2. REVIEW OF LITERATURE

Qualitative and quantitative fruit losses between harvest and consumption were commonly noticed. Rapid postharvest changes were observed in fruits before marketed. During ripening various biochemical changes result in characteristic taste, aroma, palatability and senescence spoil the fruit ultimately unfit for consumption. Several postharvest storage methods being adopted include pre-treatments, cold storage, modified atmosphere packaging, control atmosphere storage, skin coating with waxes and other chemicals as a result create a oxidative stress. Effects of various postharvest storage methods on extension of storage life and postharvest biochemical changes during storage and ripening were reviewed as follows.

2.1. Pretreatments

2.1.1. Precooling:

Temperature is one of the most important environmental factors that influence the deterioration of harvested commodities and hence its management plays a major role for extending the shelf life of horticultural commodities. Rapid removal of field heat by precooling was first introduced by Powell and his co-workers in US in 1904. Precooling being accomplished commercially by several methods: hydro cooling, vacuum cooling, air cooling and contact icing (package icing). The mechanism of pre-cooling by these methods create a rapid transfer of heat from the commodity to a cooling medium, such as water, air, or ice and duration of treatment vary from 20 minutes or less than 24 hours or more for adequate cooling (Hardenburg, 1968). Suitability of the products and adequate temperatures for storage during postharvest vary with the climatic conditions of the cultivated regions (Ryall and Pentzere, 1982). Pre-cooling can immediately lower the field heat of commodity
following harvest (Nowak and Mynett, 1985) and slow down metabolism and reduce deterioration prior to transport or storage (Janick, 1986). Reduction in temperature has an added advantage of reducing the production and sensitivity of the produce to ethylene that accelerates ripening and senescence (Prange, 1994). Highly perishable products like asparagus, snap beans leafy vegetables, broccoli and cut flowers were reported to be cooled as quickly as possible after harvest to retain the quality during holding and transportation. Similarly, pre-cooling of fruits and vegetables like apples, bananas, potatoes and pumpkins harvested from temperate regions observed to be highly economical.

2.1.2 Hot water treatment

Losses of fruits and vegetables during postharvest management could be due to many insect pests and pathogens infesting in farm and carried to storage. Thermal quarantine treatment or heat disinfection used world wide as viable non-chemical control method for the prevention of invasive pests of mango, specifically against Mediterranean fruit fly (Cevatitis capitata) and Mexican fruit fly (Anastrepha ludens) (Paull and Armstrong, 1994; Sharp et al., 1994). Adverse side effects associated with thermal quarantine treatments of mangoes resulted in increased fruit temperature in turn accelerated the respiration rate and decreased shelf life. External injury due to heat treatment include reactions leading to peel discoloration, lenticels spotting and skin scald occurrence in patches or completely on whole fruit in turn limited the postharvest life and reduced quality (Paull and Armstrong, 1994). Jacobi et al. (1998) observed that the postharvest treatment promoted uniform colour development in the mango peel of ‘Tommy Akins’ fruit. Hot water was initially used for fungal control later being adopted to disinfect insect pests also. HWT was the most preferred quarantine treatment as easily adoptable by growers and produce distributors, can be treated for
different durations depending on the commodity and also reliable in monitoring accurate fruit temperatures. This method was found to be the most efficient to kill surface decaying organisms and clean the fruit surface during treatment (Shellie and Mangon, 2000, Jacobi et al, 2001). Different quarantine pests especially fruit flies belonging to the family Tephritidae (Mediterranean fruit fly, Oriental fruit fly, Mexican fruit fly, Caribbean fruit fly) were reported as serious pests in different countries and for global marketing fresh and disinfected produce were only acceptable which otherwise observed to alter the trade at global level (Kader, 2003).

2.1.3 Fungicide treatment:

Anthracnose disease caused by *Colletotrichum gloeosporioides* in mango has been recorded as one of the most serious and challenging problems in the world (Smoot and Segall, 1963). Several fungicides were used during postharvest treatments for control of wide spectrum of decaying microorganisms and in spite of rigorous field applications of most promising fungicides, anthracnose disease free fruit production was reported to be highly impossible (Mc Million Jr. 1971). Spalding and Reeder (1972) have reduced the decay by dipping the green mature fruit in benomyl or thiabendazole for 3 min at 53°C in tap water containing 0.2% benomyl, 0.2% imazil, 0.2% prochloraz and 0.05% benomyl plus 0.05% prochlorz as pretreatments followed by storing at 13°C and satisfactorily controlled anthracnose.

2.2 Cold storage

Low temperature storage has been one of the most effective methods adopted for maintaining the quality of most of the fruits and vegetables. This treatment observed to reduce rate of respiration, ethylene production, ripening, senescence, undesirable metabolic
changes and further decay (Harderburg et al., 1986). The results of the study indicated that this treatment facilitate to extend the shelf life of most fruits and vegetables. However, the shelf life of many fruits and vegetables, especially those from tropical, subtropical origins (such as mango and banana) and temperate origin were observed to have shorter shelf life if stored at low temperatures. For examples banana and avocado was found to be sensitive to low storage temperatures (Paull, 1990). At low storage temperatures, various physiological and biochemical changes were recorded in the product’s tissues in response to chilling temperature. Many fruits and vegetables of tropical origin were prone to physiological injury when subjected to temperature below 12.5 °C even though the set temperature was recorded to be higher than the freezing temperature resulting in the chilling injury. Observed symptoms of Chilling injury (CI) vary with the plant species, tissue type, the severity based on the duration of exposure at low temperature and intensity of the injury was more prominent after shifting to non-chilling temperatures. They suggested that quantification of extent of chilling injury damage commonly estimated only qualitatively or semi-quantitatively using visual inspection of the product (Chaplin et al., 1991). Depending upon susceptibility of the fruits to chilling injury, Wang (1994) classified horticultural crops into chilling resistant, chilling sensitive and slightly chilling sensitive. The storage life of chilling resistant commodity was inversely related to storage temperature even though the storage temperature was not below the freezing point. The storage life of chilling sensitive commodities increased with decrease in storage temperature till a certain point, and then storage life decreases at critical chilling temperature, which usually occurs at 3° C or 4° C. They also reported that McIntosh apples were slightly chilling sensitive.
2.2.1. Chilling injury in Mango

Mango fruits are considered to be climacteric and they ripen rapidly after harvest. The storage, handling and transport potential of fruits is limited by susceptibility to diseases, sensitivity to storage temperatures below 12 °C, and perishability due to ripening and softening (Acosta et al., 2000). The combination of storage temperature and duration of storage are considered to be the important factors that lead to chilling induced physiological and metabolic dysfunctions in plant cells. These dysfunctions lead to various visible disorders that are commonly used to assess the degree of chilling injury experienced by the fruits (Walker et al., 1990). In mangoes, the most common visual symptoms are dark, scald-like discolorations in the peel, beginning around lenticels and spreading outwards to produce a more or less circular lesion, pitting on the fruit peel, the development of off-flavours, discolouration of the pulp, and overall poor fruit quality (Nair et al., 2003).

2.2.2. Chilling injury in banana

Chilling injury can occur in either unripe or ripe fruit. Chilling injury can easily be avoided in Musa cultivars/hybrids by simply limiting storage or handling to temperatures above the critical threshold. There are a number of commonly occurring visual symptoms which are characteristic of chilling injury in banana, cooking banana and plantain and these include surface lesions, such as pitting, large sunken areas and discolouration of the surface, dark water-soaked areas of the peel, internal discolouration (browning) of pulp, breakdown of tissues and failure of normal ripening. Fruits harvested at mature but unripe stage develop a dull, grey skin colour, starch is no longer converted to sugar and fruits fail to ripen in the expected pattern following removal to

2.3 Storage atmosphere and fruit longevity

The storage atmosphere in and around fresh fruits has a drastic influence on the metabolism of the stored produce. The terms controlled atmosphere (CA), modified atmosphere (MA) and gas storage are frequently used. These terms describe the addition or removal of gases resulting in an atmospheric composition different from that of normal air. Controlled atmosphere generally refers to a decrease in oxygen and an increase in carbon dioxide concentrations and requires precise control of these gases.

2.3.1 Modified Atmosphere Packaging (MAP)

Modified atmosphere packaging (MAP) is an atmosphere control technique that relies on the natural process of respiration of the product and the gas permeability of the package holding the product. Due to respiration, there is a buildup of CO2 and a depletion of O2, and the package material helps to maintain the modified gas levels until the package reaches steady state because of restricted gas permeability. In the steady state condition, the O2 flow entering the package equals the O2 consumed by respiration, and the CO2 flow leaving the package equals the CO2 produced by respiration. Because of the limitation of CA storage to relatively large-scale systems, the MAP technique was developed to provide the optimal atmosphere; not for the entire storage facility, but for just the product, thus maintaining the desired atmosphere during almost all of the postharvest chain even during the retail display. MAP has the benefits of water loss prevention, product protection, and brand identification. To achieve the desired atmosphere more rapidly, modification of the packed atmosphere can be accelerated.
by using perforated mediated MA packaging. Perforation-mediated MAP is a potential technique for postharvest preservation of fresh horticultural commodities. In this technique, instead of using the common polymeric films, a package is used in which the regulation of gas exchange is achieved by single or multiple perforations or tubes that perforate an impermeable package (Emond and Chau, 1990; Emond et al., 1992).

In modified atmosphere packaging the level of the gases around the produce depends on:

- The mass of the produce inside the container.
- The temperature of the produce and the surrounding air.
- The type and thickness of the plastic film or membrane used.
- Whether moisture condenses on the film or membrane surface.
- External airflow around the film or membrane.

### 2.3.2 CA storage

Controlled atmosphere storage refers to the constant monitoring and adjustment of the $O_2$ and $O_2$ levels within gas tight stores and containers. This gas mixture changes constantly due to the metabolic activity of the respiring produce in the stores as well as leakage of gases through the storage units. The gases are therefore measured regularly and adjusted to the predetermined level by the introduction of fresh air or nitrogen or removing CO$_2$ from the storage atmosphere by chemical means (Thompson, 1998). Controlled atmosphere storage is generally used in combination with cold storage, but with some commodities controlled atmosphere can be a successful substitute for refrigeration. Many volatile compounds, evolved by the produce and from other sources, may accumulate in the storage atmosphere. Ethylene is the most important of these compounds. Its accumulation above certain
critical levels may reduce storage life, so methods for its removal become important. Controlled atmosphere (CA) storage does not improve fruit quality, but it can slow down the loss of quality after harvest. CA technology results in reduced respiration, decreased ethylene production, inhibition of pathogen reproduction, and killing of insects. The greatest impact on insects is achieved by maintaining low O₂ concentrations for an extended period of time leading to oxygen deprivation in insect body tissues. The advantages of CA are thus threefold. It reduces or eliminates insect and pathogen damage and also extends commodity storage life. To retard respiration and lower the rate of metabolism in most produce, the oxygen concentration must be reduced to less than 10%. Monitoring is required to ensure that sufficient oxygen is retained in the atmosphere to prevent anaerobic respiration (fermentation), resulting in off flavours. The storage temperature during CA is very important. As the temperature is lowered the required concentration of oxygen is also reduced. The critical level of oxygen at which anaerobic respiration occurs is determined mainly by the rate of respiration and is, therefore, greater at higher temperatures. The level of oxygen where aerobic respiration cannot be supported any longer varies among different commodities. The critical level of oxygen may vary with the time of exposure, with lower levels being tolerated for shorter periods. It may also be affected by the level of CO₂, as lower levels of oxygen often seem to be tolerated well when CO₂ is absent or present at a low level (Saltveit, 2003).

2.4 Fruit ripening:

Fruit ripening is highly co-ordinated, genetically programmed and irreversible phenomenon involving a series and physiological, biochemical and organoleptic changes that lead to the development of a soft and edible ripe fruit with desirable quality. A spectrum of metabolic
changes such as increased respiration, ethylene production, cell wall degrading enzymes, chlorophyll degradation, biosynthesis and carotenoids, anthocyanins, essential oils, flavor and aroma components are the major changes involved during fruit ripening (Yang, 1985), increase in respiration mediated by mitochondrial enzymes, especially oxidases and denovo synthesis of enzymes catalyzing ripening specific changes (Tucker and Grierson, 1987).

2.4.1 Ethylene fruit ripening hormone

Ethylene, commonly known as fruit ripening - "phyto-hormone" play the role both as a ripening stimulator and product of ripening, present at very low concentration in fruit tissue at all stages of growth and development and the production increased sharply with the climacteric rise of respiration rate (Wills et al., 1989). Ethylene has been observed to enhance taste and flavour by stimulating fruit ripening and also organoleptic qualities of the fruits. Wang (1990) observed that chilling stress as a result enhanced fruit ripening induced ethylene production. The ascorbic acid content of mature green harvested fruit and ripened with the aid of C2H4 was higher than that of untreated fruit. In papaya content of ascorbic acid was significantly higher in fruit ripened with the aid of C2H4 than that of ethylene untreated fruit. Ethylene synthesized auto catalytically at levels as low as 0.001μl L⁻¹ and 0.05-0.25μl L⁻¹ triggered the ripening process of mango and banana respectively (Johnson et al., 1997). No significant difference in the effectiveness of applying C2H4 to ripened fruit was observed and best quality of fruits were produced when the concentrations of C2H4, CO2 and O2 in atmosphere and duration of exposure, temperature and humidity were carefully controlled and maintained at optimum levels (Saltveit, 1999) Although the half-maximal response for most of the C2H4 effects was being 0.1 μl 1⁻¹ air, concentrations from 10 to 1000 μl 1⁻¹ were used
commercially to promote the ripening of bananas, mangoes, avocados, stone fruit and tomatoes. Most commonly \( \text{C}_2\text{H}_4 \) has been used at 10-150 \( \mu \text{l} \text{ } \text{l}^{-1} \) for 2-3 days in a flow through system at elevated temperatures (15-25° C) in specially constructed ripening rooms for bananas, mangoes and tomatoes at regional distributional centers. Ethylene enhanced the appearance of many fruits by stimulating their ripening. In bananas, \( \text{C}_2\text{H}_4 \) stimulated chlorophyll loss and appearance of yellow colour and also promoted ripening of the pulp. Removal of \( \text{C}_2\text{H}_4 \) or inhibition of its action had delayed colour change in storage and prolonged the storage life of fruits (Saltveit, 1999).

2.4.2 Respiration

Respiration is a process by which stored organic materials (carbohydrates, proteins, and fats) are broken down into simple end products with a release of energy. Oxygen (O2) is used in this process and carbon dioxide (CO2) is produced. Under normal atmospheric conditions, aerobic respiration takes place, whereby metabolic oxidation of glucose for example, leads all the way to CO2 as described by the simplified equation: \( \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \longrightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + \text{Energy (heat)} \). During the respiration process there is a loss of stored food reserves in the commodity. This leads to hastening of senescence because the reserves that provide energy are exhausted. Also, there is loss of flavor quality, especially sweetness. The energy released as heat, affect postharvest technology considerations, such as estimations of refrigeration and ventilation requirements. The rate of deterioration of harvested commodities is generally, proportional to the respiration rate. Respiratory activity is markedly affected by temperature and modified atmosphere. Respiration rates alter during a commodity's natural process of ripening, maturity and senescence. Certain climacteric fruits, e.g. apples, avocados pears and tomatoes, experience a marked and
transient increase in respiration during their ripening which is associated with increased production of and sensitivity to ethylene (Pesis, 2004). The ratio of CO2 produced to O2 consumed, known as the respiratory quotient (RQ), is normally assumed to be one, but can range from 0.7 to 1.3 depending on the metabolic substrate utilized.

2.4.3. Textural softening during ripening.

Firmness is one of the most important product attributes determining product acceptability to the consumer. Fruit ripening is associated with textural alterations, which is dramatic in climacteric fruits. Textural change is the major event in fruit softening and is the integral part of ripening, which is the result of enzymatic degradation of structural as well as storage polysaccharides (Hulme, 1971; Tucker and Grierson, 1987). As the fruit proceeds towards ripening, there will be a progressive decrease in the firmness of the fruit. In some fruits like mango and banana, the ripe fruits are so soft that often it becomes extremely difficult to handle them. Softening is brought about by changes in cell wall constituents among which pectic substances play a major role. Depending upon their inherent composition and mature, different fruits soften at different rates and to varying degrees (Tucker and Grierson, 1987). Fruits like mango, banana, sapota, papaya, avocado undergo drastic and extensive textural softening from ‘stone hard’ stage to ‘soft’ pulpy stage.

2.5. Fruit quality

The quality of all fresh fruit and vegetables is determined by their appearance, colour, uniformity, shape, taste, flavour, texture, aroma, nutritive value, chemical composition, defective marks on the skin, chemical residues, additives and any other parameter the consumers judge to be acceptable on the basis of their experience and education.
Quality standards for fresh produce are available for most countries. These standards are tested by means of inspection of samples; usually done by subjective assessment of experienced workers. Quality standards must be pragmatic and realistic and those that cannot be met, sustainably measured or assessed are useless. Standards may be enforced through government legislation or, as is more common, by the purchaser refusing commodities which do not meet his requirements (Thompson, 1996). Extensive consumer acceptance studies have been done on mango and banana. The most important factors for consumers when it comes to mangoes and banana seem to be external, the fruit has to be firm to the touch and have a uniform, ripe colour.

2.5.1 Measurement of quality

There are essentially two ways in which the quality of fresh produce can be measured. These are subjectively by organoleptic analysis (sensory evaluation) or objectively either by eye or with instruments.

The physical and chemical characteristics of foods are stimuli for the eye, ear, skin and muscle, nose and mouth. The receptors of these organs initiate impulses to the brain, where perception occurs. It is the flavour and appearance of the food rather than the nutritional content that is generally sought by consumers (Thompson, 1996). A great number of instruments have been created and developed to measure fruit quality. These vary from the most basic and easy to handle (usually used in the field by unskilled testers) to complex and expensive instruments that require specialised technicians to operate. All types of quality parameters can be measured and analysed including fruit firmness, colour development, chemical composition, metabolism as well as weight loss.
2.5.2 Fruit Appearance

Appearance and texture are of importance as it is indicative of the quality of a product. According to Wills et al. (1989), appearance is probably the most important quality factor determining the market value of produce, as people 'buy with their eyes'. A rapid, visual assessment can, with experience, be made on the criteria of size, shape, colour, condition (such as freshness), and the presence of defects or blemishes. After flavour, colour is probably one of the most important quality assessment factors in the fresh produce industry. Colour is an external manifestation of the composition of plant pigments.

2.5.3 Fruit firmness

Firmness is the primary textural attribute measured in fruits and vegetables. Fruit firmness is an important tool to determine ripeness and quality (Kagan-Zur et al., 1995). Texture is the overall assessment of the feeling the food gives in the mouth (Wills et al., 1989). According to Shewfelt (1993), firmness is the primary textural attribute measured in fruits and vegetables. The consumer generally evaluates texture or firmness of fruits and vegetables by squeezing the product. Firmness of fruits may be due to a combination of turgor and cell wall integrity (Bourne, 1982).

2.5.4 Sugar content

The sweetness of fruits and vegetables is an important quality criterion to determine ripeness and quality. In practice, the soluble solids (measured as % Brix), are measured in the juice of fruit samples. Sugars constitute the largest part of the soluble solids in fruit, so measuring the soluble solid content in fruit juice can usually give a reliable measure of its sugar content. % Brix is measured with a Brix hydrometer or refractometer, both being extremely quick and easy to use. Shining a
near-infrared light on a fruit or vegetable and measuring the amount of transmitted light can also be used to measure the soluble solids content (Thompson, 1998).

2.6. Postharvest oxidative stress: The balance between reactive Oxygen species and the Antioxidants enzymes and Antioxidants:

Fruits after harvest will rarely in a position to avoid postharvest oxidative stress, only removing the commodity from a stress will allow for the avoidance of such strategy. The cellular homeostasis is achieved by a coordinated action of various biochemical pathways. Stress factors may affect normal biochemical pathways. Reactive oxygen species (ROS) are produced due to various metabolic activities and the production increases under various stress conditions. (Hodges and Forney, 2000) ROS are partially reduced forms of molecular oxygen resulting from either the excitation to form singlet Oxygen or the transfer of one, two or three electrons to O₂ to form super oxide hydrogen peroxide and hydroxyl radical respectively. Oxidative stress occurs when the generation of ROS exceeds the capacity of the fruit or plant to maintain cellular redox homeostasis. The generated ROS affect metabolism of the fruit or plant by oxidative damage to various cellular compartments including membrane lipids, proteins and nucleic acids fruits have protection system to protect oxidative stress is characterized by the activation of many antioxidant defense enzymes, include SOD, CAT POX, Ascorbate peroxidase, Glutathione reductase and by many antioxidants, such as alpha tocopherol, ascorbic acid beta carotene, uric acid.

The development of oxidative stress in the fruits mainly depends upon its cellular antioxidant levels, physical atmosphere of the fruit and its handling during postharvest storage/ripening.
2.6.1 Harvest maturity:

Oxidative injury disorders are mainly/highly dependent upon the maturation of fruit an observation hypothesized to be related to scavenging capacities of water lipid-soluble antioxidants such as glutathione, ascorbic acid tocopherols and carotenoids and the high levels of antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), peroxidase (POX), ascorbate peroxidase and glutathione reductase (GR) (Toivonen, 2003). In tomato fruit, SOD and peroxide activities declined steadily from the immature green stage to the red-ripe stage (Rabinowitch et al., 1982). Larrigautiere et al. (2001) observed that fruit scald disorder has been associated with decreased antioxidant capacity and are related to harvest maturity (Toivonen, 2003).

2.6.2 Storage temperature

Control of storage temperature is used to optimize or maintain quality attributes of fruits, such as texture, flavour and appearance. Low temperature storage extends the shelf life of plant commodities, but product specific temperature thresholds exist beyond which symptoms of chilling induced oxidative injury and oxidation related disorders will occur. An effect of chilling temperatures is to alter the homeostasis between ROS generation and defense mechanisms with the result that the net AOS burden increases and damage ensues (Hodges, 2003). Sala and Lauente (2000). found that SOD activity of the flavedo (The pigmented skin) of mandarin fruits increased in both chilling-sensitive and chilling tolerant varies, while CAT, ascorbate peroxide (APX) and GR increased only in the chilling tolerant cultivars.

2.6.3 Storage atmosphere

Altering fruit environments through controlled atmosphere (CA) or modified atmosphere packaging (MAP), which decreases respiration, and
metabolism, generally reduces oxidative stress, tissue senescence, sensitivity to ethylene, low temperature injury, and pathogen/insect damage (Toivonen, 2003). Controlled atmosphere (CA) storage in low O₂ and high CO₂ concentrations is a common practice which extends the storage life of many fruits and development of oxidative stress appear to be commodity specific (Hodges and Forney, 2002), injuries include core browning, flesh browning in apples and pears (Richardson and Kupferman, 1997; Hall and Scott, 1977; Pesis et al., 1988). Veltman and Van Schaik (1997) observed that fruit containing high ascorbic acid content develops slight browning. Modified atmosphere packaging of broccoli enclosed in 7.5% CO₂ plus 11.2% O₂ vs. air decreased oxidative stress through the retention of ascorbic acid, carotenoids, chlorophyll and poly unsaturated fatty acids (Zhuang et al., 1994, Barth and Zang, 1996, Toivonen, 2003). CA storage with low temperature, decrease in O₂ concentrations and increase in CO₂ concentration can be considered as an environmental stress (Biemelt et al., 1998; Rusterucci et al., 1996; Qiu and Liang, 1995).

2.6.4 Ripening and ROS

During ripening, levels of ROS progressively increase, mainly due to the declining activity of antioxidant enzymes that diminish AOS levels. Rogiers et al. (1988) clearly showed that the ripening of climacteric Saskatoon fruit (Amelanchier alnifolia) is associated with rise in ROS that affects membrane lipids. In ripening Pepper fruits, higher ascorbate peroxidase and Mn-SOD activities in the mitochondria play a role in avoiding the accumulation of ROS (Jimenez et al., 2003). The increase in lipid peroxidation during fruit ripening was suggested by the evolution of ethane and the development of thiobarbituric acid reactive substances (TBARS), both of which are indicates of the breakdown of oxidized membrane lipids. At the same time the activities of SOD and CAT
enzymes declined 4-fold and 18-fold respectively and under these circumstances cytotoxic levels of H₂O₂ might accumulate

2.6.5 Defense mechanism against ROS

In addition to causing damage to a range of cell components, ROS also serve as a messenger that triggers an increase in the production of antioxidants and active oxygen scavenging enzymes (Vranova et al, 2002). The level of ROS in plant tissues must therefore be regulated. This regulation is achieved by a variety of mechanisms, which includes an elaborate scavenging system that depends upon the active oxygen scavenging enzymes such as super oxide dymutace (SOD), Catalase (CAT) and various peroxidases, and a range of lipid soluble (tocopherol and carotenoids) and water soluble (ascorbic acid, glulathione and the flavonoids) antioxidants (Noctor and Foyer, 1998).

2.6.6 Water soluble antioxidants

An antioxidant can be broadly defined as “any substance that when present at low concentrations compared to those of an oxidisable substracts indefinitely delays or prevents oxidation. (Halliwell and Gutteridge, 1999).

Ascorbic acid is one of the most important free radical scavengers in plants, animals and humans. Present in the chloroplast, cytosol, vacuole and extra cellular compartments (Foyer and Halliwell, 1976). Ascorbic acid can directly and indirectly scavenge ROS with or without the involvement of enzyme catalysts, and indirectly by recycling oxidized tocopherol to the reduced form (Foyer, 1993).
2.6.7 Polyphenolic compounds:

Polyphenolic compounds commonly serve as a protective mechanism in plants, warding of predators and microbiological attack. Many factors affect polyphenolic concentrations, including cultivar differences, growing conditions, maturity and postharvest handling of fruit (Hakkinen and Torronen 2000; Lakshminarayana et al. 1970; Selvaraj and Kumar, 1989). Polyphenolic compounds such as benzyoic acids, cinnamic acid, flavonoids and tannin possess an aromatic ring bearing hydroxyl substituents that will readily take part in hydrogen bonding unless sterically hindered, allowing them to donate hydrogen ions to free radicals. Therefore polyphenolic acts antioxidants. Reduction in phenolic content was noticed in plums stored in plastic tags covered with PVC film. Phenolic compound, were found decrease in litchi fruits during storage (Filguciras et al. 1988).

2.6.8 Carotenoids:

Carotenoids are tetraterpenoids with a basic structure consisting of eight isopenoid residues arranged in two, 20-carbon units formed by head-to-tail condensation (de Mann, 1999) carotenoids are among the widest distributed class of pigments, present in photosynthetic and non-photosynthetic organisms. In all photosynthetic organisms, carotenoids, serve two major functions, act as an accessory pigments of light harvesting and prevention of photooxidative damage (Van der Berg et al., 2000). Conjugated double bonds provide a reactive electron rich system that is susceptible to attack from electrophillic compounds (Van de Berg et al. 2000). This structural characteristic contributes largely to carotene antioxidant functions. (Beutner et al., 2000; Lowe and Young, 2000; Mascio et al., 2000; Stahl and Seis, 1996; Van de Berg et al., 2000).
2.6.9 Senescence:

Senescence is considered the terminal phase of life of plant organs including leaves, flowers and fruits. Senescence in plant tissue is associated with excess production of ROS (Buchanan-Wollaston, 1997). Jimenez et al., (2003) comparing green versus red Peppers (*Capsicum annuum*), found that superoxide dismutase, glutathione reductase, CAT and Ascorbate peroxidase (APX) exhibited higher activity levels in the red Peppers, which were more senescent, than in the green fruits, which were less senescent.