CHAPTER -II

REVIEW OF LITERATURE

Mango fruits being highly perishable in nature need proper care in post-harvest handling and storage. Much work has been done on the post-harvest technology in India and abroad. Various techniques have been tried by different workers for enhancing the storage life of mango and reducing the damage caused by the pathogens and other factors. Post-harvest deterioration to fruits may be due to a variety of factors i.e. physiological change, physical and mechanical damage, chemical and chilling injury, varietal character and microbial infection. The use of various kind of wrappers. Wax coating, hot water treatment and dipping in growth regulator solution independently or in combinations, before storage or during transit have been found effective in prolonging the normal post-harvest life of fruits

2.1 PHYSICAL CHANGES

2.1.1 Physiological loss in weight of fruits

The effects of different wrappers and chemicals either alone or in combination of both on loss in weight of fruits due to physiological causes during storage have been at varying degrees in different fruits. Mango fruits kept in polyethylene bags showed considerably less physiological losses.

Cheema et al. (1939) investigated the effect of different wrappers on mango fruits. They reported that the wrapping definitely slowed the ripening process even after 42 days of storage at 8.8-C and this effect was most marked in fruits wrapped with wax paper.

Mustard and Stab (1949) studied the effect of wrappers on transpiration losses, quality and storage life of fruits and they reported that wrapping materials retarded ripening and moisture losses from mangoes and avocados.

Dalai et al. (1962) used wax emulsion for extending the storage life of Sathgudi oranges in an investigation at C.F.T.R.I. The physiological loss in weight during storage was found to show delaying effects on the reduction of acidity, increase in TSS and retention of vitamin C.

Agnihotri et al. (1963) observed that the waxing retarded deterioration, delayed the ripening and reduced the respiration in stored mango fruits as compared to untreated ones at 33.8°C.
Dharkar (1966) found extended storage life in Alphonso mango, when irradiated with gamma rays. Unripe and mature mangoes when irradiated at an optimum dose of 25 Krads under air nitrogen or carbon dioxide nitrogen atmosphere, could be kept for a long time without much of physiological losses.

Singh et al. (1967) recorded that the weight of Dasehari mango fruits decreased gradually with increasing storage period at room temperature. Roy et al. (1980) also obtained similar result in Himsagar and Langra mango fruits during storage.

Srivastava (1967) reported that when mango fruits kept in polyethylene bags with 0.4 per cent ventilation caused minimum losses in weight.

Garg et al. (1971) reported that the pre packaged mango of Dasehari cultivar showed, significantly lesser percentage of loss in weight than those treated with wax emulsion. They further reported that pre packaging plus wax coating proved to be superior to pre packing or wax coating alone.

Garg et al. (1976) found the minimum loss in weight (4.36 percentage) in Dasehari mango fruits treated with 2,4, 5-T, while the maximum weight loss of 5.52 per cent was observed in the fruits treated with cycocel. In Langra and Sundar Prasad mango fruits, Roy et al (1980) found minimum loss in weight in fruits treated with 52°C±1°C hot water + captan (0.5 percentage) for 5 minutes.

Gaur and Bajpai (1978) found the minimum loss in weight of litchi fruits which were kept in open basket and maximum in those which were stored in polyethylene bags with paper cuttings.

Bhullar et al. (1980) recorded the minimum weight loss (7.45 percentage) in benlate treated fruits of Kinnow mandarin followed by captan and aureofungin (8.95 percentage). The maximum physiological loss in weight (29.80 percentage) was observed in control at the end of storage period. Dhuna et al. (1977) and Jawanda et al. (1978) also reported reduction in weight loss by coating citrus fruits with various chemicals.

Dhillon et al. (1982) observed a progressive decrease in loss in weight of Flordasum peach with the increase in Gibberellin, concentration. However the loss in weight in Sharbati peach was not affected with the increasing concentration of GA3.

Tongde et al. (1982) recorded that binomial treated litchi fruits stored at 20°C showed only 0.1 per cent weight loss after 11 days of storage. Randhawa et al. (1980) recorded minimum loss in weight of pear treated with 4 per cent CaCl2 followed by GA3 at 50 ppm concentration. Subtropical peaches showed the minimum loss in weight, under 1000 ppm GA3.
Choudhary (1983) recorded that the weight of mango fruits decreased gradually with increasing storage period in all the treatments, being maximum (15.43 percentage) in untreated fruits followed by (15.30 percentage) in newspaper wrapped ones and minimum (7.28 percentage) in polyethylene wrapped fruits treated with 8 per cent waxol up to a period of 10 days.

Ghosh and Sen (1984) observed maximum PLW of sweet orange fruits under control followed by those treated with Carbendazim, ethylene chlorohydrin, calcium carbonate and copper sulphate during storage.

Joshi and Roy (1985) observed that the PLW of Alphanso mango fruits gradually increased till the end of shelf life. Roy and Pandey (1983) and Kalara et al. (1986) also obtained similar result.

Khurdia and Sagar (2001) recorded that mango fruits can be kept in LDPF (400 gauge) and ALPF (200 gauge) for the retention of good quality in respect of colour, flavour and texture without much physiological loss in weight up to 6 month at low temperature (7°C). Singh et al. (2005) recorded that ber fruits treated with cycocel 1000 ppm, either alone or in combination with potassium sulphate (2 percentage) and benlate (500 ppm) could be stored well up to 8 days with a minimum PLW.

Singh et al. (2007) worked on post-harvest management of peaches packaging materials and reported that for local markets HDPE crates (52X34X41 cm3) and CFB boxes (38X30X20 cm3) can be used for effectively checking the PLW during transportation and transit by spending Rs. 7.5-9.0/kg and Rs. 2/kg, respectively. Similarly they found wooden boxes (47X30X12.5 cm3) were most suitable to cater the same purpose for long distance marketing of peaches with an average expenditure of Rs. 2.20-2.85 for a kg. According to them, the storage life of peaches can be extended for 40-45 days by adopting post-harvest treatments, suitable packaging and appropriate storage.

2.1.2 Physiological loss in volume and size of fruits

The effects of physiological processes during storage are manifested on the volume and size of fruits also. Fruits under different treatments behave differently. Shrinkage of the fruits is closely related with the volume and size of the fruits.
Gaur and Bajpai (1978) reported that length and diameter of litchi fruits were minimum in case of those which were kept in open basket and maximum in those stored in polyethylene bags.

Garg et al. (1979) observed least shrinkage after fourteen days of storage in 2,4,5-T treated apple fruits, closely followed by cycocel.

Randhawa et al. (1980) reported that the firmness of the pear fruits decreased during storage, but this decrease was minimum under 100ppm GA3, followed by the 50ppm GA3 treated fruits. Least firmness was recorded in untreated fruits under control.

Choudhary (1983) recorded minimum loss in volume (9.36 percentage) in mango fruits cv. Langra treated with waxol 8 per cent and wrapped in polyethylene.

Krishnamurthy and Rao (1983) recorded at I.I.H.R. that post storage treatment of wrapped fruits of mango held at 15 °C for 3 weeks could be improved (shape and size) by hot water treatment.

Parihar and Bajpat (1985) studied the losses in apple and found after ordinary storage condition that physiological condition i.e., weight, length and breadth of fruits decreased continuously up to 60 days of observation.

Sharma (1985) observed the minimum (1.417 percentage) reduction in volume of litchi fruits under storage which were treated with 0.2 percentage Carbendazim solution and kept in polyethylene bags without vent followed by wrapped fruits in polyethylene bags without vent.

### 2.1.3 Specific Gravity of fruits

Specific gravity of fruits is affected under different methods of storage. According to Mustard and Lynch (1945) the density in mango varied from 0.973 to 1.065 while Harding et al. (1954), recorded the density from 0.999 to 1.027.

Mukherjee (1959) observed that increase in starch content and specific gravity are self associated, with maturity of mango fruits.

Teaotia et al. (1968) concluded that in Langra the specific gravity, acidity and starch content are quite relevant for predicting maturity.
Verma and Bajpai (1971) recorded that the specific gravity of fruit was the same as in fresh condition showing some higher value in Chausa than other cultivars.

Mann and Singh (1973) recorded that there was a continuous increase in average specific gravity as the maturity period advanced. The palatability of Dasehari fruits on ripening was rated as excellent at specific gravity of 1.008 or more. However, in Langra fruits the palatability varied from good to excellent at the specific gravity of 1.078. Singh et al. (1976) also reported that with the progress of maturity of fruits there was a continuous increase in the specific gravity (1.025 to 1.017) in Neelum mango fruits. Similar results were also reported by Singh et al. (1978) in Taimuna and Sukul cultivars of mango.

Gaur and Bajpai (1978) found superiority of litchi fruits in respect of specific gravity under storage which were treated with sodium hypochlorite and kept in perforated polyethylene bags. Sharma (1085) observed that the specific gravity of litchi fruits reduced most significantly in fruits under control during storage. Significantly less reduction in specific gravity was found in fruits treated with 1.0 per cent copper sulphate solution and kept in vented polyethylene bags.

According to Joshi and Roy (1985), the moisture content of Alphonso fruits was proportional to the specific gravity. The moisture content of the fruits was maximum at harvest and declined gradually during transport and storage irrespective of specific gravity.

2.1.4 Respiration rate of fruits

Respiration is the most vital physiological process of living being. Ripening of any fruit is directly proportional to the rate of respiration. Pre treatments before the storage of fruits greatly manipulated the rate of respiration ultimately increasing the economic life.

Mukherjee (1959) reported that the climacteric respiration occurred in mango fruits just before maturity. The immature fruits respire at higher rate than the mature ones. Agnihotri et al. (1963) observed that waxing retarded Deterioration, delayed the ripening and reduced respiration in stored mango fruits as compared to untreated ones at 33.8 C.

According to Ram et al. (1970), the higher concentration of MH-40 and 2,4,5-T retarded the rate of respiration in Kagzi Lime in storage where as increasing trend was observed both at room and low temperature when treated with 200 ppm IBA.
Garg *et al.* (1971) reported that the rate of respiration of untreated fruits was the maximum 55 mg CO2/kg/hour after 4 days whereas different peaks were observed after 7th days of storage at room temperature in wax emulsion dipped treatments viz 45 mg CO3/Kg/hour 41 mg CO./kg/hour in pre packing and 38mg CO2/kg/hour in wax emulsion cum pre packing. The respiration rate there after showed a decreasing trend. Ram *et al.* (1971) also recorded similar observations.

Srivastava *et al.* (1973) observed an increasing trend of respiration in orange up to 20th day of storage after which it declined, Garg *et al.* (1977) reported that the Cycocel and MH-40 proved to be equally effective to retard the respiration rate of guava fruits in storage.

Subashchandra and Rao (1985) reported that the respiration rate was maximum in untreated fruits of guava, while it was minimum in fruits treated with wax emulsion and kept under polyethylene cover in storage.

### 2.2 CHEMICAL CHANGES

#### 2.2.1 Total soluble solids (Brix) of Fruits

Increase and decrease in total soluble solids of the fruits have usually been observed during the storage period.

Increase in TSS has been found with the advancement of maturity in mango, Mukherjee (1959) and Singh *et al.* (1976). Garg (197G) observed that all the fruits of mango (cv. Dashehan) whether treated or untreated showed a total rise in TSS during storage.

Randhawa *et al.,* (1977) and Bhullar *et al.* (1980) reported that the TSS content was higher in grapes packed with paper wrappers as compared to those packaged in polyethylene bags. Highest TSS was recoded in fruits under control.

Gaur and Bajpai (1978) observed the superiority of litchi fruits in TSS content which were treated with sodium hypochlorite solution and kept in perforated polyethylene bags in comparison to those kept in unperforated ones.

Choudhary (1983) found in his trial that the TSS content of mango fruits increased gradually under storage till the day of termination of experiment. Untreated fruits showed
maximum changes whereas minimum change in TSS was found in the fruits wrapped with polyethylene after treating with waxol.

**Sandhu et al. (1983)** observed maximum TSS (13 percentage) in Kinnow mandarin treated with 30 ppm GA3 and covered with sugarcane trash followed by control. The lowest TSS (10.40 percentage) was obtained in fruits treated with 20 ppm GA and covered in paddy straw. According to **Ghosh and Sen (1984)** the total soluble solids were higher in sweet orange fruits treated with GA and stored at room temperature and lower in fruits kept at 100°C.

**Deol (1985)** recorded that TSS increased with the increase in storage period in Chausa cultivar of mango. The rate of increase was same in all the treatments. Wrappers with or without fungicidal wax and growth regulators including control did not show any appreciable difference among themselves. Similar results were obtained by **Sandhu (1964)** in Langra and **Bhullar (1966)** in Dashehan mango, wrapped with polyethylene.

**Joshi and Roy (1985)** reported that the TSS content of Alphonso mango fruits accelerated during transport and for certain period during storage. After attaining the peak, the TSS declined very slowly till the end of the shelf life.

**Kalara et al. (1936)** reported that there was optimum development of TSS in the fruits of paper packed Dasehari mango as compared to wheat straw used as conventional material for ripening of mango.

**Singh et al. (2005)** recorded that TSS of ber fruits increased as the period of storage progressed up to 4 days and then decreased.

**Srivastava, V.P. (2007).** Efficacy of some fungicides and hot water treatment in control of post-harvest decay of mango fruits. Pesticides, 18(1):63-64

### 2.2.2 Acidity of Fruits

Important organic acids i.e., citric, tartaric and maleic acids are predominantly present in the fruits. These organic acids play important role in augmenting the maturity, flavour, texture and other organoleptic qualities. These are influenced very much by the pre-storage treatments, other than natural storage of fruits.
Agnihotri et al. (1963) found that the titrable acidity remained constant for eleven days and then fell rapidly in stored Dasehari mango fruits.

Garg et al. (1971) recorded the titrable acidity was significantly higher in the waxed fruits as compared to untreated samples during storage at low temperature.

Garg and Ram (1973) observed gradual decline in titrable acidity of both treated and untreated samples of Lucknow safeda cv. of mango.

Verma (1974) observed more percentage of decrease in acidity in litchi fruits kept in unperforated polyethylene bags, followed by fruits stored in perforated polyethylene bags, paper wrapped and untreated fruits.

According to Mann and Singh (1975), the titrable acidity of Dasehari and Langra mango fruits decreased with the advancement of maturity.

Srivastava and Mukherjec (1961) also obtained similar results in ripening of Langra and Neelum mangoes.

According to Garg et al. (1976) a general decreasing tendency of acidity in fruits of mango cv. Dasehari was found with increasing storage period while there was no significant difference in the acidity by different growth regulator treatments.

Randhawa et al. (1980) recorded maximum decrease in acidity under the influence of CCC both at 500 and 1000ppm concentrations.

Choudhary (1983) observed in his trial that acidity declined under all treatments during storage of Langra mango fruits. Acidity was maximum in polyethylene wrapped fruits already treated with waxol and minimum was in fruits under control.


Joshi and Roy (1985) recorded that the acidity declined steadily during transport and storage of Alphonso mango fruits. Kapse et al. (1985) also observed similar trend. There was quick decline in acidity from 2.0 to 0.2 per cent in Totapari mango fruit at ambient temperature.
**Upadhyaya and Tripathi (1985)** reported that in Gourjeet mango, the acidity expressed as anhydrous citric acid was higher in mature fruits as compared to ripe. Continuous decreasing trend in acidity was observed up to 6th day of storage.

Wrappers, growth regulators and fungicidal treatments influenced the acidity per cent in Chausa mango (**Deol, 1985**).

According to **Kalara (1986)** there was optimum development of acidity in the fruits of paper packed Dasehari mango as compared to wheat straw used as conventional material for ripening of mango.

**Singh (1988)** recorded maximum and rapid decrease in acidity in fruits of Langra and Zardalu cultivars of mango in control and lowest degree of decrease was recorded in fruits kept in perforated polyethylene bags with 50ppm GA3 treatments, which was closely followed by those kept in perforated polyethylene bags with 2000ppm captan treatment.

### 2.2.3 pH Value of fruits

The effects of post-harvest treatments of wrappers, growth regulators, waxing etc. used alone or in combination on pH content of mango and other fruits have also been observed by various workers.

**Verma and Bajpai (1971)** reported that pH increased as the period of storage life prolonged. They recorded pH 4.7 in Chausa mango in fresh condition and 5.5 after 75 days of storage.

**Singh (1988)** recorded in his experiment that the pH of both the Zardalu and Langra mango gradually increased as the storage advanced. The rate of increase in pH was higher in case of untreated fruits and fruits treated with hot water in comparison to other treatments. Fruits treated with 50ppm GA3 in combination with perforated polyethylene bags exhibited the slow increase in their pH. Similar results were obtained by **Verma and Bajpai (1971)**, **Gaur and Bajpai (1979)** and **Joshi and Roy (1985)**.

**Dutta and Dhua (1996)** observed that pH was to be correlated with the acidity of the fruits. Acidity of the fruits decreased continuously during storage and reverse was true for pH of the fruits. pH also increased as the ripening process enhanced. The decrease of acidity was recorded more in control and hot water treated fruits. **Singh et al. (2005)** recorded that acidity of ber fruits decreased with the advancement of storage period.
2.2.4 Ascorbic acid content of fruits

Ascorbic acid content of fruits during storage plays an important role. According to Garg et al. (1971) the ascorbic acid content of Dasehari mango during storage decreased day by day in all the treatments while fruits coated with wax alone or in combination with pre packing in vented polyethylene bags proved superior and showed significantly higher ascorbic acid at room temperature.

Mann and Singh (1975) observed that under all conditions of ripening of Dasehari and Langra mango, there was a decrease in ascorbic acid content with the advancement of storage period.

Chundawat et al. (1976) observed a steady decline of vitamin C content of guava fruits during storage, maximum in Lucknow 49 and minimum in Allahabad safeda while Singh et al. (1979) reported that ethephon 600ppm treatment of guava resulted in retention of vitamin C content. They also recorded that the level of ascorbic acid dropped down after 8 days of storage.

Roy et al. (1980) recorded that mango fruits treated with hot water in combination with 0.5 per cent captan showed the better retention of ascorbic acid.

Singh et al. (1984) observed maximum retention of vitamin C in prepackaged guava fruits treated with wax emulsion on the termination of storage.

Sharma (1985) recorded that the ascorbic acid content of litchi fruits decreased significantly during storage on eleventh day of storage, it was found highest in fruits treated with 0.2 per cent Carbendazim solution and kept in vented polyethylene bags and lowest in untreated fruits.

According to Joshi and Roy (1985), the ascorbic acid content of Alphonso mango declined continuously till the end of the shelf life of the fruits.

Deol (1985) reported that the ascorbic acid content of mango fruits (cv. Chausa) under control gradually fell from the initial value during storage period. The growth regulators treatment retarded the loss of ascorbic acid throughout the storage period. All the growth regulators at higher concentrations found to exercise greater preservation effect on ascorbic acid. Similar results were recorded by Kohli and Bambota (1965) in Kagzi lime treated with growth regulators.
Singh (1988) observed that the ascorbic acid content of fruits decreased gradually in both Zardalu and Langra mango fruits during storage under all the treatments. The rate of decrease was faster in untreated fruits (control) in comparison to those of other treatments. Treatment with 50ppm GA3 and kept in perforated polyethylene was found most effective in minimizing the loss of ascorbic acid in both the cultivars i.e., Zardalu and Langra.

Singh (1996) also recorded similar results in case of mango fruits under storage.

Singh et al. (2005) observed decrease in ascorbic acid content of ber fruits with the advancement of storage period.

2.2.5 Sugar content of fruits

With almost all fruits, trend is appreciable increase in sugar content as the fruits ripen and until most of the starch is not converted. Such changes also occurs in mango (Banerjee et al, 1934; Singh et al, 1937; Deol, 1985).

2.2.5.1 Reducing Sugar

Garg et al. (1971) found increasing trend of reducing sugar during storage in Dasehari mangoes at room temperature but further reported that waxing was significantly effective in checking the rise in reducing sugar content of the fruits in contrast to the untreated fruits. On 10th days of storage the reducing sugar decreased in all the treatments.

Garg and Ram (1973) noticed increasing trend of reducing sugar in Lucknow Safeda mango during storage but skin coating apparently checked the rise of reducing sugar.

Randhawa et al. (1976) had also reported more reducing sugar in paper wrapped grapes as compared to polyethylene wrapped.

Garg et al. (1979) found the reducing sugar of apple showed more or less continuously rising trend during storage.

According to Upadhayaya and Tripathi (1985), continuous increasing trend in reducing sugar was noted up to 6th day and thereafter their value declined gradually in stored fruits of mango.
Deol (1985) observed that the reducing sugar increased up to 12th days of storage in Chausa variety of mango but decreased thereafter. The use of cellophane paper in combination with fungicides was helpful in the maximum retention of reducing sugars.

Joshi and Roy (1985) reported that the reducing sugar increased gradually during transport and rapidly up to certain period during storage. After attaining peak, it declined very slowly till the end of shelf life of Alphonso mango.

Singh (1988) observed that in both cultivars Zardalu and Langra of mango reducing sugar of the fruits increased gradually in all the treatments as the storage period advanced. Treatment with 2000ppm captan followed by wrapped in perforated polyethylene bag effectively increased and maintained maximum reducing sugar (3.74 percentage) in Zardalu cultivar whereas 50ppm GA3 in combination with perforated polyethylene bags effectively increased and maintained maximum (3.31 percentage) reducing sugar in Langra cultivar.

2.2.5.2 Total sugar
Research workers have found at varying degrees the effect of different chemicals, wrappers and hot water treatment either alone or in combination on sugar content of fruits during storage.

Verma and Bajpai (1971) reported that Chausa fruits of mango contained highest percentage of total sugar in fresh condition i.e., 16.62 per cent. It decreased to 15.24 per cent after 90 days of storage at low temperature.

According to Garg and Ram (1973) the total sugar content of Lucknow Safeda mango during storage increased continuously up to the end of storage period. The wax emulsion treatment retarded the rate of increase.

Gaur and Bajpai (1979) observed that the total sugar content in Litchi fruits kept in open baskets increased gradually, up to fourth day of storage at room temperature but declined afterwards.

According to Roy et al. (1980), the total sugar of mango fruits treated with hot water in combination with 0.5 per cent captan had shown a slower increase in total sugar during storage.

Randhawa et al. (1980) obtained the maximum amount of total sugar in pear under GA 100 ppm and CCC 1000 ppm closely followed by GA3 50ppm and untreated fruits during storage.
Saini et al. (1982) noticed that the total sugars in peaches were also increased during storage but the maximum total sugar were recorded (4.80 to 5.10 per cent) in fruits treated with 100ppm GA3 as compared to (4.55 to 4.75 per cent) fruits under control.

According to Joshi and Roy (1985), the total sugar increased gradually during transport and rapidly up to certain period during storage. After attaining peak, the total sugar went on decreasing very slowly till the end of shelf life during storage of Alphonso mango fruits.

Upadhyay and Tripathi (1985) observed that the total sugar content increased continuously up to 6th days and thereafter it declined gradually in the stored fruits of mango.

Singh (1988) recorded that total sugar content of mango fruits showed increasing trend up to certain period during storage after that it declined. Slow but gradual increase of total sugar was observed in 50ppm GA3 treated fruits under perforated polyethylene wrappers both in Zardalu and Langra cultivars. Fruits under control exhibited minimum total sugar in fruits of both the cultivars. i.e., Zardalu and Langra.

2.3 SPOILAGE OF FRUITS

Post-harvest treatments i.e. wrappers, waxing, growth regulators, fungicides, hot water treatments play an important role in minimizing the spoilage percentage of fruits during storage as reported by different research I workers.

Ram et al. (1970) noticed decrease in spoilage percentage in Kagzi lime when treated with 2,4, 5-T or MH.

Garg et al. (1976) found minimum spoilage of 13.33 per cent in Dasehari mango fruits dipped in 2,4,5-T,2,4-D and cycocel, failed to check spoilage. Kohli and Bhambota (1965) had observed similar reduction in rotting percentage of orange with application of 2,4 -D and 2,4,5 -T.

Vyas (1979) also reported that Carbendazim and dithane Z-78 at 500ppm and aureofungin at 1000 ppm were equally superior to control fruit rot of apple.

According to Roy et al. (1980), the spoilage percentage of mango fruits under storage was lower in all the treated fruits with hot water (52±1°C, 55±1°C, 58±1°C) + captan (0.5percentage) for five minutes as compared to untreated fruits.
According to Bhullar et al. (1981), there was minimum fruit rot of Kinnow mandarin in the benlate treated fruits under storage. Captan was the next best fungicide in checking the rot. Maximum rot was observed in untreated fruits.

Krishnamurty and Rao (1983) also observed that the post-harvest dip treatment of Alphonso mango with benlate in cold water (28°C) reduced the fungal spoilage significantly during storage. Benlate combined with hot water dip treatment did not show further reduction in spoilage. Captan and thiobendazole were found to be the next best fungicides for controlling spoilage of Alphonso mango. Edible quality of the fruits was not altered due to these treatments.

Choudhary (1983) observed that in case of Langra cv. of mango, the fruit rot increased with the increase of storage period. Rotting reached 40 per cent under control and newspaper wrap. The low rotting percentage (4 percentage) was noticed in waxol (8 percent) + captan (0.5 percent) and wrapped in polyethylene bag, up to 10 days.

Kalara et al. (1986) found 40 per cent spoiled fruits of Dashehan mango when kept in polyethylene bags after eight days of storage, whereas no spoilage was recorded in paper wrapped fruits.

Singh (1988) recorded highest spoilage percentage i.e., 34.99 in Zardalu and 40.33 per cent in Langra under control on the 13th day of storage. This was significantly minimum 11.66 and 11.99 per cent in Zardalu and Langra fruits respectively, when treated with 2000ppm captan in combination with newspaper wrappers.

Singh (1996) recorded that pre treatment of fruits with the antibiotic aureofungin reduced the wastage of mango fruits to a minimum during storage.

Krishnamurthy and Rao (1996) recorded that post storage ripening shrink wrapped fruits of mango (Alphonso and Banganapalli) held at 15°C for 3 weeks could be improved by hot water treatment and it also reduced the spoilage.

Medlicott (2003) suggested that disease incidence by microorganism infections can be reduced by appropriate handling and post-harvest treatments. Washing in static water tanks will increase disease incidence, therefore water should be changed frequently and provided with sodium hypochlorite (100ppm) and or fungicide. Post-harvest applications of specific fungicides will assist disease control.
2.4 ORGANOLEPTIC EVALUATION OF FRUITS

The general appearance and organoleptic qualities i.e., shape, size, colour, texture, flavour and aroma and taste of the fruits altogether determine the consumers acceptability of the fruits. Organoleptic characters are very much influenced by the post-harvest treatment of fruits.

Singh (1957) reported that the litchi fruits kept in perforated and unperforated polyethylene bags had their natural colour up to 7th and 6th days of storage respectively. He also referred that the fruits of litchi had very good colour under 0.5 per cent copper sulphate solution (for three minutes) and packed in perforated polyethylene bags.

Garg et al. (1971) observed that skin coated with wax emulsion and prepackaged Dasehari mango under storage were organoleptically superior over waxed or prepackaged or untreated fruits alone.

According to Srivastava et al. (1973), hill orange fruits packaged in bags with 0.2 per cent ventilation were best in quality at all the stage of storage followed by fruits under 0.4 per cent ventilation.

Chundawat et al. (1973) obtained the best taste and flavour in the mango in fruits treated with 500ppm ethrel under storage.

Mann and Singh (1975) observed that both Dasehari and Langra cultivars of mango were organoleptically superior when ripened under paper cuttings.

Gaur and Bajpai (1978) recorded that litchi fruits treated with sodium hypochlorite and packaged in perforated polyethylene bags with paper cuttings gave the superior flavour aroma and taste during storage.

Adsule and Tandon (1983) found that guava fruits stored in 600 gauge thick LDPF bags had the highest organoleptic score and good marketability up to ten days of storage.

Choudhary (1983) recorded that mango fruits of Langra cultivar treated with waxol 6 per cent and wrapped either in polyethylene or newspaper, maintained good organoleptic tastes.

Kapse et al. (1985) observed the organoleptic score for colour, flavour, and texture of mango fruits attained maximum at ambient temperature within 9-10 days and remained at that level till 14th day.
Upadhayaya and Tripathi (1985) found the highest organoleptic score for Gaurjeet mango on 6th day at room temperature. On the 6th day of storage the flavour, colour, taste and quality of fruits were best for consumption and thereafter, fermentation and rotting started.

Singh (1988) recorded that mango fruits of both Zardau and Langra cultivars treated with 50ppm GA3 in combination with perforated polyethylene bags maintained good organoleptic quality scoring above 80 per cent marks up to 13th day of storage.


Rathore et al.(2009) Mango fruits CV. Chausa treated with GA3 showed uniform texture and maximum firmness of fruits after 19 days of storage.

2.5 ECONOMIC LIFE OF FRUITS

Different pre harvest treatments with wrappers, chemicals, growth regulators and hot water treatment have influenced the economic life of the fruits as evidenced in literature.

Mukherjee (1962) reported that mango fruits kept in polyethylene bags at 7.2°C remained fresh during 6 weeks storage and on removal ripened at room temperature.

Srivastava (1967) extended the storage life of mango fruits by keeping in polyethylene bags with 0.4 per cent ventilation. Even fully ripe mangoes kept very well at room temperature in perforated 200 gauge polyethylene bags.

According to Garg and Ram (1973), the economic storage periods for untreated and wax coated were five and eight days respectively. Wax coating thus extended the storage life of Lucknow Safeda mangoes by about three days.

Garg et al. (1976) found 2,4,5-T as the best growth regulator for enhancing the storage life of Dashchari mango at room temperature followed by 2,4-D in retarding the role of ripening. MH-40 and cycocel, did not prove to be effective in increasing the shelf life of mango fruits.

Roy et al. (1980) reported that hot water treatment at 52±1°C, 55±1°C or 58°C±1°C with captan (0.5percentage) for 5 minutes retarded the ripening of Langra cv. of mango. Most of recommendations for extending the storage life of fruits have been involved in dipping of fruits in water, heated to a temperature of 50°C for 10 to 30 minutes.
Johnson et al. (1990) and Jocelyn et al, (2004) recommended dipping of freshly harvested mango fruits in hot water (52°C-55°C) increased the storage life.

Krishnamurthy and Rao (1983) reported that post storage ripening of mango kept at 15°C for three weeks could be improved by hot water treatment.

Deol (1985) was able to extend the storage life of mango fruits cv. Chausa for 20 days by treating the fruits with 2,4-D solution and holding them under room temperature. He also observed that mango fruits stored under polyethylene wrapper showed the maximum delay on ripening effect at ambient temperature.

Ghosh and Sen (1985) reported that the lime fruits could be stored in perforated polyethylene bags for more than a month at ambient temperature. High percentage of retention was also noted in waxol coated and Carbendazim treated fruits up to 20 days. Ethylene chlorohydrine + calcium carbonate, GA3 aureofungin and NAA also gave good response in extending the storage life up to the extent of 2-10 days.

Kalara et al. (1986) found in Dasehari mangoes that the paper wrapper slowed the ripening process in storage. The fruits were partially ripened after 4 days and fully ripened after 6 days of storage.

Investigations conducted by Singh and Singh (1993) to ascertain the efficiency of various treatments on extending the post-harvest life of Zardalu and Langra cultivar of mango fruits at room temperature showed that spoilage reduced to greater extent when fruits were treated with 50ppm GA3. This treatment extended the economic storage life of fruits by 3-5 days.

Prakash (2005) recommended efficient post-harvest management practices (hot water, chemicals, growth regulators waxing, chilling, sulphitation), for increasing the storage life fruits and keep them fresh for longer periods without hampering the physico-chemical characters.

2.6 PATHOLOGICAL FACTORS

Infection by micro-organisms is generally the most serious cause of post-harvest losses in mango. Disease incidence can be reduced by good orchard managements, pre-harvest cultural practices, appropriate handling and post-harvest treatment procedures.

Mango fruits were immersed (10, 12, 24 and 48 hours after harvest) in water at 54±1°C for five minutes and treated with benomyl at 0.025, 0.05 and 1.0 per cent by Sampaio et al.
(1981). They concluded that anthracnose was almost completely controlled. Incidence of stem end rot appeared to be diminished with these treatment.

**Pandey et al. (1982)** observed that -Saprol and Delan at 1000 and 1250ppm, respectively, effectively controlled Aspergillus niger on mango fruit when applied as dips.

**Choudhary (1983)** recorded only one type of fruit rot i.e., stem end rot (SER) during storage of mango fruits cv. Langra. There was no rot up to fifth day of storage. Thereafter the tendency of fruit rot increased with increasing storage period. It reached to 40 per cent under control (no treatment and news paper wrap alone). The low rot percentage was noted in waxol 8 per cent + captan (0.5 per cent) and wrapped in polyethylene bag, up to 10th day of storage.

Anonymous (1988) applied fungicides and one bacteriocides on Neelum and Chausa cultivar of mango before keeping under storage. The treated fruits were kept in perforated polyethylene bags. Neelum cultivar of mango remained healthy up to 10 days in Difolatan. Treatment with Carbendazim controlled the stem end rot. In Chausa cultivar also fruits remained fresh with Difolatan treatment up to 10 days. In Carbendazim treated fruit after 7 days, stem-end rot and Aspergillus niger rot appeared.

**Singh and Singh (1993)** reported that the spoilage percentage was found significantly highest in control 34.99 and 40.33 per cent rot in Zardalu and Langra cultivar of mango, respectively on 13th day of storage. This was significantly low (11.66 and 11.99 per cent) with 2000ppm captan in combination with newspaper wrapping.

**Swart (2003)** observed that soft brown rot (SBR) and anthracnose are the most serious post-harvest problems of mango with losses of overseas markets reported to be 10.60 per cent and 19.10 percent, respectively.