2.76	2.82	2.91	2.96	3.05	3.05	2.82
150 Gauge+Bael leaf extracts (2%)	2.69	2.63	2.70	2.74	2.78	2.75	2.82	2.92	2.96	3.06	3.06	2.82
News Paper+Bael leaf extracts (2%)	2.69	2.67	2.72	2.79	2.65	2.60	2.54	2.49	2.45	2.36	2.36	2.58
Mean	2.69	2.64	2.70	2.75	2.75	2.71	2.74	2.79	2.82	2.86	2.89	

CD at 5% -Storage = 0.01

CD at 5% -Treatments = 0.01

CD at 5% - Storage x Treatments =0.03

packed fruits again decreased on 35th day whereas from 42nd day upto 70th day of storage a regular increase in non reducing sugars was observed in all polyethylene packed fruits. Non-reducing sugars decrease from 2.69% to 2.64% on 7th day again increased to 2.71% on 14th day and value reached upto 2.83%. On 28th day and 35th day again the values decreased to 2.73%. On 42nd day onward in polyethylene packed fruits non-reducing sugar content increased from 2.78% to 3.06% on 70th day of storage. In Newspaper packed fruits non-reducing sugars were maintained upto 7th day (2.69% to 2.70%). However the values increased to 2.78% on 21st day of storage. From 28th onward non-reducing sugars decrease from 2.70% to 2.39%. On 70th day of storage. Similar results was obtained in Newspaper packed fruits treated with Neem leaf extracts and Newspaper packed fruits treated with Bael leaf extracts.

7. Organoleptic rating :-

The observations on organoleptic rating during storage in kinnow as affected by different thickness of polyethylene, Neem and Bael leaf extracts were collected and pooled data are presented in Table 11.

The data reveals that organoleptic rating of fruits has been done by visual observations by panel of five judges and the average value for all parameters had been presented in Table 11. As far as the colour of fruits is concerned, fruits packed in polyethylene with or without Neem

TABLE 9. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on orgonoleptic rating during storage in kinnow fruits

Treatments	Colour	Flavour	Taste	Appearance	Marketability	Mean
50 Gauge Polyethylene (unipack)	8.0	7.5	7.2	7.5	6.5	7.3
100 Gauge Polyethylene (unipack)	8.0	7.0	7.0	7.0	5.6	6.9
150 Gauge Polyethylene (unipack)	7.5	7.0	6.5	7.0	5.1	6.6
News paper (unipack)	4.5	4.0	3.6	4.0	3.0	3.8
50 Gauge+Neem leaf extracts (2%)	9.0	8.0	7.5	8.0	7.0	7.9
100 Gauge+Neem leaf extracts (2%)	8.5	7.5	7.2	7.5	6.5	7.4
150 Gauge+Neem leaf extracts (2%)	8.0	7.0	7.0	7.5	6.5	7.2
News Paper+Neem leaf extracts (2%)	5.0	4.5	3.8	4.5	3.4	4.2
50 Gauge+Bael leaf extracts (2%)	9.0	8.0	7.7	8.0	7.5	8.0
100 Gauge+Bael leaf extracts (2%)	8.5	8.0	7.5	7.5	6.5	7.6
150 Gauge+Bael leaf extracts (2%)	8.2	7.5	7.0	8.0	7.0	7.5
News Paper+Bael leaf extracts (2%)	5.2	4.5	4.0	4.5	3.6	4.4

Marks on basis of conditions of fruits :-

10. Excellent
9. Very good
8. good
7. Fair
6. acceptable
5. just acceptable
4. Unacceptable
3. rejected

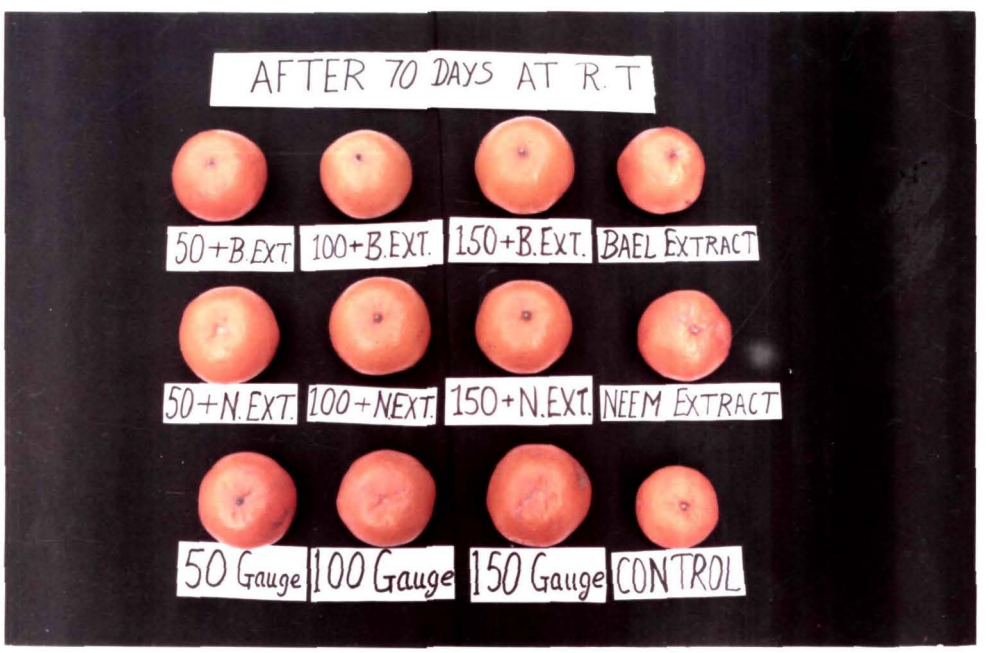


Fig. (ii) General appearance of fruits packed in different thickness of polyethylenes treated with or without Neem and Bael leaf extracts after 70th day at room temperature.

: B. EXT - Bael Leaf extract

: N. EXT - Neem Leaf extract

leaf extracts had organoleptic rating of 8 which indicates that the fruits were in good condition. However, Newspaper packed fruits had organoleptic rating of 4.5, 5.0 and 5.2 without or with Neem and Bael leaf extracts respectively. But all these values indicates that the fruits were just acceptable and unacceptable as far as colour is concerned. Similar response was observed for flavour, taste, appearance and marketability.

The scoring in respect of all these parameters as given by different judges decrease in order of colour maximum followed by flavour, taste, appearance and marketability. Thus, the marketability had least scoring among the various physical parameters. Fruits packed in Newspaper had a scoring of 3.4 and 3 6 for the marketability which was meant for the rejected fruit, whereas for all other treatment scoring for marketability was in the acceptable range i.e 5-7. Over all maximum scoring (8.0) was observed in fruits packed in 50 gauge polyethylene and treated with Neem leaf extracts and least (3.8) was observed in fruits packed in Newspaper as shown in fig. (ii).

Pathological parameters :-

1. Decay loss :-

Result on decay loss in kinnow during storage as affected by different thickness of polyethylene, Neem and Bael leaf extracts have been presented in Table 10.

Data in Table 10. reveals that decay loss of fruits increased with increasing period of

TABLE 10. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on decay loss (%) in kinnow fruits during storage

Treatments	Days of storage					
	35	42	49	56	63	70
50 Gauge Polyethylene (unipack)	0	7.48	12.46	15.60	20.41	24.33
	(5.74)	(16.92)	(21.52)	(24.04)	(27.55)	(30.21)
100 Gauge Polyethylene (unipack)	0	8.54	13.03	16.46	21.47	25.93
	(5.74)	(17.98)	(21.99)	(24.69)	(28.28)	(31.25)
150 Gauge Polyethylene (unipack)	6.65	8.66	12.81	16.72	21.68	25.28
	(16.06)	(18.10)	(21.81)	(24.63)	(28.43)	(30.55)
News paper (unipack)	9.21	11.21	13.40	15.62	20.21	24.85
	(18.63)	(20.45)	(22.29)	(24.05)	(27.39)	(30.55)
50 Gauge+Neem leaf extracts (2%)	0	0	12.67	14.51	20.40	25.35
	(5.74)	(5.74)	(21.69)	(23.18)	(27.59)	(30.87)
100 Gauge+Neem leaf extracts (2%)	0	12.39	14.26	14.56	19.89	25.25
	(5.74)	(21.45)	(22.99)	(23.32)	(27.18)	(30.81)
150 Gauge+Neem leaf extracts (2%)	0	0	0	14.26	20.29	23.42
	(5.74)	(5.74)	(5.74)	(22.98)	(27.47)	(30.28)
News Paper+Neem leaf extracts (2%)	0	0	0	13.31	20.16	24.44
	(5.74)	(5.74)	(5.74)	(22.21)	(27.37)	(30.28)
50 Gauge+Bael leaf extracts (2%)	0	0	12.55	19.58	23.43	25.21
	(5.74)	(5.74)	(21.59)	(26.97)	(29.61)	(30.78)
100 Gauge+Bael leaf extracts (2%)	0	0	13.98	17.25	23.13	26.51
	(5.74)	(5.74)	(22.76)	(25.28)	(29.41)	(31.71)
150 Gauge+Bael leaf extracts (2%)	0	8.34	12.74	16.20	22.92	26.57
	(5.74)	(17.78)	(21.74)	(24.49)	(29.27)	(31.66)
News Paper+Bael leaf extracts (2%)	0	0	0	9.19	13.81	20.64
	(5.74)	(5.74)	(5.74)	(18.61)	(22.63)	(27.71)
CD at 5%	0.20	0.36	0.32	0.45	0.36	0.37

Figures in parenthesis are angular transformation

storage in all treatments. There was no decay loss in any of the treatments upto 28th day of storage. However, on 35th day of storage fruits packed in 150 gauge polyethylene showed a decay loss (6.65%) and fruits packed in Newspaper had a decay loss of (9.21%) whereas, in all other treatments there was no decay loss on these day of storage. On 42nd day of storage, fruits packed in 50, 100 and 150 gauge polyethylene showed decay loss (7.48%), (8.54%) and (8.66%) respectively. Among the leaf extracts treatment, fruits treated with Neem leaf extract and packed in 100 gauge had decay loss of (12.39%) and similarly fruits treated with Bael leaf extracts and packed in 150 gauge had decay loss of (8.34%) whereas in all other treatments of Neem and Bael leaf extracts fruits had no decay loss. On 49th day of storage fruits packed in 150 gauge and treated with Neem leaf extract and Newspaper packed fruits treated with Neem or Bael leaf extracts showed no decay loss, whereas all other treatments had the decay fruits. On 70th day of storage, fruits treated with Bael leaf extract and packed in Newspaper had a minimum (20.64%) decay loss followed by (23.42%) fruits treated with Neem leaf extract packed in 150 gauge polyethylene.

2. Disease incidence :-

Results on disease incidence in kinnow during storage as affected by different treatments have been collected and presented in Table 11.

Data in Table 11. reveals that disease incidence in fruits increased with increasing period of storage in all treatments. There was no disease incidence in any of the treatment upto 28th

TABLE 11. Effect of different thickness of Polyethylene, Neem and Bael leaf extracts on disease incidence (%) during storage in kinnow fruits

Treatments	Days of storage					
	35	42	49	56	63	70
50 Gauge Polyethylene (unipack)	0	7.24	12.34	14.55	19.36	23.26
	(5.74)	(16.68)	(21.42)	(22.43)	(26.12)	(28.85)
100 Gauge Polyethylene (unipack)	0	8.37	12.98	15.39	20.39	24.82
	(5.74)	(16.81)	(21.97)	(23.12)	(26.87)	(29.89)
150 Gauge Polyethylene (unipack)	6.37	8.52	12.73	15.67	20.59	24.13
	(15.75)	(17.97)	(21.75)	(23.33)	(27.01)	(29.43)
News paper (unipack)	9.01	11.06	13.32	14.56	19.18	23.74
	(18.33)	(20.33)	(22.24)	(23.44)	(25.92)	(29.17)
50 Gauge+Neem leaf extracts (2%)	0	0	12.57	13.43	19.34	24.26
	(5.74)	(5.74)	(21.61)	(21.50)	(26.10)	(29.53)
100 Gauge+Neem leaf extracts (2%)	0	12.28	14.06	13.51	18.76	24.17
	(5.74)	(21.38)	(22.85)	(21.57)	(25.68)	(29.47)
150 Gauge+Neem leaf extracts (2%)	0	0	0	13.08	19.16	22.32
	(5.74)	(5.74)	(5.74)	(21.21)	(25.98)	(28.20)
News Paper+Neem leaf extracts (2%)	0	0	0	12.27	19.02	23.34
	(5.74)	(5.74)	(5.74)	(20.51)	(25.86)	(28.90)
50 Gauge+Bael leaf extracts (2%)	0	0	12.42	18.46	22.32	24.11
	(5.74)	(5.74)	(21.49)	(25.46)	(28.20)	(29.41)
100 Gauge+Bael leaf extracts (2%)	0	0	13.71	18.14	22.01	25.46
	(5.74)	(5.74)	(22.56)	(25.22)	(27.98)	(30.32)
150 Gauge+Bael leaf extracts (2%)	0	8.24	12.68	17.11	21.81	25.49
	(5.74)	(17.70)	(21.72)	(24.44)	(27.84)	(30.35)
News Paper+Bael leaf extracts (2%)	0	0	0	8.02	12.74	21.53
	(5.74)	(5.74)	(5.74)	(16.45)	(22.92)	(27.66)
CD at 5%	0.18	0.38	0.36	0.46	0.38	0.39

Figures in parenthesis are angular transformation

day of storage. However, on 35th day fruits packed in 150 gauge polyethylene showed a disease incidence of (6.37%) and fruits packed in Newspaper a disease incidence of (9.01%) was observed whereas, in all other treatments there was no disease incidence on these day of storage. On 42nd day of storage fruits packed in 50, 100 and 150 gauge polyethylene showed disease incidence (7.24%), (8.37%) and (8.52%) respectively, whereas fruits packed in 100 gauge treated with Neem leaf extract and similarly fruits packed in 150 gauge and treated with Bael leaf extract had disease incidence of about 12.28% and 8.24% respectively as compared to all other extract treatments. On 49th day of storage no disease incidence was observed in 150 gauge polyethylene packed fruits treated with Neem leaf extracts. Similarly in Newspaper packed fruits treated with or without Neem and Bael leaf extracts had new disease incidence as compared to all other treatments which had the disease incidence. On 70th day of storage, fruits treated with Bael leaf extract and packed in Newspaper had a minimum disease incidence (21.53%) followed by (22.32%) fruits treated with Neem leaf extracts and packed in 150 gauge polyethylene.

3. Pathogens responsible for decay :-

The observations on pathogens responsible for decay during storage in kinnow were collected and pooled data are presented in Table 12.

In all the decayed fruits, the decay organisms or pathogen responsible were isolated in collaboration with Department of Plant Pathology. It was observed that *Alternaria alternata* were the main organisms responsible for decay in most of the fruits during storage. This was

TABLE 12. Effect of different thickness of Polyethylene and Neem and Bael leaf extracts on pathogens responsible for decay during storage in kinnow fruits

Treatments	Days of storage					
	35	42	49	56	63	70
50 Gauge Polyethylene	-	A	AB	ABC	ABC	ABC
100 Gauge Polyethylene	-	AB	AB	ABC	ABCD	ABCD
150 Gauge Polyethylene	A	AB	AB	ABC	ABCD	ABCD
News paper	A	AD	AD	ACD	ACD	ACD
50 Gauge+Neem leaf extracts (2%)	-	-	A	AC	ACD	ACD
100 Gauge+Neem leaf extracts (2%)	-	B	BD	BCD	BCD	ABCD
150 Gauge+Neem leaf extracts (2%)	-	-	-	A	AB	ABC
News Paper+Neem leaf extracts (2%)	-	-	-	AB	ABC	ABCD
50 Gauge+Bael leaf extracts (2%)	-	-	B	BC	BCD	BCD
100 Gauge+Bael leaf extracts (2%)	-	-	AC	ACD	ABCD	ABCD
150 Gauge+Bael leaf extracts (2%)	-	BC	BC	BCD	BCD	BCD
News Paper+Bael leaf extracts (2%)	-	-	-	AB	ABC	ABCD

Marks on basis of conditions of fruits :-

A- *Alternaria alternata*

B- *Botryodiplodia theobromae*

C- *Penicillium digitatum*

D- *Penicillium italicum*

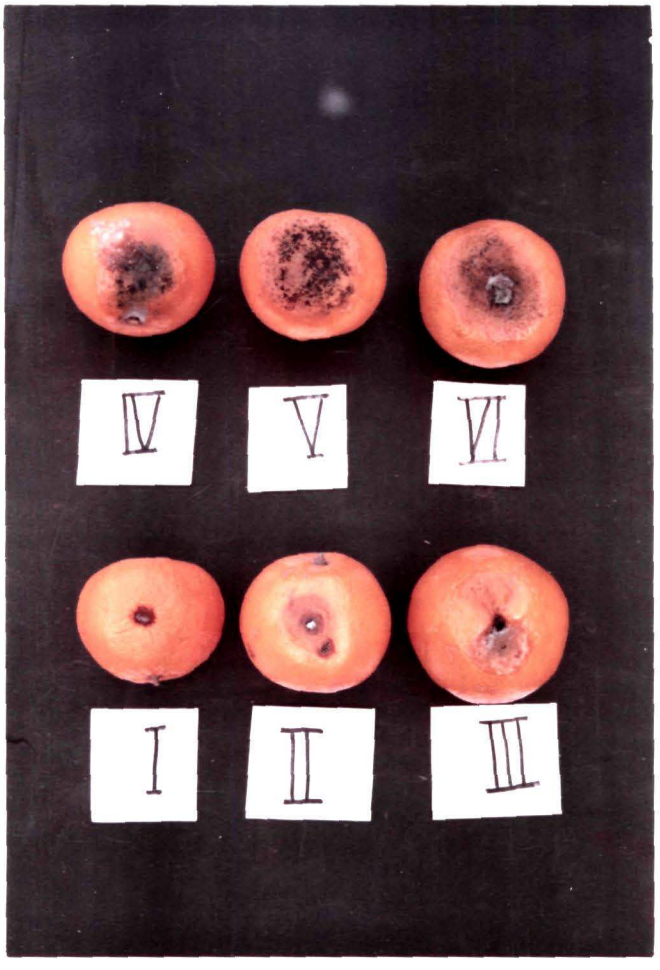


Fig. (iii) Fruits showing infection at different stages :

I. Initial stage of infection.

II. After 2-3 days of infection.

III. Rotting and softening of fruits

IV. Infection with *Penicillium digitatum.*

V. Infection with *Alternaria alternata.*

VI. Advance stage of infection with the growth of *Penicillium italicum.*

followed by *Botryodiplodia theobromae* and *Penicillium digitatum*. On 63rd day of storage, majority of treatment also had infection of *Penicillium italicum* along with above three organisms already discussed. However, in very few decayed fruits *Penicillium italicum* was also observed on 49th day of storage. Among all the treatments decay was mainly due to *Alternaria alternata* followed by *B. theobromae*, *P. digitatum* and least by *P. italicum*.

CHAPTER - V

DISCUSSION

The important results obtained in the present research entitled "Effect of polyethylenes and plant extracts on the shelf life of kinnow" have been discussed in this chapter under various headings.

1. Physiological loss in weight :-

An increase in physiological loss in weight (PLW) in all the treatments with the increasing period of storage is obvious as the different physiological process continue in fruits even after their harvest till it is fully destroyed. PLW is mainly due to respiration process and transpiration which are constantly going on in fruits. For respiration, fruits uses the various reserve food materials present inside the fruit. Transpiration process also continues from the surface of fruits even after their harvest. The results are in conformity with the results of Hoard and Salunkhe (1975) who have reported that PLW is mainly due to evaporation of water from the fruits, respiration and various degradation process occuring during storage.

In the present study, minimum physiological loss in weight was observed in 50, 100 and 150 gauge polyethylene packed fruit treated with or without Neem and Bael leaf extracts. This may be due to the reason that polyethylenes are helpful in reducing the rate of transpiration and respiration due to restriction on diffusion of gases and feed back mechanism. These results are in agreement with those observed by Venkatesha and Reddy (1994) in guava. Neem leaf extracts

and Bael leaf extracts when applied in Newspaper packed fruits or in polyethylene packed fruits were helpful to reduce PLW in fruits. In Newspaper packing, Bael leaf extracts was most effective whereas Newspaper packing Neem leaf extract was most effective to reduce PLW. This may due to the reason that there might be formation of an extra covering on surface of fruits which reduce the various physiological process i. e. respiration and transpiration. These results are also in confirmation with the results of Sharma *et al.*, (1994) in guava and Kumar *et al.*, (1991) in kinnow.

Juice (%)

The juice percentage decreased with increasing period of storage in all the treatments. This might be due to the various evaporational losses as well as various physiological process going in the fruits. Moreover, this decrease in juice percentage with increasing period of storage is also reported in kinnow (Bhullar *et al.*, 1985) and in Mandarin (Angadi and Krishnamurthy, 1992). Tewari *et al.*, (1992) reported that the successive decline in juice percentage of kinnow with increase in period of storage was due to evaporation of water. Maximum juice percentage was retained in all the fruits packed in 50, 100 and 150 gauge polyethylene treated with or without Neem and Bael leaf extracts. These results coincide with decrease in physiological loss in weight in this packing as reported in Table 1. Similarly, the minimum juice percentage was retained in Newspaper packed fruits treated with or without Neem and Bael leaf extracts. This was due to higher physiological loss in weight in Newspaper packed fruits. Maximum juice percentage in polyethylene packed fruits again confirms that there was less rate of various

physiological process as compared to Newspaper packed fruits. However, the juice of Bael and Neem extracts could not alter the juice percentage in fruits because the covering formed by them was not sufficient enough to reduce the juice percentage.

Total soluble solids :-

The total soluble solids (TSS) of fruits increased with increasing period of storage in all polyethylene treatments i. e. upto 70th day of storage except Newspaper packed fruits treated with or without Neem and Bael leaf extracts where the TSS content increased upto 35th day and decreased thereafter upto 70th day of storage. This increase in TSS content of fruits may be due to loss of water taking from the fruits and due to conversion of polysaccharides to monosaccharides which might have resulted in increasing the content of TSS in the fruits. However, the decrease in TSS after the 35th day may be due to the reason that during this period soluble solids mainly sugars might have been utilized in the process of respiration. These findings are in agreement with those results obtained by Adsule *et al.,* (1983) and Chauhan *et al.,* (1989). Reports of increased TSS due to hydrolysis of polysaccharides during has storage been reported in ber (Baviskar *et al.,* 1995) and kinnow (Tewari *et al.,* 1992). Maximum TSS was retained in 100. This and 150 gauge polyethylene packed fruits packed with or without Neem and Bael leaf extracts as compared to Newspaper packed fruits this might be due to slow conversion of starch into sugars. These results are in agreement with the earlier reports of Venkatesha and Reddy (1994) and Singh *et al.,* (1993) in guava. These authors have reported that during storage various physiological process slow down so conversion of starch to sugar is also slowed down as a

result of which total sugar content increases during storage at a slow rate in polyethylene packed fruits.

Acidity :-

. Acidity content of fruits slightly increased on 7th day of storage and then decreased thereafter from 14th day to 70th day of storage in all polyethylenes packed fruits treated with or without Neem and Bael leaf extracts. The acidity content slightly increased on 7th day and then started decreasing from 14th day to 28th day of storage and increased thereafter from 35th day to 70th day of storage in all Newspaper packed fruits treated with or without Neem and Bael leaf extracts. Initial increase on 7th day in different fruits packed in polyethylenes and Newspaper is not clearly understandable however, these might be due to more conversion of sugars to acid initially and increase in concentration might be due to evapotranspiration losses which might have increased the concentration of acids already existing in fruits. However, the later decrease from 14th day to 70th day may be due to the reason that acids might have been consumed during the process of respiration. These findings are in agreement with those obtained by Sharma *et al.,* (1991) in kinnow. The maximum acidity was observed in Newspaper packed fruits treated with or without Neem and Bael leaf extracts and minimum in case of polyethylene packed fruits treated with or without Neem and Bael leaf extracts. This may be due to reason that there was slow rate of conversion of sugar to acid due to lesser rate of respiration in polyethylene packed fruits. These findings are in conformity with those obtained by Adsule *et al.,* (1983).

Ascorbic acid :-

Ascorbic acid content of fruits increased upto 28th day of storage in all the treatments. Increase in ascorbic acid content during storage may be due to evapotranspiration losses. Ascorbic acid content of fruits decreased thereafter upto 70th day of storage in all the treatments. Decrease in ascorbic acid was due to oxidation and irrevesible conversible of L-ascorbic acid to dehydro ascorbic acid in the presence of enzyme ascorbinase. These results are in conformity with the results of Kumar *et al.*, (1990). Different thickness of polyethylenes in combination with Neem and Bael leaf extracts helped to maintain the higher concentrations of ascorbic acid upto 70th day of storage.

More retention of ascorbic acid in polyethylene packed fruits might be due to the reason of slow rate of evapotranspiration losses and various physiological process in these fruits. However, high reduction and minimum retention in Newspaper packed fruits might be due to high rate of various evapotranspiration losses and higher PLW which was predicted in these fruits as presented in Table 1. These results are also in conformity with findings of Jain and Chauhan in citrus and Siddiqui *et al.*, 1989 in ber.

Total sugars :-

Total sugars decreased in the beginning i. e. on 7th day of storage only in the polyethylene packed fruits. This decrease might be due to the reason that sugars present in the fruits might

have been converted into the acids in the initial stage. Similar results has also been obtained by Tewari *et al* , (1992) in citrus and Siddiqui and Gupta (1997) in guava. From 14th day onward upto 70th day total sugars content increased in all polyethylene packed fruits. This may be due to evapotranspirational losses and physiological loss in weight which have increases the total sugars. Increase in PLW during storage has already being discussed in Table1. In case of Newspaper packed fruits treated with or without Neem and Bael leaf extracts the total sugars increased upto 28th day and decreased upto last day of storage. These may be due to the reason that upto 28th day the increase was due to various physiological process whereas thereafter this sugars were substrate for respiration and resulted in decrease in total sugar content. This also lead to degradation in polyethylene packed fruits. Similar decrease in total sugars in other fruits has also been observed.

Reducing sugar :-

Reducing sugars increased with increasing period of storage upto 35th day in all polyethylene packed fruits treated with or without Neem and Bael leaf extracts. This increase in reducing sugars was due to evapotranspirational losses and physiological loss in weight. From 42nd to 70th day of storage reducing sugars decreased in all polyethylene packed fruits treated with or without Neem and Bael leaf extracts. This decrease might be due to the reason that sugars present in the fruits have been converted into acids. Similar results has also been obtained by Tewari *et al.*, (1992) in citrus. In Newspaper packed fruits treated with or without Neem and Bael leaf extracts reducing sugars increased upto 28th day and decrease upto last day of storage.

These may be due to the reason that upto 28th day the increase was due to various physiological process whereas decreased thereafter as sugars were utilized for brows of respiration.

Non-reducing sugars :-

Non-reducing sugars decreased on 7th day due to the reason that the sugar might have converted to acids in initial stages and increased thereafter upto 28th day of storage due to the reason of evapotranpirational losses were more and these non-reducing sugars again decreased on 35th day and increased thereafter upto last day of storage with the same reason in all polyethylene packed fruits treated with or without Neem and Bael leaf extracts. In Newspaper packed fruits treated with or without Neem and Bael leaf extracts increase in Reducing Sugars upto 21st day and decreased thereafter upto last day of storage. This may be due to the reason that upto 21st day the increase was due to various physiological process whereas decrease thereafter may be due to the reach that sugars were utilized as substrate for respiration which resulted in decrease in non-reducing sugars.

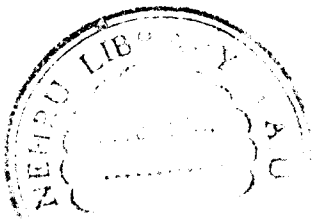
Organoleptic rating :-

Organoleptic rating was based on visual observation. Fruits packed in polyethylenes with or without Neem and Bael leaf extracts had a scoring of 8-9 for the colour which is meant for the good fruits whereas, fruits kept in Newspaper had a rating of 4-5 for the colour which was meant for unacceptable fruits. This indicates that the polyethylene packed fruits had better

colour at end of storage due to minimum degradation and other degraelative activities of the fruits. There is very well predicted from the various quality parameters as discussed in different tables. Newspaper packed fruits had unacceptable score at end of storage period which was due to high degredative activites. Similar results have also been obtained by organoleptic rating in terms of flavour, taste and appearance, Fruits packed in polyethylenes had organoleptic scoring in range of 7-8 whereas, Newspaper packed fruits had scoring from 3-4 which was meant for rejected fruits. This again confirms that polyethylene packed fruits had slow rate of various physiological activites which is helpful to maintain fruits in marketable conditions for lenger time. These results are also in conformity with the results of .

Decay loss :-

Decay loss of fruits increased with increasing period of storage in all treatments. There was no decay loss upto 28th day of storage. Decay loss increased with increasing period of storage. This is in confirmation with the results of Singh *et al.*, (1990), Kumar *et al.*, (1987) in Lemon cv. Baramasi. Increased Decay loss might be due more exposure of the fruits to different microflora and inherent biochemical changes during storage. Minimum decay loss was noticed in Newspaper packed fruits treated with or without Neem and Bael leaf extracts whereas maximum was observed in all polyethylene packed fruits treated with or without Neem and Bael leaf extracts. Higher decay loss in polyethylene was due to higher humidity inside the polyethylene which helps in multiplying the decay organisms. These results are in conformity with those obtained by decay loss which increased with increase in thickness of polyethylene.



This might be due to the reason that in thick polyethylene there might be anaerobic conditions which helped in multiplication of microflora and more humidity in packing.

Disease incidence :-

Disease incidence was calculated in terms of number of fruits as compared to decay loss which was calculated in terms of weight of fruits but the results obtained in both cases were found to be similar.

Pathogens :-

The various organisms which were observed during isolation in diseased fruits indicate that *Altemaria alternata* was the main casual organisms responsible for decay loss followed by *B. theobromae, Penicillium digitatum* and *Penicillium italicum*. This may be due to the reason that various sugars and acids present in the kinnow fruits and the environmental conditions prevailing during storage in the laboratory created a suitable medium for the growth of these micro organism. Similar results about the various casual organisms in kinnow have already been reported by Tewari *et al.*, (1992) in kinnow and Miller *et al.*, (1986) in mango during storage.

CHAPTER - VI

SUMMARY AND CONCLUSIONS

The present investigations on "Effect of polyethylenes and plant extracts on the shelf life of kinnow" were conducted in the post-harvest laboratory of the Department of Horticulture, Chaudhary Charan Singh Haryana Agricultural University, Hisar during the year 1999-2000. The results obtained are summarised and concluded as under :-

1. The physiological loss in weight in kinnow increased were the increase in storage period in all the treatments. All the polyethylenes wire found effective in checking the PLW as compared to Newspaper packed fruits.
2. The juice content of kinnow decreased with the increase in storage period. All polyethylenes were effective to retain the juice percentage in maximum amount as compared to newspaper packed fruits upto last day of storage. Minimum juice (%) was observed in newspaper packed fruits treated with or without Neem and Bael leaf extracts whereas all polyethylene packed fruits maintained the maximum amount of juice (%) during all period storage.
3. The total soluble solids content of kinnow fruits increased with increasing period of storage in all polyethylene treatments whereas, in newspaper packed fruits treated with or without Neem and Bael leaf extracts TSS increased upto 35th day and thereafter. it declined. Maximum TSS was observed in 100 and 150 gauge polyethylenes treated with or without Neem and Bael leaf extracts and minimum in newspaper packed fruits at the end of storage period.
4. Acidity content of fruits increased in begining in all treatment upto 7th day. From 14th

to 63rd day it decreased in all the polyethylene packed fruits with or without Neem and Beal leaf extracts whereas in Newspaper packed fruits with or without Neem and Bael leaf extracts the acidity content decreased upto 28th day and thereafter, it declined

5. Ascorbic acid content of the kinnow fruits increascd upto 28th day of storage and therafter, it declined in all the treatments. Maximum ascorbic acid content was observed in fruits packed in all polyethylene treated with or without Neem and Bael leaf extracts and minimum was found in Newspaper packed fruits treated with or without Neem and Bael leaf extracts.

6. Total Sugars content of juice decreased on 7th day and increased therafter upto 70th day of storage in all polyethylene treatment, whereas in all newspaper packed fruits treated with or without Neem and Bael leaf extracts increased upto 28th day and decreased thereafter upto 70th day of storage. Maximum total sugars was observed in all polyethylene packed fruits treated with or without Neem or Bael leaf extracts and minimum in newspaper packed fruits treated with Bael leaf extracts followed by newspaper packed fruits treated with Neem leaf extracts.

7. Reducing sugar increased with increasing period of storage upto 35th day and therafter , it declined in all polyethylenes packed fruits treated with or without Neem and Bael leaf extracts. In Newspaper packed fruits treated with or without Neem and Bael leaf extracts it increased upto 28th day and thereafter, it declined. Maximum reducing sugars was observed in all polyethylenes packed fruits and minimum was observed in newspaper packed fruits.

8. Non-reducing sugar decreased upto 28th day and thereafter it increased upto 70th dayof

storage in all the treatments. Maximum non-reducing sugars was observed in polyethylene packed fruits treated with or without Neem and Bael leaf extracts as compared to newspaper packed fruits.

9. Organoleptic rating as observed by different judges in respect of colour, flavour taste appearance and marketability. It was observed that organoleptic rating was maximum in fruits packed in polyethylene and fruits were marketable even after 70th days of storage whereas fruits packed in newspaper treated with or without Neem and Bael leaf extracts has organoleptic rating less than 5.0 i.e. fruit were unmarketable even after 28th day of storage.

10. There was no decay loss in any of treatments upto 28th day. Thereafter decay loss increased with increasing period of storage in all treatments. Maximum decay loss was observed in all polyethylene packed fruits as compared to newspaper packed fruit. However, Neem and Bael leaf extracts were successful to reduce decay loss in newspapers and polyethylene packed fruits.

11. There was no disease incidence in any of treatments upto 28th day. Thereafter disease incidence increased with increasing period of storage in all treatments. Maximum disease incidence was found in all polyethylene packed fruits as compare to newspaper packed fruit. However, Neem and Bael leaf extracts were successful to reduce disease incidence in newspaper and polyethylene packed fruits.

12. Pathogens which were isolated from decayed fruits were mainly *Altemaria alfernata; Botryodiplodia theobroniae; Penicillium italicum* and *Penicillium digitatum*. However, maximum infection in fruit caused by *Alternaria altemota* followed by *B. theobroniae*,

Penicillium digitatum and least by *Penicillium italicum*. All this casal organisms increased with increasing period of storage. Polyethylene packed fruits has more incidence of this casual organisms as compared to newspaper packed fruits.

On the basis of above discussion in persent investigations, it could be concluded that all the polyethylenes alone or in combination with plant extracts were most effective in increasing the shelf life of kinnow fruits at room temperature by reducing the physiological loss in weight and maintaining the quality parameters in terms of juice percentage, TSS and Ascorbic acid upto 70th day of storage. Among different thickness of polyethylenes, fruit wrapping in 50 guage polyethylene was more effective and economical in comparison to 100 and 150 guage polyethylenes in increasing the storage life of kinnow. Newspaper packed fruits were deterioriated after 28th day of storage due to higher physiological loss in weight showing more rate of various metabolite process. This increase in shelf life of kinnow polyethylenes would be helpful in avoiding glut in the market and to allow the produce to be transported to distant market.

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Appendix - I

Daily Meterological data for the month of December - 1999 and January - 2000

Date	Dec. 1999					Jan. 2000				
	Temp. (^{0}C)		R. humidity (%)		Rainfall	Temp. (^{0}C)		R. humidity (%)		Rainfall
	Max.	Min.	M.	E.	(mm)	Max.	Min.	M.	E.	(mm)
1.	26.4	6.5	83	26	0.0	14.9	3.6	97	88	0.0
2.	27.4	5.5	92	28	0.0	15.6	3.5	97	91	0.0
3.	26.2	5.5	92	29	0.0	13.3	4.0	97	84	0.0
4.	26.2	4.1	89	30	0.0	17.4	3.0	97	84	0.0
5.	25.4	4.5	81	31	0.0	16.0	6.5	97	84	0.0
6.	25.0	4.2	92	32	0.0	14.2	3.6	97	83	0.0
7.	24.9	7.5	81	31	0.0	12.6	2.0	97	63	0.0
8.	23.7	4.5	89	48	0.0	15.4	5.6	94	65	0.0
9.	21.6	3.8	89	38	0.0	16.2	7.0	93	86	0.0
10.	22.5	4.4	94	40	0.0	13.0	8.5	97	83	0.0
11.	22.7	3.4	94	38	0.0	16.9	9.8	90	52	0.0
12.	23.4	3.0	91	38	0.0	22.5	13.0	82	74	0.0
13.	23.7	3.0	88	26	0.0	20.4	9.5	97	71	0.0
14.	24.6	2.8	91	21	0.0	18.6	3.8	75	47	0.0
15.	24.9	2.0	88	25	0.0	16.0	2.7	96	43	0.0
16.	24.1	2.0	85	29	0.0	15.4	-0.6	88	43	0.0

Appendix - I

Daily Meterological data for the month of December - 1999 and January - 2000

Date	Dec. 1999					Jan. 2000				
	Temp. (°C)		R. humidity (%)		Rainfall	Temp. (°C)		R. humidity (%)		Rainfall
	Max.	Min.	M.	E.	(mm)	Max.	Min.	M.	E.	(mm)
1.	26.4	6.5	83	26	0.0	14.9	3.6	97	88	0.0
2.	27.4	5.5	92	28	0.0	15.6	3.5	97	91	0.0
3.	26.2	5.5	92	29	0.0	13.3	4.0	97	84	0.0
4.	26.2	4.1	89	30	0.0	17.4	3.0	97	84	0.0
5.	25.4	4.5	81	31	0.0	16.0	6.5	97	84	0.0
6.	25.0	4.2	92	32	0.0	14.2	3.6	97	83	0.0
7.	24.9	7.5	81	31	0.0	12.6	2.0	97	63	0.0
8.	23.7	4.5	89	48	0.0	15.4	5.6	94	65	0.0
9.	21.6	3.8	89	38	0.0	16.2	7.0	93	86	0.0
10.	22.5	4.4	94	40	0.0	13.0	8.5	97	83	0.0
11.	22.7	3.4	94	38	0.0	16.9	9.8	90	52	0.0
12.	23.4	3.0	91	38	0.0	22.5	13.0	82	74	0.0
13.	23.7	3.0	88	26	0.0	20.4	9.5	97	71	0.0
14.	24.6	2.8	91	21	0.0	18.6	3.8	75	47	0.0
15.	24.9	2.0	88	25	0.0	16.0	2.7	96	43	0.0
16.	24.1	2.0	85	29	0.0	15.4	-0.6	88	43	0.0

Date	Dec. 1999					Jan. 2000				
	Temp. (°C)		R. humidity (%)		Rainfall	Temp. (°C)		R. humidity (%)		Rainfall
	Max.	Min.	M.	E.	(mm)	Max.	Min.	M.	E.	(mm)
17.	25.1	2.5	85	31	0.0	15.6	-0.2	85	35	0.0
18.	25.9	4.7	78	28	0.0	18.0	3.0	85	41	0.0
19.	25.4	2.4	94	38	0.0	21.2	3.2	94	35	0.0
20.	23.7	4.0	85	46	0.0	22.2	4.0	88	42	0.0
21.	21.4	2.0	88	27	0.0	23.0	8.0	74	58	0.0
22.	22.9	43	83	31	0.0	23.4	12.2	78	45	0.0
23.	22.0	4.0	94	34	0.0	23.9	5.9	97	46	0.0
24.	22.9	4.0	91	30	0.0	22.4	5.5	94	37	0.0
25.	21.9	1.0	84	32	0.0	24.0	10.7	93	88	0.0
26.	21.9	1.5	97	32	0.0	16.4	5.5	97	73	8.3
27.	23.4	5.0	97	80	0.0	16.7	7.4	97	74	0.0
28.	14.8	1.5	97	52	0.0	17.9	4.2	97	50	0.0
29.	20.3	3.0	97	56	0.0	19.4	3.5	91	43	0.0
30.	21.1	3.5	97	66	0.0	22.0	4.0	89	46	0.0
31.	23.1	3.4	97	84	0.0	23.7	9.2	88	47	0.0
Total	730.5	113.5	2784	1177	0.0	569.1	168.8	2818	1881	8.3
Mean	23.6	3.7	90	38	--	18.4	5.4	91	61	--

Appendix - II

Daily Meterological data for the month of Febuary - 2000

Date	Temp. 0C		Relative humidity (%)		Rainfall
	Max.	Min.	M	E	(mm)
1.	22.6	9.5	90	47	0.0
2.	23.9	9.8	98	80	0.0
3.	18.0	9.0	93	64	0.0
4.	22.5	12.0	95	78	1.0
5.	18.9	9.9	97	93	7.0
6.	13.4	9.5	95	84	0.0
7.	15.3	7.0	97	86	0.0
8.	14.9	5.5	97	71	0.0
9.	18.9	3.5	97	64	0.0
10.	21.6	8.9	92	88	0.0
11.	18.4	10.0	95	70	2.7
12.	18.9	4.9	91	90	0.0
13.	12.1	2.3	94	78	0.0
14.	12.4	2.5	94	59	0.0
15.	19.6	4.6	94	49	0.0
16.	21.9	4.0	86	52	0.0
17.	23.4	5.8	94	53	0.0
18.	22.9	3.5	94	51	0.0

Date	Temp. 0C		Relative humidity (%)		Rainfall
	Max.	Min.	M	E	(mm)
19.	21.4	2.5	97	51	0.0
20.	22.1	4.5	94	60	0.0
21.	21.2	4.6	97	51	0.0
22.	21.5	6.6	86	56	0.0
23.	21.6	2.5	97	47	0.0
24.	22.0	4.3	94	38	0.0
25.	22.4	4.0	94	37	0.0
26.	24.0	3.8	94	56	0.0
27.	25.0	4.7	89	45	0.0
28.	27.4	6.5	88	55	0.0
29.	26.1	7.0	81	48	0.0
Total	589.5	173.2	2707	1807	10.7
Mean	20.3	6.0	93	62	--