CHAPTER-V
DISCUSSION

While presenting the results of present investigation entitled “Effect of pre and post harvest treatments of chemicals on shelf life of different cultivars of mango (Mangifera indica L.)” in the chapter of experimental results, both significant and non significant variation were noted in physical, biochemical and organoleptic parameters due to the varietal effect as well as different chemical treatments.

The appropriate reasons with observed variation recorded during the present study are explained in this chapter. Studies conducted relevant to this have been quoted and results reported by other researchers also have been used to assess the results obtained in the present study. The results of investigation have been highlighted in the following aspects.

5.1 Physical parameters

5.1.1 Fruit characters

In mango medium sized fruits weighing 250 to 300 g is most desirable size and preferred by the consumers. Neither too small nor too big fruits have very little consumer acceptance. In the present study variation was observed among the varieties and hybrid for the fruit weight, pulp weight, peel weight, stone weight, length, breadth of fruits, volume of fruits, pulp to peel ratio and pulp to stone ratio. Among the varieties studied, the variety Langra recorded the maximum weight of fruit (266.57 g), volume of fruit (263.07 cm$^3$), pulp weight (195.95 g), highest fruit length (10.31 cm), pulp to stone ratio (5.26), pulp to peel ratio (5.89) and Ratna recorded maximum stone weight (51.39 g), peel weight (36.19 g) maximum girth of the fruit (7.81 cm). Langra and Ratna recorded superior fruit characters compared to Alphonso and Kesar. Singh and Tripathi (1974), Shyamal and Mishra (1987), Minhas et al. (1991), Sharma and Josan (1995) and Anila and Radha (2003) also reported similar findings in these varieties. Whereas Kesar recorded the least fruit weight (222.45 g) and pulp weight (158.18 g). Both Kesar and Alphonso were observed similar in fruit characters. It can be concluded that variation in physical parameters of fruit may be due to the varietal characters. High pulp yield per fruit coupled with small and thin stone and thin peel are desirable characters of an ideal variety. The variation in physical characteristics of mango fruit is natural due to differences in environmental and seasonal condition has
also been observed earlier (Badyal and Bhutani, 1989). The variability in fruit weight among different cultivars might be due to genotypic and environmental influences and management practices (Mannan et al., 2003). However, these varieties showed variability in their physical characters, their storage behaviour also very important for the long shelf life. Behaviour of these varieties in shelf life and quality aspects are further discussed in this chapter.

Effect of different chemicals on fruit physical parameters listed above was found non-significant. This might be due to the fact that pre-harvest applications are more successful early in the development of fruits rather than when they are applied late just before harvest (Karmera and Habimana, 2014). Also post harvest applications might not have influenced in fruit weight but they might be influenced in minimising the weight loss and enhancing the quality during storage. Interaction effect also found non-significant here.

5.1.2 Physiological loss in weight

The observation of present study indicated that, with the increase in duration of storage there was an increase in physiological loss in weight. But the loss in weight varied among different varieties and treatments.

The physiological loss in weight gradually increased in all the varieties with the advancement of the storage period. However the minimum loss in weight was recorded in Kesar variety throughout the storage and maximum loss in weight was observed in Langra. The higher weight loss in Langra fruits might be due to greater loss of moisture owing to higher rate of evapo-transpiration and respiration (Naryana et al., 1996) under higher temperature and low relative humidity. The higher rate of physiological loss in weight in Langra might be due to early ripening, consequently enhanced rate of various physiological and degradative metabolic processes during storage (Karuna et al., 2015). The thinner skinner fruits with less waxy coating may show more loss in weight, while the reverse is true with thick-skinned fruits. Rajwana et al. (2010) observed that weight loss may be attributed to cultivar difference or ripening conditions. Similar trends are recorded by Kumar and Dhawnn (1995), Hoda et al. (2011), Reddy (2015), Karuna et al. (2015) in mango and Killadi et al. (2007) in guava.

The results of the present investigation indicated that physiological loss in weight was significantly influenced by the application of polyamines. The minimum loss in weight starting from the first day of storage up to the 20th day occurred
consistently in fruits treated with putrescine 2 mM. Similarly, the maximum loss in weight was observed in untreated fruits during the entire storage period. The reduced loss in weight of fruit was more evident in fruit treated with putrescine, it might be due to comparatively lower rates of respiration and increased fruit firmness (Valero et al., 1998). Reduction of weight loss in putrescine treated fruits can be ascribed to conjugation of polyamines to the cell membrane phospholipids and consequently stabilization as well as consolidation of both cell integrity and permeability (Hosseini et al., 2017 and Mirdehghan and Rahimi, 2016). The findings of Gavri (2015) in mango, Mirdehghan et al. (2013) in pistachio nut, Malik et al. (2006) and Shiri et al. (2012) in grape are in confirmation with the present investigation.

The interaction effect also found significant and lower physiological loss in weight observed in treatment combination of V₁C₁ (Kesar + Putrescine 2 mM). This might be due to the delayed rate of respiration, increased cell integrity and fruit firmness of putrescine treated Kesar fruits. Similar results have been reported by Venu (2017) and Babu (2014) in mango fruits cv. Kesar.

5.1.3 Marketable percentage of fruits

From the present study it was observed that percentage of marketable fruits decreased with the progress in storage period.

Among the different varieties, Kesar variety given more marketable fruits throughout the storage period and minimum marketable fruits was recorded in Langra variety. Kesar variety might have given maximum percentage of marketable fruits due to the marketability of fruit is closely related to reduced spoilage and colour of fruit. Reduction in the loss of water and delayed ripening of fruits turns to shelf life also might be a reason. The fruits of variety Langra exhibited minimum percentage of marketable fruits might be due to more spoilage probably owing to enhanced rate of respiration and ripening. Fruits become pulpy and senescent rapidly due to various physiological and biochemical events and other degradative process under normal conditions, which may increase the spoilage and reduce marketable percentage of fruits (Karuna et al., 2015). These physiological and biochemical events show variation among different genotypes. These findings are in accordance with studies conducted by Reddy (2015), Hoda et al. (2000), Araiza et al. (2015) in mango and Akter et al. (2013) in banana.

The fruits treated with putrescine 2 mM proved effective compared to control for maximum marketable fruits. This might be due to delayed ripening increased the
shelf life. Colour development might be good (due to higher carotenoid contents) in treated fruits, increased firmness with reduced spoilage of fruits might have enhanced marketable percentage of putrescine treated fruits. Similar findings are in confirmation with Gavri et al. (2016), Jawandha et al. (2013), Malik and Singh (2006), Bhat et al. (2014), Malik et al. (2003) in mango, Mirdehghan and Rahimi (2016) in grapes and Hosseini et al. (2017) in pear cv. Spadona.

The interaction effect also found significant and maximum marketable percentage was observed in treatment combination of V1C1 (Kesar + Putrescine 2 mM). This might be due to the delayed rate of respiration, good colour development and reduced spoilage percentage of owing to good shelf life of putrescine treated Kesar fruits. Also varietal character of Kesar also might have been influenced. Similar results have been reported by Gavri et al. (2016), Venu (2017) and Babu (2014) in mango fruits cv. Kesar.

5.1.4 Spoiled fruits

From the results of investigation carried out it was observed that spoilage percentage increased with increase in storage days.

The spoilage of fruits increased successively with the prolongation of storage period, irrespective of cultivars. Kesar variety gave the lowest spoilage loss during storage at all the days and variety Langra recorded the highest spoilage loss. Similar increase in rotting of fruit with the advancement of storage period was reported in mango by Reddy (2015), Karuna et al. (2015), Hoda et al. (2000) in mango and Akter et al. (2013) in banana. Increase in spoilage loss with prolongation of storage period might be due to existing pathogen on the surface of fruits, which might have proliferated with time resulting in increased rotting. The fruits of variety Langra exhibited more spoilage probably owing to enhanced rate of respiration and ripening. Fruits become pulpy and senescent rapidly due to various physiological and biochemical events and other degradative process under normal conditions.

Fruit spoilage was significantly minimised by the application of putrescine. The minimum spoilage was reported in fruits treated with putrescine 2 mM. Whereas, the maximum spoilage was observed in untreated fruits. Reduced spoilage can be attributed to a decrease in the microbial activity of fruits (Mirdehghan et al., 2013) and might be related to retarded rate of ripening (Malik et al., 2003). Polyamines conjugated to phenolic compounds and hydroxycinamic acid amides have been shown to accumulate in cells in interactions between plants and a variety of pathogens. Thus,
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Putrescine treated fruits had less fungal infection than untreated ones. Similar findings were also observed by Jawandha et al., 2013, Bhat et al. (2014) in mango, Mirdehghan et al. (2013) in pistachio nut and Mirdehghan and Rahimi (2016) in grapes.

The interaction effect also found significant and minimum spoilage percentage observed in treatment combination of V₁C₁ (Kesar + Putrescine 2 mM). This might be due to the retarded rate of ripening, reduced weight loss through transpiration and respiration and delayed the disintegration during ripening. Similar results have been reported by Malik et al. (2003) in ‘Kensington Pride’ mango and Gavri et al. (2016), Venu (2017) and Babu (2014) in Kesar mango.

5.1.5. Ripened fruits

Ripening percentage increased with increase in storage period upto 15 days. In the present study ripening tendency showed considerable variation among different varieties and chemical treatments. Ripening is a physiological process which insists the conversion of starch to sugar. Hence ripening increased with increase in storage period. Among different varieties Langra fruits showed faster ripening compared to all other varieties and Kesar showed slow ripening tendency. Delay in ripening might be associated with reduced rates of respiration, ethylene synthesis and genetic variability among different varieties. Similar findings were reported by Reddy (2015), Karuna et al. (2015) and Hoda et al. (2000) in mango.

Higher percentage of ripened fruits was found in putrescine 2 mM treated fruits and lowest was found in control fruits. Application of putrescine 2 mM could be due to delayed changes associated with the senescence such as ethylene production, browning, peroxide level and cell leakage (Jiang and Chen, 1995), preventing fungal infection (Mirdehghan et al., 2013) and retardation of fruit softening due to the inhibition of polygalacturonase activities, presumably through binding to pectic substances (Kramer et al., 1989). Malik and Singh (2003) have also observed that ethylene and polyamines showed opposite effects on mango fruit ripening and senescence. Polyamines compete directly with ethylene for S-adenosyl-L-methionine (SAM) the common precursor in their biosynthesis pathway and ethylene synthesis will be accelerated at later stages fruit senescence with decrease in the endogeneous level of polyamines (Valero et al., 2002). Therefore, this might be the probable reasons for delayed ripening in polyamines treated fruits. Martinez-Romero et al. (2002) and Venu (2017) also reported the similar findings.
The interaction effect also found significant and slow ripening was observed in treatment combination of V1C1 (Kesar + Putrescine 2 mM). This might be due to the antisenescence effects of putrescine with the reduced rates of ethylene synthesis in mango fruits. Similar results have been reported by Venu (2017) in Kesar mango fruits.

5.1.6. Average number of days taken to ripen

Days taken for ripening were varied among different varieties and treatments. Among the different varieties Kesar took more days for ripening, while ripening was faster in Langra compared to all other varieties. This might be related to the difference in varietal behaviour towards the ripening. The enhancement of ripening might be consequence of rapid changes in weight loss and other physiological processes like respiration and transpiration. Faster ripening in Langra fruits might be due to the enhanced rates respiration and early attainment of respiratory climacteric. Slow ripening might be attributed to the long shelf life of Kesar fruits. Similar results found in studies conducted by Reddy (2015), Karuna et al. (2015) and Hoda et al. (2000) in mango.

The maximum days to ripening were recorded at putrescine 2 mM treated fruits as compared to other treatments and the minimum days to ripening were recorded in treatment control. Application of putrescine 2 mM could be due to delayed synthesis of ethylene production, since polyamines and ethylene have opposite effect in fruit senescence. Delayed start of ripening in polyamines treated fruits might be associated with the reduction of endogeneous levels of polyamines occurred only in the later stage of storage, which triggered the ethylene production in the later stages of storage compared to untreated fruits (Valero et al., 2002). Similar studies conducted by Malik et al. (2003), Malik et al. (2006), Venu (2017), Martinez et al. (2001) in mango and Mirdehghan et al. (2013) in pistachio nut, are in confirmation with the present investigation.

Interaction among the different varieties and treatments found significant. Treatment combination of V1C1 (Kesar + Putrescine 2 mM) reported the maximum days taken for ripening. This might be related to the delay in ripening initiation in putrescine treated fruits due to the suppression of ethylene synthesis (Valero et al., 2002) and varietal response of Kesar.
5.1.7. Shelf life

The shelf life of fruits determines their keeping quality. Shelf life showed variation within the varieties and different chemicals. Prolonged shelf life of mango fruits can attribute to the superior quality, achievement of better prices in market and long distance transport.

Varieties found differing in their shelf life. Kesar fruits showed maximum shelf life in the present study while shelf life was observed minimum in Langra variety. At the same time Alphonso and Ratna showed better shelf life compared to Langra. Longer shelf life might be due to the the lower spoilage of fruits, higher firmness, lower losses in weight, higher peel thickness, reduced rates of respiration, evapo-transpiratons, decreased rates of chlorophyll breakdown, less carotenoid accumulation, protein breakdown and decrease in enzyme activities. The observed variation among the varieties might be attributed by the genetic makeup, growing conditions, agroclimatic variations and prevailing temperature during storage. Langra might have been showed shortest shelf life due to the increased rates of respiration, higher spoilage rates and physiological losses in weight (Karuna et al., 2015) owing to short shelf life as reported by many scientists. Postharvest shelf life and quality of mango fruit is decreased with enhanced textural softness and respiration rate during ripening period (Razzaq et al., 2013). These findings have support of works done by Reddy (2015), Hoda et al. (2000), Rajwana et al. (2010), Naz et al. (2015), Araiza et al. (2015) in mango and Akter et al. (2013) in banana.

The significant improvement was observed in shelf life of mango fruits by the application polyamines. The maximum shelf life was recorded in fruits treated with putrescine 2 mM and the minimum shelf life was observed in untreated fruits. The probable reasons for increased shelf life by application of putrescine could be due to delayed changes associated with the senescence such as ethylene production, browning, peroxide level and cell leakage (Jiang and Chen, 1995), preventing fungal infection (Mirdehghan et al., 2013) and retardation of fruit softening due to the inhibition of polygalacturonase activities, presumably through binding to pectic substances (Kramer et al., 1989). Similar findings were also observed by Malik et al. (2006), Babu (2014), Venu (2017), Gavri et al. (2016), Bhat et al. (2014) in mango, Khan and Singh (2008) in plum, Mirdehghan et al. (2013) in pistachio nut and Hosseini et al. (2017) in pear.
Shelf life has significantly increased by the different treatment combinations. Among the different combinations maximum shelf life was showed by the treatment combination of V₁C₁ (Kesar + Putrescine 2 mM) this might be due to delayed ripening, minimum degradation and spoilage, lower weight losses, delayed colour changes, reduced rates of respiration and genetic makeup of varieties. Similar results was reported by Malik et al. (2003) in ‘Kensington Pride’ mango and Gavri et al. (2016), Venu (2017) and Babu (2014) in Kesar mango.

5.1.8 Firmness of fruits

Fruit firmness is an important criteria for evaluating the shelf life and quality of fruits. In the present study firmness of fruits showed considerable variation.

Among the different varieties, Kesar recorded the highest fruit firmness throughout the storage period and minimum was maintained by Langra. The rapid decline in fruit firmness during ripening is the result of enzymatic degradation of structural as well as storage polysaccharides. Cell walls of fruit undergo a natural degradation during fruit ripening, reducing cell wall firmness and intercellular adhesion. During ripening, softening of fruit is caused by the increase in soluble pectin (Maduwanthi and Marappana, 2017). Lower firmness noted in Langra might be due to its thinner peel as compared to rest of the varieties leading to an early structural change in cell wall, resulting into decline in firmnes. The observed difference among varieties could be due to variation in physiological and physical characteristics among cultivars such as skin thickness and the rate of decline in textural properties was found to be cultivar specific (Jha et al., 2013). Similar findings of decrease in firmness of fruits during storage, was reported by Araiza et al. (2015) in mango and Killadi et al. (2007) in different guava varieties.

Putrescine 2 mM fruits recorded higher firmness compared to control throughout the storage period. The increase in fruit firmness with putrescine application could be attributed to their influence on inhibiting ethylene biosynthesis (Kassem et al., 2011) and the activity of cell wall degrading enzymes such as pectinesterase, pectin methylesterase and polygalacturonase involved in fruit softening (Valero et al., 2002). Cross linking of polyamines to the -coo- group of pectic substance in the cell wall binds or blocks the access of degrading enzymes, reducing the rate of softening during storage leading to rigidification and increased fruit firmness (Valero et al., 1998). The increase in fruit firmness with the application of putrescine was reported in a variety of fruits by earlier workers, Malik et al. (2003),

Interaction between the varieties and chemicals also was found significant. The treatment combination of V₁C₁ (Kesar + Putrescine 2 mM) recorded highest firmness during entire period of storage. This might be due to the role of putrescine on inhibiting ethylene biosynthesis and the activity of cell wall degrading enzymes and the genetic response of varieties towards that chemical. Similar results have been reported by Gavri et al. (2016) in mango fruits cv. Kesar.

5.2 Biochemical parameters

5.2.1 Total soluble solids (TSS)

There was an increase in TSS with increasing period of storage. The initial TSS was low and that is gradually increased first and then decreased slightly in the last stage. The initial rise in TSS could be due to accumulation of starch in hydrolysis, while the later decrease was due to consumption of sugar for respiration during storage (Medicott et al., 1986; Selvaraj et al., 1989 and Kumar et al., 1994).

The TSS content of mango fruits increased with advancement of storage period up to 20th day of storage. However, in case of Langra it was declined after 10th day and a slight decrease in TSS was observed in Ratna at the end of storage period. But both the varieties, Kesar and Alphonso maintained increasing tendency of TSS up to last days of storage. On the termination day (20th day) of experiment the highest TSS was noticed in Kesar followed by Alphonso and Ratna and Langra was recorded lowest TSS. The gradual increase in TSS of fruit pulp could be due to the breakdown of starch into soluble sugars with the progress of storage period. The increase in TSS may be accounted to the moisture loss, hydrolysis of polysaccharides and conversion of organic acids into sugars. Slow and gradual increase in TSS in Kesar might be due to delayed ripening. The results are in agreement with the studies conducted by Reddy (2015), Karuna et al. (2015), Jadhao et al. (2000), Naz et al. (2015), Hoda et al. (2000), Araiza et al. (2015) in mango and Akter et al. (2013) in banana.

Increase in TSS was observed in mango fruits treated with different chemicals. The TSS was gradually increased first and then decreased slightly in the later stages. On termination day of storage highest TSS was recorded in putrescine treated fruits and control recorded the lowest. Putrescine treated fruits showed slow rise in TSS
compared to other treatments. This might be due to hydrolysis of starch and other polysaccharides to soluble forms of sugar. The role of putrescine in maintaining TSS would be attributed to delay in respiration, ethylene synthesis and subsequently retarding the ripening process (Valero et al., 2002). These findings were also observed by Gavri et al. (2015), Ali et al. (2017), Jawandha et al. (2013), Malik et al. (2006) and Malik et al. (2003) in mango, Mirdeghan and Rahimi (2016) in grape, Kassem et al. (2011) in ber, Khosroshahi et al. (2008) in sweet cherry and Hosseini et al. (2017) in pear.

Interaction effect also found significant during entire storage period. On the last day of storage highest TSS was recorded by the treatment combination of V1C1 (Kesar + Putrescine 2 mM). This might be due to the delayed ripening in putrescine treated fruits and varietal characters. These results are also in agreement with the findings of Gavri (2015) in mango fruits cv. Kesar.

5.2.2 Acidity

The present study revealed that acidity decreased steadily during the entire period of storage. The level of titratable acidity of mango fruits declined slowly throughout the period of storage in all the cultivars. However, the trend of the decline varied among different cultivars. Maximum acidity was recorded in Kesar throughout the period of study. However, minimum acidity was recorded in Langra might be due to faster ripening. Decline in titratable acidity during storage is result of conversion of acids into salts and sugars. It has been opiined that decline in acid content is due to utilization of organic acids in energy production and alcoholic fermentation (Purvis, 1933). Delayed ripening, slower rate of physiological events and reduced biochemical degradation might be responsible for high acid in cultivar Kesar. These findings are in accordance with the studies conducted by Akthar et al. (2009), Kumar (2009), Reddy (2015), Karuna et al. (2015) and Hoda et al. (2000), Mitra et al. (1999), Anila and Radha (2003), Araiza et al. (2015) and Naz et al. (2015) in mango.

Total titratable acidity was decreased in all the treatments during storage, but the decline was rapid in control compared with putrescine 2 mM treated fruits. At the end of storage highest acidity was retained in putrescine 2 mM treatment. The slower changes in reduction of titrable acidity in putrescine might be due to the reduction in respiration rate, ethylene synthesis and subsequently retarding the ripening process (Valero et al., 2002). This might have been reduced the utilization of organic acid in respiration. Similar results are obtained in studies conducted by Jawandha et al.
Among the different combinations maximum acidity was maintained by the treatment combination of V_{1}C_{1} (Kesar + Putrescine 2 mM). This might be attributed due to the varietal characteristics and delayed respiration by putrescine. Similar results have been reported by Venu (2017) in Kesar mango.

### 5.2.3 Ascorbic acid

The ascorbic acid content in fruits decreased gradually with the advancement of storage period in all the cultivars and chemical treatments. During storage period the oxidative enzymes like ascorbic acid oxidase, peroxidase, catalase and polyphenol oxidase might be activated causing decreases in ascorbic acid content of the fruits. This may also be due to rapid oxidation of L-ascorbic acid into dehydroascorbic acid by enzyme ascorbinase (Mapson, 1970).

On the end day of storage experiment (20\textsuperscript{th} day) Kesar variety gave maximum ascorbic acid whereas lowest was noted in Langra. Variation in decreasing trend might be due to different level of oxidation in different varieties. Reduction in Vit. C contents of the fruit during ripening may be attributed to the susceptibility of ascorbic acid to oxidative destruction particularly at high ambient storage temperature (Thomas & Oke, 1980). These findings are in close conformity with the findings of Reddy (2015), Karuna \textit{et al.} (2015) and Hoda \textit{et al.} (2000) in mango.

Among different chemical treatments putrescine 2 mM treated fruits had beneficial effect in delaying the reduction in ascorbic acid content. Putrescine treated fruits maintained higher ascorbic acid and slower reduction in acid level throughout the storage period. This beneficial effect of putescine might be due to the exogeneous application of putrescine inhibits ascorbic acid oxidation by decreasing ascorbate oxidase activity and consequently maintaining ascorbic acid (Hosseini \textit{et al.}, 2016). The findings of this investigation is similar with the findings of Ali \textit{et al.} (2017) in mango, Hosseini \textit{et al.} (2016) in banana, Davarynejad \textit{et al.} (2013) in apricot, Khan and Singh (2008) in plum, Kassem \textit{et al.} (2011) in ber and Hosseini \textit{et al.} (2017) in pear.

Interaction effect of varieties and chemical found non-significant throughout the storage period.
5.2.4 Total sugar, reducing sugar and non-reducing sugars

In the present study the level of total sugars, reducing sugar and non-reducing sugars increased significantly with the prolongation of storage period and it reduced slightly at the end of storage period. The possible reason for an increase in sugars might be due to conversion of starch and polysaccharides into soluble sugars. The reduced rate of respiration, slow conversion of starch and polysaccharides into soluble sugars and their less utilization in respiration and other catabolic process might be the probable cause of high content of sugars in fruits. The decline of sugars on the last of storage might be due to break down of sugars during prolonged period of storage.

Among the different varieties the sugars increased with the storage period up to 20th day of storage except in Langra and Ratna. In case of Langra sugars increased to maximum up to 10th day of storage and slightly decreased. Whereas in Ratna sugars reduced on last day of storage. Maximum sugars recorded in variety Kesar on last day of storage might be due to the delayed ripening, respiraton rates and slow conversion of starch to sugars. This variation might be cultivar dependant. Similar trend was also reported by studies of Reddy (2015), Karuna et al. (2015), Hoda et al. (2000) and Mitra et al. (1999) in mango.

Putrescine 2 mM treated fruits exhibited higher amount of sugars on the last day of storage compared to control. 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). Slower accumulation of sugars might be due to arrested respiration of putrescine treated fruits. These findings are in agreement with Gavri (2015) in mango cv. Kesar. Similar effects of putrescine also found in studies of Babu (2014) in mango and Kassem et al. (2011) in ber.

Interaction effect of varieties and chemicals on sugars found significant. Among the different combinations, V1C1 (Kesar + Putrescine 2 mM) recorded higher sugars on last day of storage. This might be due the slower break down of starch into sugars in putrescine treated fruits. These results are in agreement with Gavri (2015) in mango cv. Kesar.
5.2.5 Total carotenoids

Total carotenoids found increasing with the progress in storage period. Carotenoid pigments are the precursor of vitamin A and nutritionally important.

Total carotenoid was recorded maximum in Kesar and minimum in Langra. It increased up to last day of storage in Kesar and Alphonso. Whereas in Langra and Ratna total carotenoids declined in later stages. Carotenoid reduction occurs at overripe stage in several varieties of mango (Sahni and Khurdiya, 1989), a major colour pigment in ripe mango fruits produce due to chlorophyll degradation (Hulme, 1971; Rathore et al., 2007). Inherent variations in carotenoids composition are expected due to the factors such as, stage of maturity, varietal differences, geographic or climatic effect and storage conditions (Rajwana et al., 2010). Kesar name was given because the yellow orange coloured (saffron colour) pulp (Chovatia et al., 1995) because of higher carotenoid content. This might be the reason for attractive pulp colour of the Kesar pulp. These findings are in close conformity with the Hoda et al. (2000) and Rajwana et al. (2010) in mango.

Carotenoid content was maintained highest in putrescine 2 mM treated fruits. Initially putrescine treated fruits recorded lower carotenoids content compared to control, thereafter it is increased in treated fruits. The reason leading to an increase in total carotenoids contents are yet to be investigated. Putrescine application at preanthesis stage has also been reported to increase anthocyanin content in litchi fruits (Mitra and Sanyal, 1990). In transgenic tomato plants with enhanced expression of yeast S-adenosylmethionine decarboxylase gene, putrescine was metabolized into spermine at later stages of fruit ripening which increased the lycopene content (Mehta et al., 2002). Similar findings were reported by Gavri (2015) and Babu (2014) in mango.

Interaction effect also found significant. Highest carotenoid content retained by V1C1 (Kesar + Putrescine 2 mM) fruits during storage. This might be due to the varietal effect of Kesar treated with putrescine. These findings are in agreement with the studies of Gavri (2015) in mango cv. Kesar.

5.3 Organoleptic score for different tests

Some of the key components that contribute for the production and acceptance of high quality fresh mangoes by the consumer are flavour, volatiles, texture and chemical constituents (Mamiro et al., 2007).
Highest scores for fruit colour, pulp colour, taste and overall acceptability were recorded in Kesar. Whereas, Langra recorded lowest scores for fruit colour, pulp colour, taste and overall acceptability. Biochemical constituents of mango pulp can be correlated with organoleptic characters (Kapse, 1993). A number of biochemical reactions or metabolic activities are involved in the ripening process of mango fruit such as increased respiration, ethylene production, change in structural polysaccharides causing softening, degradation of chlorophyll and synthesis of carotenoids, changes in carbohydrates or starch conversion into sugars, organic acids, lipids, phenolics and a number of volatile compounds. All these changes lead to ripening of fruit with softening of texture to acceptable quality. These factors predominantly contribute towards developing a total high organoleptic scores and sensory profile of the mango fruit (Herianus et al., 2003) and shows variation between cultivars. Superior organoleptic quality of Kesar might be associated with the congenial climatic conditions and soil, which imparts the best quality of mangoes of Saurashtra region (Chovatiya, 2015). Akthar et al. (2009), Reddy (2015), Karuna et al. (2015), Rajwana et al. (2010) and Bhalekar et al. (2016) in mango and Killadi et al. (2007) in guava also reported the similar results.

Among the different chemical treatments, putrescine treated fruits shown highest scores for fruit colour, pulp colour, taste and overall acceptability. Higher pulp colour of fruits might be due to increased carotenoid synthesis of carotenoids with increased maturity. Higher score of taste can be attributed to higher TSS, total sugars and reducing sugars. Close association of aroma and taste of fruits with TSS and sugars are already well established. The overall acceptibility of putrescine treated fruits over control might be associated to the better retention of firmness of fruit for a long period of time. Overall better results in organoleptic score might be related to the biochemical changes of fruits treated with putrescine. Similar findings are also reported by Gavri et al. (2016) in mango.

Highest organoleptic scores for fruit colour, pulp colour, taste and overall acceptability was maintained by V1C1 (Kesar + Putrescine 2 mM) fruits during storage. This might be due to the superior quality traits of Kesar treated with putrescine.