Mango fruits are harvested at the mature, hard green pre-climacteric stage. The ripening process involves numerous rapid biochemical changes taking place within 9 to 12 days postharvest at ambient temperature, depending on the cultivar and stage of maturity at harvest (Gomez-Lim, 1997). Ripening associated with many changes in a fruit. Such a short shelf life of mango fruit limits its distribution to distant domestic and export markets. Various approaches have been attempted to extend its postharvest life with limited success including controlled atmosphere (CA) storage (Bender et al., 2000; Lalel et al., 2001), low temperature storage (Ketsa et al., 1999), edible surface coating (Abdulah and Basiony, 2000), and postharvest treatments with Ca, GA\textsubscript{3} and polyamines (Martinez-Romero et al., 2000; Singh et al., 2000).

To facilitate access to the domestic and offshore markets, mango fruit storage potential and fruit quality consistency needs to be improved (Simmons et al., 1997). Further keeping quality of fruits is also an important criteria during the selection of varieties to a particular region. Mango is a climacteric fruit which shows rapid increase in respiration after harvest and cannot be stored for long time at ambient condition due to fast ripening and degradative metabolism. Higher yield, better quality and longer life span of the produce are the slogans of the day. Mango cultivars differ in flavour (Berardini et al., 2005), nutritional characteristics (Ahmad et al., 2007) and storage behaviour (Elahi and Khan, 1973; Kim et al., 2007). High market losses, inadequate information on postharvest physiology and biochemistry of cultivars are the limiting factors in international mango trade (Medlicott and Thompson, 1985). Bose and Mitra (1990) reported that despite of enormous wealth of mango cultivars available in the country but ideal cultivar of mango is still lacking. Horticulturists are trying to develop such cultivars. Most of the present day cultivars appeared to have been selected for characters like size, quality and period of maturity. An increase in the storage life and improvement of mango fruits quality is really desirable to prevent these gluts in the market and to curtail the post-harvest losses.
(Siddiqui et al., 2014). So during the selection of a variety, high yield potential with longer shelf life are important aspects to fulfill the demand of the day.

Keeping all the above facts under considerations the present investigation of effect of pre and post harvest application of various chemicals was carried out with four varieties of our region named Kesar, Alphonso, Langra and Ratna. The research highlights of mango and other fruit crops with aspects of varieties of mango and chemical treatments have been reviewed to constitute the research and support results of this experiment.

2.1 EFFECT OF VARIETIES ON PHYSICAL AND BIOCHEMICAL CHARACTERS

Saini et al. (1971) reported total soluble solids content ranges from 19.5 to 20.0 ºBrix in Chausa, Langra, Dashehari and Lucknow local varieties.

Teotia and Singh (1971) described the physic chemical properties of Neelum, Bride of Russia, Katikibahar, Anupam, Nisarpasnd, Langra Dudhia and Kesar varieties. Taking into consideration of all general characterestics such as fruit weight, size, taste, pulp content and appearance, Langra Dudhia seemed to be the best as it contains extraordinary high value of vitamin C and attractive milkish shade on fruits.

Lodhi et al. (1974) observed the physical properties of fruits of some commercial varieties of mango. They reported that Benganaplli, Langra and Totapuri had higher pulp content as compared to other varieties studied. Langra was sweetest variety followed by Benganaplli, Pairi and Alphonso.

Singh and Tripathi (1974) reported that stone weight was 60 g (medium) in Rashu-E-Jahan, 44.00 g in (large) in Langra Bengal, 43.00 g in (large) in Sheroli, 22.00 g (medium) in Rahmat Khas, 18.00 g (medium to large) in Amin Abdul Ahed Khan and 9.00 g (medium) in Katiki Farukhabadi.

Katrodia et al (1985) studied the performance of sixty mango cultivars under south Gujarat condition. They found that among the different cultivars evaluated Alphonso shown highest T.S.S.

Krishnamurthy (1985) observed the fruits of Alphonso and Langra with specific gravity less than one showed low ºBrix index and high acidity and ripened in 13 to 15 days as compared to fruits with specific gravity of 1.02, which ripened in 9 to 12 days.
Shyamal and Mishra (1987) concluded that cv. Langra recorded maximum pulp-stone ratio, ascorbic acid, total soluble solids, reducing sugar and non-reducing sugar compare to other cultivars studied.

Salvi and Gunjate (1988) reported the total soluble solids of Ratna fruits as 23, Neelum 17.50 and Alphonso 19 °Brix. They found that the length and breadth of Ratna fruits as 10.69 and 8.36 cm, respectively.

Badyal and Bhutani (1989) studied about physical characteristics of seven cultivars of mango varieties at ripe stage. Mallika was found to be superior in fruit weight (338.47 g) and pulp percentage (72.12 %) followed by Langra (67.94 %) and Bombay Green (66.22 %) in respect to pulp percentage.

Minhas et al. (1991) studied about physical constituents of six different cultivars of mango at mature stage. The maximum fruit weight (203.60 g) and pulp weight (117.4 g) were recorded in cv. Langra.

Kesar name was given because the yellow orange coloured (saffron colour) pulp (Chovatia et al., 1995) colour because of higher carotenoid content.

Kumar and Dhawan (1995) reported that weight loss with advancement of storage period might be due to the loss of moisture and food substances affected by the process of transpiration and respiration.

Mitra et al. (1999) conducted an evaluation trial with eighteen mango varieties (Ali Pasand, Ali Bux, Anupam, Baramasia, Bira, Biswanata Chatterjee, Champa, Dilshad, Gulab Khas, Kesharia, Kuopahar, Meghlanthan, Mohan Bhog, Phunia, Sabsang, Safdar Pasand, Saradamani Bhog, Talabi and Totapuri Red Small), the variety Biswanath Chatterjee was found superior to all other varieties with respect to average fruit weight (280.2 g), size and percentage of pulp (80.53 %). The fruits of Safdar Pasand contained highest amount of total soluble solids (21.60 %) and total sugar (18.2 %), while the fruits of Meghlanthan were very poor in total sugar (6.6 %) and TSS: acid ratio (33:13).

Sharma and Josan (1995) observed the maximum fruit weight in Mallika (428.00 g) followed by Langra (289.00 g) and the lowest in Alphonso (175.00 g) and the maximum pulp weight was recorded in Mallika (428.00 g) followed by Langra (289.00 g), while the minimum pulp weight was recorded in Alphonso (175.00 %).
Chaudhary et al. (1998) studied about twenty two North Indian mango varieties for yield and physical characters at mature stage. Among them, Langra and Dashehari gave the best physical composition.

Hoda et al. (2000) studied the storage behaviour of different mango hybrids. Among the different hybrids Mallika recorded minimum physiological loss in weight (31.30 per cent) and 'Mahmood Bahar' was found most inferior, recording 44.00 percentage loss on day 15 of storage. The maximum spoilage loss was in 'Amrapali', while the minimum in 'Mallika' on day 15 of storage. Total carotenoids content were found maximum in 'Amrapali', followed by 'Mallika', 'Neeluddin' and 'Neeleshan'. It increased upto to day 9 of storage in all the varieties except 'Mallika' in which peak was recorded on day 11 of storage and thereafter declined. On the basis of spoilage, the maximum economic life was shown by 'Mallika' and 'Ratna', ie 15 and 11 days respectively. During storage, the titratable acidity and ascorbic acid gradually decreased in all the varieties. Total sugar and total soluble solids also increased gradually during the storage.

Jadhao et al. (2000) analysed thirteen cultivars of mango for their chemical composition. They concluded that total soluble solids content was the highest in cv. Kesar and Alphonso.

Ravikher and Sharma (2002) observed the maximum fruit weight in Mallika (440.00 g), followed by Langra (250.00 g) and the least in Dashehari variety (175.00 g).

Anila and Radha (2003) conducted an evaluation of physical, morphological and biochemical characters of four varieties and two hybrids of mango were made under Kerala conditions. It was observed that Ratna fruits had the maximum length, breadth, weight, volume and circumference. The minimum contribution of stone to fruit weight was in Ratna and the maximum in Muvandan. Fruits of hybrids Ratna and H-151 recorded the highest values of total soluble solids, sugar and ascorbic acid contents. The overall perusal of the data revealed that hybrid variety Ratna had all the desirable characteristics in terms of length, breadth, weight, volume, circumference, minimum stone weight, total soluble solids and sugar content.

Dhillon et al. (2004) observed that maximum fruit weight in Fazli variety (304.00 g) followed by Langra (240.00 g) and Krishan Bhog (235.00 g) and the minimum fruit weight in B. G. Malda (158.00 g) variety, also recorded peel weight of
54.00 g in Fazli, 37.00 g in Krihsna Bhog, 36.00 g in Langra, 36.00 g in S. B. Chausa, 26.00 g in Dahnsehari and 19.00 g in Alphonso cultivars of mango.

Kumar and Singh (2005) observed highest fruit pulp in Mallika (69.00 %) followed by Langra (65.00 %) and Bagbahar (64.00 %) and the lowest pulp content in Bangalora (57.00 %) variety.

Akhtar et al. (2009) evaluated four different varieties Dashehari, Chaunsa, Ratol and Langra grown in three major areas of Pakistan; Multan (MUL), Rahim Yar Khan (RYK) and Mir Pur Khas (MPK). Langra variety exhibited higher acidity, lower pH and total soluble solids (TSS) among all the tested varieties. Colour characteristics of Langra variety collected from all three regions were found to be superior among the tested varieties. However, this variety was rated inferior for other sensory attributes (flavour, taste and overall acceptability). Variety Ratol was shown to be highly acceptable for flavour, taste and overall acceptability in all three sites of its production.

Kumar (2009) reported that the fruit length (14.71 cm) was more in Totapuri, weight of the fruit (521.70 g), volume of the fruit (512.25 ml) was more in Totapuri whereas, Mundappa (9.98 cm) recorded maximum fruit diameter and the highest pulp weight (372.80 g) was noticed in Totapuri. The lowest peel weight (45.30 g) as well as stone weight (27.60 g) were noticed in variety Kalapady. Manibhatta variety showed highest total soluble solids (21.00 °Brix). The lowest titratable acidity was found in variety Ratna (0.23 per cent). Highest total sugars and reducing sugars (28.20 % and 4.89 % respectively) found in variety Kare Ishad.

Rajwana et al. (2010) carried out studies to compare the fruit ripening behaviour and quality of this new promising mango hybrid cultivar Faiz Kareem with its parents under ambient (28±2 °C; 65-70 % RH) conditions. Under ambient conditions all the cultivars took 7 days to ripe. However, Faiz Kareem expressed better firmness, which indicates its potential for extended shelf life. Highest levels of total sugars (25.88 %), total soluble solids (26.75 °Brix) and total carotenoids (69.99 μg/g) were observed in Chausa while lowest in Faiz Kareem (23.71 %, 25.54 °Brix and 24.60 μg/g, respectively) which can be an advantage for extended storage and for sugar conscious consumers. Taste panel studies also showed clear preference for hybrid cultivar Faiz Kareem followed by Chausa and Anwar Ratole.
Firmness and toughness of fruit, peel and pulp of seven different mango cultivars were studied over a ripening period of ten days. The textural characteristics showed a rapid decline in their behaviour until mangoes got ripened and thereafter, the decline became almost constant indicating the completion of ripening. However, the rate of decline in textural properties was found to be cultivar specific. In general, the changes in textural attributes were found to be significantly influenced by ripening period and stage of harvesting. Among the evaluated cultivars Kesar maintained good firmness (Jha et al., 2013).

Singh et al. (2013) evaluated twenty mango varieties of different zones of India. The results shown that total soluble solid content was maximum in Dashehari (23.60 °Brix) followed by Langra (23.45 °Brix), Mallika (22.10 °Brix) and Bombay Green (22.10 °Brix).

Mannan et al. (2003) studied some varieties of mango (Amrapali, Sharmai Fazli, Neelambari, Indian Lota, and Madrasi Tota). Among these varieties studied, maximum edible portion (78.53 %) and highest total soluble solids was recorded in Madrasi Tota.

Kaur et al. (2014) evaluated physical and chemical characteristics of different mango varieties of North-West India. Among all the genotypes Alphonso, Malda and Chausa was identified superior for traits like total soluble solid/acid ratio. Chausa and Langra recoded for high pulp percentage and pulp to stone ratio.

Araiza et al. (2015) conducted the experiment using mango fruits from five different cultivars (‘Kent’, ‘Tommy Atkins’, ‘Ataulfo’, ‘Gouveia’ and ‘Osteen’) harvested at physiological maturity. Fruits were evaluated at arrival and stored under simulated marketing conditions (20 ± 2 °C and 80 % RH) to follow the changes on firmness, colour (external and internal), titratable acidity, total soluble solids content and pH, every three days. Weight loss, respiration rate and ethylene production were determined daily. Morphological characteristics such as seed weight and size, among others parameters were determined once on 50 fruits by cultivar. Total soluble solids content increased in all cultivars reaching after 15 days values that ranged from 15.00 °Brix on ‘Osteen’, up to 20.40 °Brix on ‘Gouveia’. ‘Tommy Atkins’ presented the firmer fruits at the end of the study with 35.50 N, while ‘Osteen’ was the softer with 5.70 N. Based on appearance, the new varieties evaluated did not present extended shelf-life as compared with ‘Tommy Atkins’ and ‘Kent’.
Shelf life of ‘Gouveia’ and ‘Osteen’ stored under the simulated marketing conditions was two weeks.

Chovatiya (2015) reported that Talala pocket of Saurashtra region produces best quality mango cv. Kesar due to congenial climate and soil conditions of this region.


Karuna et al. (2015) studied the shelf life of eleven mango hybrids Alfazli, Amrapali, Jawahar, Mahmoodbahar, Mallika, Neeleshan, Neeludin, Prabhashankar, Ratna, Sabri, Sunder Langra and Langra. On termination day of storage (15th day) the minimum PLW (18.65 %) and spoilage (22.36 %) was noted in Mallika while highest PLW (34.85 %) and spoilage (58.67 %) were obtained in check variety Langra. Total soluble solids content in fruits increased up to 12th day and further extension in storage period it declined in all the cultivars. The titratable acidity and ascorbic acid content in fruits decreased progressively upto end of the experiment. The highest ascorbic acid produced by Langra (92.86 mg/100g juice) while, the lowest ascorbic acid was noticed in Mahmoodbahar (15.18 mg/100g juice). Total sugar enhanced gradually up to 9th day of storage, except in Mallika which showed increasing trend up to 12th day. On last day of storage the maximum total sugars was noticed in Mallika (14.98 %) however, the lowest was recorded in Langra (11.74 %). The keeping quality of Mallika, Alfazli, Ratna and Amrapali were better than other hybrids and check variety Langra.

Kulkarni (2015) observed that the pure pulp of Alphonso was better over Ratna, Sindhu and their blends with Alphonso. Mamiro et al., 2007 reported that the criteria for production and acceptance of high quality fresh mangoes by the consumer depends on flavour, volatiles, texture and chemical constituents.

Naz et al. (2014) studied eight cultivars of mango, among them Fajri produced the maximum green and ripe fruit weight, fruit length and perimeter and physiological weight loss (453.00 g, 403.00 g, 13.80 cm, 21.57 cm and 10.97 %), respectively. The higher softness values were noticed in Aman Dusahri. There is an increase in pH
values (5.47, 5.40 and 5.33) among Samar Bahisht Chaunsa, Aman Dusahri and Anwar Ratual, respectively with a progressive decrease in ascorbic acid and titrable acidity during ripening period. Whereas appreciably higher total sugar contents were observed in pulp of Langra, Samar Bahisht Chaunsa and Anwar Ratual (20.67, 20.43 and 20.33 %, respectively). 19.83 ° Brix total soluble solids and 0.64 per cent protein contents were recorded in Langra. The sensorial attributes varied significantly according to cultivars. Out of eight cultivars, Langra obtained higher scores, while Anwar Ratual found to be highly satisfactory followed by Samar Bahisht Chaunsa for flavour and taste. Both of these cultivars were equally acceptable for overall acceptability.

Reddy (2015) studied six mango hybrids, Amrapali, Mallika, Neelashan, Prabhashankar, Ratna, Sabri and Langra were taken as local check to study their shelf life. The physiological loss in weight and spoilage of fruit increased with prolongation of storage period, regardless of cultivars. On termination day of storage (10th day) the minimum physiological loss in weight (16.65 %) and spoilage (28.36 %) was noted in Mallika while highest physiological loss in weight (32.85 %) and spoilage (42.67 %) were obtained in check variety Langra. Total soluble solids content in fruits increased up to 8th day and further extension in storage period it declined in other cultivars. On concluding day of experiment (8th day) the maximum total soluble solids was noted in Mallika (23.02 °Brix) while the lowest was obtained in Langra (18.12 °Brix). Total sugar enhanced gradually up to 8th day of storage, except in Mallika which showed increasing trend up to 10th day. On last day of storage the maximum total sugars was noticed in Mallika (14.98 %) however, the lowest was recorded in Langra (11.74 %). On 8th day of storage Mallika was organoleptically rated as excellent. On last day of storage, Amrapali, Mallika were fair while rest of the cultivars were under poor grade quality. The keeping quality of Mallika, Ratna and Amrapali were better than other hybrids and check variety Langra. Especially fruits of Mallika can be stored for longer period at ambient conditions.

Bhalekar et al. (2016) reported that organoleptic evaluation for quality parameters viz. pulp colour, flavor, fiber content, taste, juiciness etc. It was observed that cv. Maya recorded highest overall score (65.90 %) which was followed by cv. Kesar (64.10 %).
Review of literature

Guava

Killadi et al. (2007) reported that among three guava cultivars (Allahabad Safeda, Sardar and Lalit). Lalit had a longer shelf life of 9 days with minimum rates of respiration and ethylene production, better firmness (2.1 kg/cm²) and palatable TSS: acid ratio, high vitamin C content (227.33 mg/100) with minimum physiological loss in weight (8.6 %) under ambient conditions. However, Allahabad Safeda had a shelf life of 6 days.

Banana

Akter et al. (2013) reported that banana varieties Sabri, Champa and Amritasagar showed significant differences in time periods to reach successive stages of ripening. Longer period was required to reach ripening stages in variety Sabri than those of Champa and Amritasagar. The variety Sabri had the highest total soluble solids content than that of Champa and Amritasagar. An increasing trend in total soluble solids contents was observed in all varieties at all stages of ripening. Disease incidence was the lowest in Sabri variety than that of Champa and Amritasagar. Results showed that the shelf lives of bananas of the variety Sabri, Amritasagar and Champa were 10.81, 9.00 and 10.11 days, respectively. Sabri had the longest shelf life (16.25 days) than two other varieties.

2.2 EFFECT OF PUTRESCINE ON PHYSICAL AND BIOCHEMICAL CHARACTERS

Malik et al. (2003) assessed the impact of pre and post harvest applications of putrescine on fruit ripening, quality and shelf life of ‘Kensington Pride’ mango. Fruits were sprayed with putrescine (0.00, 0.50, 1.00 or 2.00 mM) seven days prior to harvest and subjected to postharvest fruit dip treatments for 6 minutes. One batch of treated fruits was allowed to ripen at room temperature (21 ± 1 °C) while the second batch was stored at 13 °C and 85 % RH for 20 days. Putrescine treatments significantly reduced ethylene production. They observed that pre and post harvest application of putrescine increased fruit firmness and retarded fruit colour development. Putrescine treatment at 1 mM was effective in delaying fruit ripening at ambient temperatures, whilst 2 mM extended shelf life and improved fruit quality of ‘Kensington Pride’ mango.

Mango fruits of cultivar ‘Kensington Pride’ were soaked in different concentrations of putrescine (0.0, 1.0, 2.0 and 3.0 mM/L) for 6 minutes, air dried and stored at 13 °C (RH 85 ± 5 %) for 3 or 4 weeks. Application of putrescine 1 mM
resulted in the highest fruit firmness (18.20 %) and TSS (16.20 °Brix). Also, noted that exogenous application of putrescine at 1 mM after harvesting of fruits significantly decreased the weight loss (3.85 %) over control (4.62 %) in mango cv. Kensington Pride (Malik et al., 2006).

Malik and Singh (2006) investigated the effect of putrescine (0, 0.01, 0.1, 1 mM) when applied as foliar spray at Final Fruit Stage (FFS) in mango cv. ‘Kensington Pride’. They observed that foliar application of putrescine at 0.1 mM improved fruit quality by increasing total carotenoid (4.40 mg/100 g) and reducing acid content (0.2 %) of ripe fruit.

Jawandha et al. (2012) conducted an experiment to study the effect of putrescine on storage life and quality of mango fruits cv. Langra. Results revealed that fruits treated with putrescine at 2.00 mM/L retained the best quality in terms of high palatability rating, good blend of Total soluble solids (TSS) and acidity and low physiological loss in weight and spoilage percentage.

Jawandha et al. (2013) studied the effect of putrescine and LDPE packaging on storage life and quality of mango fruits cv. Langra. Physiologically mature and uniform fruits of mango were dipped in aqueous solutions of putrescine (0.0, 1.0, 2.0 and 3.0 mM/L). Treated fruits were air dried in shade and stored at 13 °C and 90-95% relative humidity (RH) for four weeks. Fruits treated with putrescine at 2.0 mM retained the best quality in terms of high palatability rating, good blend of TSS and acidity and low physiological loss in weight and spoilage percentage.

Babu (2014) concluded that mango fruits of cv. Kesar sprayed with putrescine 0.1 mM minimized physiological loss in weight (%), titrable acidity (%), spoilage (%), increased fruit firmness (kg/cm2) and registered higher organoleptic scores. Higher TSS (°Brix), reducing sugars (%), total sugars (%), total carotenoids (mg/100 g pulp) and shelf life (days) were observed in the same treatment. It increased the shelf life by around 4 days over control (15 days).

Bhat et al. (2014) conducted an experiment to determine the effect of postharvest application of putrescine on shelf life and chilling injury in fruits of mango cv. Dashehari fruits were dipped for 10 minutes in different concentrations (0.5 and 1 mM) putrescine. Mango fruits treated with polyamines could be stored for longer duration in refrigerated storage without any sign of chilling injury. They observed that fruits treated with putrescine (1.0 mM) resulted in the lowest
physiological loss in weight (11.77 %) compared to 18.49 per cent in the control while spoilage was significantly reduced to 3.3 per cent in mango fruits treated with 0.5 mM putrescine compared to 13.30 per cent in control after 28 days of storage under refrigerated condition. Storage life was extended to 4 weeks in mango fruits treated with 1 mM putrescine compared to 2 weeks in control under refrigerated condition.

Gavri (2015) reported that pre harvest spray + post harvest dip of putrescine at 2 mM emerged as the best treatment combination for mango cv. Kesar for improving total soluble solids (17.00 °Brix), reducing sugar (3.58 %), non reducing sugar (7.46 %), total carotenoids content (2.53 mg/100g) on 15th day and minimum physiological loss in weight on 5th and 10th day of storage and pulp weight (343.33 g).

Gavri et al. (2016) reported that pre harvest spray + post harvest dip of putrescine at 2 mM emerged as the best treatment combination for mango cv. Ksar. They found that fruits exposed to this treatment could be stored for 20 days at 11±1 °C & 90-95 % RH. Fruits thus treated had the lowest spoilage, maximum firmness and the highest organoleptic scores. These results throw light on the potential use of putrescine in prolonging the shelf life of mango without any detrimental effect on fruit quality. The experiment suggests that this technology can be put to use when transporting fruits to high end and distant markets.

Ali et al. (2017) evaluated mango trees productivity and quality as affected by boron and putrescine. Studies revealed that mango trees of variety ‘Zebda’ sprayed with putrescine (0.45 mM) or boron (0.30 %) increased quality parameters like total carotenoids, pulp (%), vitamin C, TSS (%) and TSS/TA ratio and decrease in fruit firmness.

Venu (2017) reported that mango cv. Kesar sprayed with putrescine 150 ppm improved shelf life parameters like fruit firmness (14.53S kg/cm²), days to ripening (16.58 days), shelf life (20.63 days) and acidity (0.37 %) as well as reduced physiological loss in weight (13.05 %) and spoilage (8.64 %).

**Banana**

Hosseini et al. (2016) reported that weight loss, fruit softening, skin colour changes, total soluble solids, pH, the activity of PPO and PG increased during fruit ripening but the rate of changes was significantly slowed in putrescine treated banana fruits. Moreover, putrescine application maintained higher levels of titrable acidity, ascorbic acid and reduced the loss of sensory acceptability and decay incidence.
compared to control. Also, suggested that the post harvest dip treatment of putrescine could be an effective means for extending the storage life of *Musa acuminata* L.

**Lemon**

Valero *et al.* (1998) observed that putrescine treated fruits shown higher level of firmness and lower weight loss and delayed colour change than calcium chloride treated fruits or non-treated lemon fruits.

**Pistachio**

Mirdehghan *et al.* (2013) designed an experiment to study the effects of foliar spraying of putrescine before harvest and evaluating the post harvest behavior of fresh pistachio nut cv. ‘Kalleh Ghochi’. They found higher fruit firmness (2.5 kg/cm$^2$) and decreased weight loss (1.96 %) and less microbial activity at a concentration of 2.0 mM.

**Apricot**

Apricot infiltrated with exogeneous putrescine before storage showed higher firmness than the control and a delayed colour change. Putrescine treated fruits showed different physiological behaviour than control. Colour change, weight loss, ethylene emission and respiration rate were reduced in putrescine treated fruits in apricot cv. Maurico (Martinez- Romero *et al.*, 2002).

Davarynejad *et al.* (2013) evaluated the influence of putrescine on storability, postharvest quality and antioxidant activity of two Iranian apricot (*Prunus armeniaca* L.) cultivars. Putrescine treatments reduced weight loss and maintained fruit firmness. The highest titratable acidity and ascorbic acid were observed in the treatment comprising 4 mM putrescine.

**Plum**

Serrano *et al.* (2003) found that putrescine treated plum cultivars shown higher fruit and flesh firmness, lower soluble solids and titratable acidity, reduced weight loss and delayed colour changes during storage.

Khan and Singh (2008) reported that pre and post harvest application of putrescine on plum cv. ‘Angelino’ gave higher fruit firmness (29.2 kg/cm$^2$) at a concentration of 2.0 mM and resulted in higher acidity (1.11 %), lower total carotenoids (0.58 mg/100gm), ascorbic acid (24.1 mg/100gm) and delayed fruit softening. These treatments can be used to delay the ethylene production with acceptable fruit quality during ripening at ambient temperature or to extend the storage life of plum up to six weeks with minimum losses of fruit quality.
Grape

Shiri et al. (2013) reported that combination of 1 mM putrescine and 1 % chitosan reduced the weight loss, decay incidence, browning, and berry shattering and cracking of grape fruits. Postharvest putrescine treated berries (1 and 2 mM) exhibited higher total phenolic content, catechin, total quercetin and antioxidant activity and the lower quercetin 3-galactoside as compared with other treatments.

Mirdehghan and Rahimi (2016) reported that polyamines (Putrescine and Spermine) treated fruits increased firmness, antioxidant activity, anthocyanin content of grape berries. Polyamines treated fruits reduced loss in weight and microbial infection compared to control. Furthermore they exhibited lower changes in total soluble solids and acidity.

Ber

Kassem et al. (2011) evaluated the effect of different agrochemicals when sprayed on Puyun jujube trees after fruit set. They recorded significantly higher total soluble solids (15.10 °Brix), ascorbic acid (39.40 mg/100ml juice), reducing sugars (5.98 %), non-reducing sugars (4.59 %) and total sugars (10.57 %) with the application of putrescine (1.00 mM).

Sweet Cherry

Khosroshahi et al. (2008) investigated the effect of putrescine on postharvest life and quality of sweet cherry fruits cv. ‘Surati-e Hamedan’ at 2 °C. Fruits were treated with 0.5, 1, 2, 3, and 4 mM putrescine as well as distilled water for 10 minutes, then transferred into the refrigerator (2 °C). They observed that application of putrescine increased the soluble solids content and decreased weight loss as well as titrable acidity.

Pear

Hosseini et al. (2017) reported that pre-harvest foliar spraying with putrescine (at 0.5, 1 and 2 mM) on quality and postharvest life of Pyrus communis cv. Spadona maintained higher levels of acidity, vitamin C, maintained higher firmness, reduced decay incidence during storage compared to control. Weight loss, fruit softening, TSS and pH increased during storage but the rate of changes was significantly lower in fruit treated with putrescine at 1 and 2 mM. Furthermore, higher doses of putrescine were effective in terms of prolonging the storage and marketability of fruits more than 127-142 days.
2.3 EFFECT OF SPERMINE ON PHYSICAL AND BIOCHEMICAL CHARACTERS

Malik et al. (2003) concluded that the endogenous plant growth substances polyamines have been involved in the development and ripening of mango fruit which ultimately affect its storage life and quality. The study revealed that higher levels of endogenous free polyamines especially spermidine and spermine at initial fruit development suggest their possible role in cell division and the concurrent increase in polyamines and ethylene during mango fruit ripening suggest that endogenous polyamines level may have increased in response to higher ethylene production. Prolonged shelf life and improved quality of exogenously treated mango demonstrate involvement of polyamines biosynthesis during ripening process and its possible use to extend shelf life for distant marketing.

Malik and Singh (2003) observed that ethylene and polyamines showed opposite effect in mango ripening.

Malik and Singh (2005) observed that pre storage dip application of polyamines retarded development of mean fruit softness (10.3 %), visual colour (26.3 %) and reduced weight loss (6.80 %) during storage without significant reduction of ethylene production and respiration rate. During ripening of 3 week stored fruit, 0.5 mM SPM (Spermine) treated fruit exhibited significantly lower mean respiration rates compared with the control. Application of polyamines significantly increased fruit firmness and ascorbic acid content, while reducing carotenoids and total soluble solids (TSS)/acid ratio of ripe fruit compared with the non polyamines treatment. In conclusion, pre storage dip application of polyamines improved the shelf life of mango fruit without impairing fruit quality.

Malik and Singh (2006) observed that application of spermine (0.01 mM) treatment reduced fruit softness, colour development and reduced physiological weight loss while increased fruit firmness, acidity and total carotenoid content compared with the control.

Bhat et al. (2014) found that spermine 0.5 mM given maximum total soluble solids of 19.60 °Brix of cv. Dashaheri after 14 days of storage compared to other treatments.
Litchi

Jiang and Chen (1995) reported that litchi fruit (cv. Huaizhi) were treated with 1 mM of the polyamines putrescine, spermidine and spermine, respectively, and then stored for up to 30 days at 5 °C. Addition of each polyamine increased the levels of the other two in almost every case and delayed the changes associated with senescence such as browning, peroxide level, ethylene production and cell leakage. Among those polyamines tested, spermine was the most effective.

Papaya

Purwoko et al. (1998) assessed the effect of polyamines on quality changes in papaya fruits. Fruits were treated with putrescine at 0, 1, 3 and 10 mM and with spermidine and spermine at 0, 0.3, 1 and 3 mM. Fruits were then stored at room temperature. Spermine treatments delayed softening and the increase in total soluble solid and peel color score, thereby extending the shelf life by up to 2.60 days.

Kiwi

Jhalegar et al. (2012) evaluated the effect of spermine on physiological and biochemical attributes of kiwi cv. ‘Allison’. Kiwi fruits were dipped in aqueous solutions of spermine (0.5, 1.0 and 1.5 mM) and stored under ambient conditions for 15 days. Spermine at 1.5 mM gave the best results in extending the shelf life of kiwi fruits. It extended the shelf life of kiwi cv. ‘Allison’ by six days.

Peach

Ullah and Jawandha (2013) studied the effect of polyamines on colour of stored peach fruits. Physiologically mature, uniform and healthy fruits of ‘Shan-i-Punjab’ were harvested and dipped for 5 minutes in spermine, spermidine and putrescine at three concentrations viz. 1.0, 2.0 and 3.0 mM, respectively. Result indicated that change green color of peach was delayed by the application of polyamines.

Strawberry

Abdi et al. (2013) studied the effect of spermine on post harvest life and quality of strawberry cv. ‘Camarosa’. Fruits were dipped for 5 minutes in a solution of spermine (0, 0.5, 1, 2 and 4 mM), dried and placed in a refrigerator at a temperature of 5 °C. Strawberry fruits treated with 2 mM were marketable even after 14 days of storage. It also prevented the loss of firmness during storage and resulted in good fruit quality.

Grape

Potential use of spermine as a postharvest dip treatment for maintaining quality and extending storage life of table grapes (Vitis vinifera L.) cv. ‘Flame Seedless’ was
investigated. Grape clusters were dipped in different concentrations (0.0-contol, 0.5, 1.0 and 1.5 mM/L) of spermine for 5 minutes, thereafter stored in a cold room (3-4 °C, 90-95 % RH). Spermine at a dose of 1.0 mM/L effectively maintained berry firmness and peel colour. In addition, it effectively retarded the degradation of total soluble solids and titrable acidity. Post harvest dip treatment of 1.0 mM/L spermine extended the postharvest life of grape cv. Flame Seedless up to 60 days in contrast to control which was commercially acceptable only up to 45 days (Champa et al., 2015).

**Apricot**

Ali *et al.* (2010) investigated the effect on quality by foliar application of spermine on ‘Canino’ apricot cultivar. They found that spraying spermine at $10^{-4}$ mM and $10^{-5}$ mM resulted in the highest TSS (15.73 °Brix) and lowest acidity (1.82 %) respectively.

Asadi *et al.* (2013) noted that foliar application of spermine (20 mM) at flower bud differentiation stage and ten days after flowering stage significantly increased the total soluble solids (11.53 %).

Nikfar and Abdoosi (2013) recorded the highest content of total soluble solids with the treatment of spermine (15 mM/L) when sprayed on apricot cv. ‘Shahroodi 48’ at Iran.

**2.4 EFFECT OF GIBBERELLIC ACID ON PHYSICAL AND BIOCHEMICAL CHARACTERS**

Gibberellins are a group of growth substances known to retard ripening and senescence of fruits. They are synthesized in young fruits by the developing seeds (Leopold and Kriedemann, 1975) and are believed to participate in promoting early fruit growth. In mature fruits, gibberellins have been reported to be involved in many of the physiological steps leading to ripening and senescence. Dailly (1969) has reviewed the effect of Gibberellin acid (GA) on the ripening of fruits.

Majumdar *et al.* (1981) observed that the mature unripe mangoes, cv. Alphonso, were dipped in $10^{-6}$ M $GA_3$, $10^{-6}$ M IAA or $10^{-5}$ M kinetin solutions delayed ripening.

Khader *et al.* (1988) reported that mango fruits cv. Mallika treated with 100 ppm significantly delayed ripening. $GA_3$ treatment retarded the total loss in weight, chlorophyll and ascorbic acid content, and reduced amylase and peroxidase activity during storage.
Khader (1992) suggested that post harvest treatment (dipping) mango cv. Mallika fruits in GA₃ 200 mg_l⁻¹ or with vapour guard (2.5 %) significantly reduced fruit ripening retarded ascorbic acid degradation in the flesh and other metabolic activities during storage. It also reduces percentage weight loss during storage at ambient temperature (34-37 °C) for 16 days.

Singh (2000) evaluated the efficacy of GA₃ and plant extracts on shelf life and quality of mango cv. Langra fruits. The treatments consisted of a control, GA₃ at 500 and 1000 ppm, and neem (Azadiracta indica) leaf extract, onion extract, castor oil and neem oil, each at 10 % concentration. Application of GA₃ at 500 ppm recorded the maximum organoleptic rating during the storage.

Jain and Mukherjee (2001) reported that mango fruits cv. 'Langra' treated with gibberellic acid at the rate of 200 or 300 mg_l⁻¹ significantly delayed ripening when stored between 36.15-27.08 °C temperature. GA₃ treatment retarded the increase in total soluble solids, loss in ascorbic acid content and acidity and reduced spoilage percentage in mango fruits.

Reddy and Haripriya (2002) conducted a laboratory experiment to test the efficiency of certain postharvest treatments using fungicide (carbendazim), growth regulator (GA₃, maleic hydrazide and 2,4,5-T) and subsequent storage in polyethylene bags with ethylene scrubbers, or the wrapped fruits in wooden boxes on the shelf life and quality of mango cultivars Bangalora and Neelum at room temperature. Among the subjected treatments, GA₃ (200 ppm) treated fruits stored in ventilated polyethylene bags with ethylene absorbent significantly reduced the physiological loss in weight, rate of respiration, delayed colour development and ripening and had longer shelf life.

Sakhale et al. (2004) concluded that the fruits treated with 100 ppm GA₃ and 8.00 % CaCl₂ were observed superior in respect of pre-ripening quality attributes. The treatment retarded the physicochemical changes feasible for manifestation of ripening quality features and certainly helped considerably in delaying the ripening. This has profoundly notified the extended storage life of Kesar mango.

Singh (2008) carried out experiment at the J.N.K.V.V College of Agriculture, Rewa (M. P.) and found that spraying of GA₃ (50 ppm) at marble stage or 20 days before harvest enhanced the specific gravity and pulp percentage and improved the organoleptic rating with consumers acceptability i.e. appearance, flavour, taste and
texture of 30 Sunderja mango fruits during 12 days after storage. GA₃ has also encouraged the total soluble solids and total sugar up to 8 days thereafter it was slightly decreased up to 12 days and discouraged the acidity of fruits. Carbandazim (200 ppm) followed by GA₃ (50 ppm) increased the marketable fruit percentage by reducing the spoilage of fruits during 12 days after harvest CaCl₂ (1.00 %) and 2, 4-D (20 ppm) enhanced the fruit weight, while physiological weight loss decreased due to 2,4-D. Thus, the findings allude that GA₃, carbandazim and 2,4-D have got significant role in maintaining and augmenting the physicochemical properties of mango fruits up to 12 days of their storage.

Anon. (2010) found that pre-harvest spray of GA₃ at 15 ppm and carbendazim 0.05 per cent reduced physiological loss in weight and increased shelf life in mango.

Islam et al. (2013) concluded that physicochemical properties viz., physiological weight loss, moisture content, pulp pH, total soluble solids, sugar (total, reducing and non-reducing), were rapidly increased in GA₃ treated mango cvs. ‘Langra’and ‘Khirshapat’. GA₃ at 400 ppm showed better performance in delaying the changes in physicochemical properties and extended shelf life of mango.

Siddiqui et al. (2014) studied the influence of gibberellic acid (GA₃) at concentrations of 0, 50, 100 and 150 mg/l water sprayed 20 days before commercial harvest on postharvest behaviour and quality of mango cv. ‘Himsagar’ was studied under ambient storage conditions. GA₃ (100 and 150 mg/l) delayed the onset of ripening and caused a reduction in respiration rate as compared to the untreated fruits and retained the total chlorophyll content of fruit peel. Pre-harvest spray of GA₃ at 100 mg/l significantly delayed the onset of the climacteric rise of CO₂ production, which depicted delayed ripening over control. The treated fruits also remained firmer and maintained the freshness during storage. The results shown that treatment with 100 mg/l GA₃ could be a useful method.

Patel et al. (2015) conducted a trial to study the effect of pre-harvest spray of chemicals on shelf life of mango cv. Kesar. The results of the experiment revealed that physical parameters like highest marketable fruit, minimum spoiled fruit, minimum ripened fruit as well as lowest days for ripening were recorded in pre-harvest spray of GA₃ 25 ppm + borax 1 %. The quality parameters like total soluble solids, acidity, ascorbic acid, vitamin–A, colour, flavour, texture, taste and overall
acceptability etc. were performed better in pre-harvest spray of GA\textsubscript{3} 25 ppm + CaCl\textsubscript{2} 2 \% and GA\textsubscript{3} 25 ppm + ZnSO\textsubscript{4} 0.05 \%.

**Banana**

Sembok *et al.* (2016) reported that GA\textsubscript{3} was able to delay the climacteric peak of Berangan banana and also retard the peel color changes, fruit softening and extend its shelf life up to 16 days.

**Sapota**

Choudhary *et al.* (2003) conducted an investigation to study the effect of certain chemicals on sapota fruits variety Pala subjected to various pre and post-harvest treatment such as GA\textsubscript{3} (100 ppm and 200 ppm ), Topsin M (0.1 and 0.2 \%), Bavistin (0.1 and 0.2 \%), CaCl\textsubscript{2} (1 and 2 \%) and water. All the treatments responded well in extending the shelf life, reducing physiological los in weight and rotting as well as augmenting biochemical attributes such as TSS and acidity as pre-harvest spray and post harvest dip.

Sudha *et al.* (2007) found that pre-harvest spray of 50 ppm GA\textsubscript{3} with post harvest dipping of GA\textsubscript{3} 50 ppm along with 0.2 \% Bavistin recorded the lowest physiological loss of weight, shrinkage percentage, increased the shelf life and reduced spoilage. The pre harvest 3, 2 sprays of 50 ppm GA\textsubscript{3} with post harvest dipping of CaCl\textsubscript{2} 1 \% along with 0.20 \% Bavistin recorded highest firmness. The same treatment recorded higher total sugar, increased ascorbic acid, reduced acidity. The same treatment recorded highest total soluble solids.

**Papaya**

Yadav and Varu (2013) reported that pre harvest spray of GA\textsubscript{3} 15 ppm + carbendazim 0.05 \% and post harvest dip in CaCl\textsubscript{2} 1.00 \% individually as well as their combination (S\textsubscript{4}D\textsubscript{2}) were found to be more effective in reducing physiological loss in weight, highest percentage of marketable fruit, lowest percentage of ripened fruit, lowest days to start ripening and highest shelf life. Similarly for biochemical parameters and organoleptic score, highest total soluble solids, lowest acidity, highest ascorbic acid, total sugar, vitamin A and fungus intensity as well as organoleptic parameters like color, texture, taste, flavor and overall acceptability were also found better in GA\textsubscript{3} at 15 ppm + carbendazim 0.05 \% as pre harvest spray and CaCl\textsubscript{2} 1.00 \% (D1) as post harvest dip. The interaction effect was also found significant and better performance was observed in treatment combination S\textsubscript{4}D\textsubscript{2}.
2.5 EFFECT OF CALCIUM CHLORIDE ON PHYSICAL AND BIOCHEMICAL CHARACTERS

Singh et al. (1993) investigated the changes in postharvest quality of mangoes affected by pre harvest application of calcium salts. All Ca\(^{+2}\) treatments delayed ripening and had a favourable effect on the quality of the fruits during storage. The Ca\(^{+2}\) treated fruits showed a higher Ca level in the peel and flesh, a lower cumulative physiological loss in weight and a reduced respiration rate. Fruits from the most favourable treatment (0.60 % Ca\(^{+2}\) as CaCl\(_2\)) could be stored for 10 days.

Gunjate et al. (1979) reported that the pre-harvest calcium dip treatments significantly reduced the occurrence of spongy tissue in ripe Alphonso fruits. Calcium chloride was more effective in reducing occurrence of spongy tissue than calcium nitrate.

Singh et al. (2000) reported that treatment with 8.00 % calcium chloride significantly delayed fruit ripening, increased fruit firmness and reduced fruit rot as compared to the untreated fruits of mango cv. Haden. The treatment of calcium chloride increased the acid content of the fruits. All the treatments with calcium chloride significantly increased total soluble solids, total sugars and eating quality. Also the research findings proved that post harvest calcium treatments combined with modified atmospheric packaging improved fruit quality and prolonged shelf life of mango.

Singh (2000) reported that the post harvest application of calcium chloride increased the marketable percentage of fruits and beta carotene in mango.

Jain et al. (2001) reported that the post harvest application of wax emulsion (8.00 %) and calcium nitrate (1.00 %) in combination with cool chamber storage markedly reduced the rate of ripening and helped to retain the quality characteristics of mango fruits during storage. At the end of the storage period, maximum ascorbic acid and highest organoleptic score were obtained with calcium nitrate (1%) + cool chamber storage.

Ruicheng et al. (2001) studied effects of post-harvest treatment with calcium on some physiological aspects of mango. The result of the experiment indicated that under 20±0.5 °C, 3.00 % of calcium chloride is ideal, which can effectively slow down the physiological activities of post-harvest mango but will not cause physiological diseases.
Silva and Menezes (2001) evaluated the postharvest quality of ‘Tommy Atkins’ mango after the pre harvest application of CaCl₂ and refrigerated storage. The studied factors were concentrations of CaCl₂ (1.00 % and 2.00 %) and numbers of applications (2, 3 and 4 times). The spraying began 35 days after anthesis in intervals of 15 days. Of the 280 harvested fruits, 175 were taken for immediate analysis, while 105 were left in a cold chamber (10 °C) during 30 days for later analysis. Significant difference was observed between the tested concentrations of CaCl₂ and the witness, for most of the appraised quality characteristics, except for total sugars (fruits analyzed after 30 days), while the number of applications presented.

Anjum and Ali (2004) revealed that calcium chloride delayed the fruit ripening about 3 days as compared to control and resulted in better aroma of the mango fruits cv. SS-1 (Kala Chausa), however, it induced skin shrivelling. The increase in concentration of calcium salts resulted in delayed ripening but had negative effect on fruit quality by increasing skin shrivelling and lowering flavour and taste of the fruits. Calcium chloride at 5.00 % delayed the ripening for 4 days and resulted in better skin and pulp colour but with increased skin shrivelling and poor flavour and taste, indicating poor eating quality.

Santos et al. (2004) concluded that as compared to controls, 8.00 % CaCl₂ treatment provided a five-day increase in shelf-life of mature-green ‘Rosa’ mango stored at 10 ± 1 °C. Upon transference to room temperature, 8.00 % CaCl₂ provided lowest weight losses, while maintaining total soluble solids, total titrable acid content, fruit firmness, and best internal and external appearances, even though, no significant delay on skin colour development was detected.

Bringas-Taddei et al. (2005) observed that ‘Kent’ mangoes treated with 1.00 % CaCl₂ + wax, compared with the other treatments, had significant differences in respiratory rate and weight loss, and had a good appearance, without spots and rots at the 12 days of the evaluation to 20 °C.

Waskar and Gaikwad (2005) found that the shelf life of mango fruits could be extended upto 65 days when treated with a combination of CaCl₂ (2.00 %) + wax (6.00 %) + Bavistin (0.1 %) and stored in cool store, upto 35 days when stored in cool chamber and upto 24 days when stored at room temperature. On the contrary, the shelf life of untreated fruit was found to be hardly 18 days at room temperature. Also,
observed that this treatment recorded lower physiological loss in weight and high organoleptic score when stored in cool store and cool chamber as compared to room temperature storage

Singh et al. (2013) studied the effect of chemicals and packaging on quality of mango fruits under cold storage. The experiment revealed that calcium chloride at 2.00 % + LDPE treatment were found significantly effective in maintaining firmness, total soluble solids, titratable acidity and retaining more ascorbic acid at the end of the storage.

Karmera and Habimana (2014) investigated the effect of pre-harvest calcium chloride on post harvest behavior of mango fruits (Mangifera indica L.) cv. Alphonso. The results revealed that 1.50 % CaCl₂ significantly increased the number of days taken for ripening of fruits, the shelf-life of fruits, physicochemical parameters and organoleptic evaluation of mango fruits compared to control.

Khaliq et al. (2015) studied the effect of gum arabic (GA) 10.00 % and calcium chloride 3 per cent on the physiological and biochemical properties of mango. The combined treatment of calcium chloride 3.00 % + GA 10.00 % significantly alleviated the increase in decay incidence. Furthermore, GA 10.00 % alone or combined with calcium chloride 3 per cent effectively reduced weight loss, colour changes, soluble solid concentration, respiration rate, ethylene production and maintained high firmness, titratable acidity and ascorbic acid. These results suggest that application of GA 10.00 % coating combined with calcium chloride 3 per cent might be a simple and effective technique for preserving mango fruit quality during low temperature storage.

Singh et al. (2015) reported that pre harvest application of CaCl₂ at 2.00 % with polythene mulching is effective for improving the fruit marketability and decreasing the physiological loss in weight of ‘Dashehari’ mango.

**Sapota**

Laksmana and Reddy (2000) reported that application of CaCl₂ 1.50 % increased post harvest life and reduced the physiological loss in weight of sapota fruits.
**Grapes**

Kalloo (2003) mentioned that pre-harvest spraying with calcium compounds prolonged the storage life of grapes. Spraying of 1.00 % calcium nitrate 10 days before harvesting reduced the desiccation and decay in grapes.

**Papaya**

Rajkumar et al. (2005) conducted a study in order to examine the efficacy four levels each of CaCl$_2$, Ca(NO$_3$)$_2$ (1 %, 2 %, 3 % and 4 % each) and GA$_3$ (50, 100, 150 and 200 ppm) on the post-harvest behaviour of papaya fruits. The post harvest treatment of papaya fruits in CaCl$_2$ at 2.00 % and GA$_3$ at 100 ppm recorded significantly the lowest level of loss in fruit weight, ripening percentage and rate of decay and registered high firmness, high total soluble solids content, high ascorbic acid content, titrable acidity and also higher score for sensory evaluation. The study suggests that both GA$_3$ at 100 ppm and CaCl$_2$ at 2.00 % as post harvest treatment could preserve the physiological changes and improve the shelf life up to nine days and the quality in papaya.

**Guava**

Jayachandran et al. (2005) studied the effect of pre-harvest spray of three different sources of calcium viz., calcium chloride, calcium nitrate and calcium sulphate at concentrations of 0.5 and 1.0 % each on fifteen year old Lucknow- 49 trees 15 days before harvest. Pre-harvest spray of calcium compounds reduced physiological loss in weight and titratable acidity, while they increased total soluble solids, reducing sugar and pectin contents. However, higher concentration of calcium nitrate was more effective than other treatments. The fruits firmness increased as the concentration of calcium increased in the fruits. Calcium nitrate delayed softening and enhanced the shelf-life of fruits.

**2.6 CHANGES DURING FRUIT RIPENING**

Mango fruit undergo biochemical changes during ripening. A typical biochemical change during ripening is the hydrolysis of starch to sugars. In green mangoes, starch content of 14 per cent was reported to fall to 0.3 per cent during ripening (Medicott *et al.*; 1986; Selvaraj *et al.* 1989; Kumar *et al.*, 1994). Ascorbic acid content in fruits decrease during ripening. During storage period the oxidative enzymes like ascorbic oxidase, peroxidise, catalase and polyphenol oxidase are activated. In this time rapid oxidation of L-ascorbic acid into dehydro ascorbic acid by ascorbinase increases (Mapson, 1970; Thomas & Oke, 1980). This will lead to the
reduction in ascorbic acid content. Titrable acidity decreases during ripening and storage. Decline in the acidity is due to the utilization of organic acids in energy production and alcoholic fermentation (Purvis, 1993). Carotenoids content increase with progress in ripening. Carotenoids are produced due to chlorophyll degradation (Hulme, 1971; Rathore et al., 2007) and reduction in carotenoids occurs in several varieties at over ripe stage (Sahni and Khurdiya, 1989). Kapse (1993) opinioned that biochemical constituents of mango pulp can be correlated with organoleptic charaters. During ripening starch to sugar conversion occurs and this influence the quality characteristicas of a fruit. The increase in sugars during storage might be possibly due to the breakdown of complex organic metabolites into simple molecules or due to the hydrolysis of starch into sugars (Bhakshi and Masodi, 2009). This all biochemical changes contribute to high organoleptic quality (Herianus et al., 2003) and consumer acceptance. Narayana et al., 1996 concluded that due to high rates of evapo-transpiration and respiration, weight loss gradually increase during storage. Rotting of fruit with the advancement of storage period was reported in mango (Kumar and Nagpal, 1997), and Kinnow orange (Kumar and Chauhan, 1990) may be due to increased proliferation of microbial organisms on the surface of fruits. Textural softness and respiration rate leads to short shelf life of fruits (Razzaq et al., 2013), spoilage and rotting will enhance the reduction in shelf life. During ripening, softness of fruit increases due to increase in soluble pectin (Maduwanthi and Marappana, 2017). Cell wall of fruit undergoes natural degradation during fruit ripening and reduces cell wall firmness. This may lead to the attack of spoilage organisms and reduce shelf life of fruits.