



Effect of preservatives on physicochemical, microbial and sensory attributes of mangoes

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Abstract

Mango (Mangifera indica L.) is a dicotyledonous plant having order sapindales belonging to the family Anacardiaceae is juicy, with a single large kidney-shaped seed. The flavor is pleasant, rich and high in sugars and acid. Mango, often considered as king of tropical fruits, is an important fruit crop cultivated in the region. Mango has turned out to be one of the imperative commercial fruit crops in the whole world, being the second largest tropical crop next to bananas in terms of production, acreage, and popularity. Worldwide mango production was estimated at 22.4 million tons in 2000. Because of worldwide distribution of mango production and technologies that control flowering, it is possible to supply fresh mango to worldwide markets year round. The fruit of mango varies in size, and it ranged from hen's egg as the smallest being to the 1.11 Kg weight. The mango fruit having different shape as heart shaped, slender and long, kidney shaped, round and oval. Skin colour of ripened mango fruit can vary and it may be green, yellow, red, yellow green and yellow red. The yellow-orange flesh have been surrounded the single flat seed which is contained in every mango. About 0.6% protein, 1.1% fiber has been contained by ripened mango pulp and from the above concentration considerable amount (2-4%) is of starch and calcium pectate has been anticipated to be 0.7%. The human diet can be maintained or balanced by consuming mango which provides up to 64-86 calories of energy to the humans. Chemical preservatives are used for providing the preservation effect to the stored mango pulp. These are also used for the control of microorganisms, or cease the activity of enzymes and also maintain the keeping quality of stored mango pulp.

Key words: Mango, mango pulp, chemical preservatives, sensory evaluation of pulp and microbial attributes of mango

Introduction

In Pakistan for about two thousand years, mangoes have been produced and the statistics showed that in the whole world, Pakistan is became the fifth largest producer of it (one million tons per annum) followed by India, China, Mexico and Thailand, and in the world market 7.6% share of mango production is contributed by Pakistan. The basic production of mango is centered in two regions of Pakistan, the Sindh and the Punjab, and from the total production the share of sindh is 32% and the share of Punjab is 67%. The core producer of the mango is Asia which is contributed about 76.9% of the overall world production, which is followed by America having 13.38% contribution, Africa having 9% and less than 1% contribution each one for Oceania and Europe. The entire varieties which are grown-

up in Pakistan are of Indian origin and all of these are characterized by rich aroma and brix constituents.

Mango export witnessed more than 20% decline in 2008 than 2007 as Pakistan received the lowest per kg rate for its mangoes in the international market due to poor quality. The decline in export of mangoes can be attributed to lack of proper post-harvest handling which is yet a significant reason of poor quality of this fruit. Moreover, farmers are not able to determine the proper time of fruit maturity.

In the global market the attractiveness of mango is owing to its stunning colour, striking fragrance, pleasing flavour, good taste and healthy nutritional properties. When we considered the losses of mango fruit after harvesting especially considering the developing countries, then the

post harvest losses of mango are extremely conspicuous. The losses are basically due to the mango fruit harvesting at inappropriate maturity, offensive field handling, chilling injury, fruit softening, mechanical injury, decay of mango fruit, lenticels discoloration, squishy tissue, sap burn and pest or disease damage. The basic nutritive and quality losses are occur due to stiff fruit packing, by using inappropriate transportation and meager field management. Mango fruit are commonly processed into juice or puree form and added to many different types of food systems, including fruit juice blends. Fruit juice blends containing mango are becoming more popular with the rise of tropical fruit juices. Processed mango products undergo heat treatment, or pasteurization, to destroy all pathogenic and spoilage organisms. Pasteurization is effective in assuring sanitation; however, application of heat treatments can adversely affect quality characteristics with regard to aesthetic and nutritional quality.

As the chemical preservation is the most economical method among the other preserving techniques, so in Pakistan commonly the mango pulp is preserved with the help of these chemicals. Prevention of the food spoilage due to microbial attack is done by using the chemical preservatives. And these chemicals showed their batter effect when use in different combination and concentration for the control of microbial growth. No preservative on its own is absolutely efficient against the entire microorganisms. For the longer time storage or preservation of fruit pulp especially mango, the frequently used preservatives are potassium metabisulphite (PMS), citric acid and sodium benzoate (SB) because of their superior antimicrobial action.

Sodium benzoate concentration has a direct impact on the microorganism inhibition, as greater amount of sodium benzoate manifest the better antimicrobial effect, when applied on different species of *Aspergillus*. In the pulp preservation sodium benzoate and potassium metabisulphite have an inhibitory effect to all bacteria and other microorganisms, while addition of chemical preservatives adversely affects the sensory attributes and physico-chemical characteristics of mango pulp. The previous studies proposed that as the storage proceeded of the preserved mango pulp, chemical preservatives significantly affect the sensory profile and physico-chemical characteristics will cause a raise in brix value, acidity contents, reducing sugars constituents while sucrose contents were decreased.

The highest level for the utilization of these chemical preservatives as mentioned in the codex standards applied in 2001 and 2006 respectively are 1000 mg/kg sodium benzoate as benzoic acid and 500 mg/kg potassium metabisulphite as remaining SO₂ in the fruit processing and their storage, including nectars, purees and pulp. Unsystematic use of these chemicals is a huge concern to the healthiness and physical conditions of the human beings, and has been the basis for the development of resistant

bacteria and microorganisms, and as a result leading to the incidence of up-and-coming food borne diseases.

Physicochemical characteristics

Youngmok Kim et al., (2007) found that mango applied to heat applications as hot water application and irradiation to demolish microbes and pests. They also found that certain polyphenolic changes in fruits following hot water immersion treatment. These observations paying attention on antioxidant and polyphenolic changes of mangoes followed by different times of application of hot water and also note the changes which occur during storage of it. Gallic acid and gallotannins which are the chief polyphenolics in mango fruit, and also the entire soluble phenolics, decreased as a end result of lengthened hot water treatment, but the antioxidant activity remained unaffected in whole heat-treated mangoes instantaneously after hot water treatment. But the outer quality or out look of mangoes and as well as polyphenolics were non effected by this hot water application but it decreased the activity of antioxidants and phenolics in the mango, while not considering of the length of application times.

Their are numerous categories of carotenoids and ascorbic acid in mango, which have diverse properties of health nourishing, principally due to antioxidant activity (Talcott et al., 2005).

Because of ripening, phenolic constituents which are present in mango were observed to reduce during the storage, and as a result of this there is a failure of astringency, which is a feature of mango fruit (Lakshminarayana et al., 1970; El Ansari et al., 1971; Saleh et al., 1975; Mitra et al., 1997).

Jacobi et al., (2000) found that hot water treatment at 46.20C for 69, 91 and 110 min have no effects on the mango fruits TSS contents. The found that the TSS contents were 9.93, 10.47, 9.81 and 10.23 Brix⁰ in hot water treatment at 0, 69, 91, and 110 min, respectively. They also observed that, mangoes that were given the hot air treatment at different temperatures from 21 to 410C for 8 h followed by hot water application at 460C for 15 min did not differ in TSS content after 4 days of heating application.

Jacobi et al., (2001) observed the vitamin C contents during post harvest treatments. The vitamin C contents were shown to be decreased by oxidation reaction occurred during heat application (Lee et al., 2000).

Wu et al., (2004) observed that there is comparatively low hydrophilic antioxidant activity of mango as compared to other frequently consumed fruits. The study showed that the mainstream of antioxidant activity of mangoes probable to present in its polyphenolic constituents, while the study results of changing to polyphenolics contents were no longer enough to result in a momentous variation of antioxidant activity.

Talcott et al., (2005) found that as the majority of fruits are eaten fresh; decrease of the antioxidant activity is not entertained by consumers. Due to the poor effect of heat or oxidation reactions that are caused by heat dispensation, antioxidant activity going to be decreases.

Musingo et al., (2001) and Soong et al., (2006) observed that mangoes which is going to be heat-treatment lose their antioxidant capacity through oxidation during storage. They also found that as the storage period goes on acidity is going to be increases and pH is decreases.

Sofos et al., (1986) found that mango contain higher amount of antioxidants contents and it is suggested to be used in our daily diet because of its health promoting activities as lessen the occurrence of heart disease, and also have anti viral and anti cancer properties. The observed that the basic aim of post harvest treatments is to lengthen the storage period and keep the quality characteristics, functional and nutritional properties.

Kader, (2008a) found that mangoes are excellent source of vitamin C, phenolic constituents and carotenoids and many different dietary bioactive components. These compounds especially ascorbic acid r used to decrease the acidity of mango and act as preservative. The also observed that ascorbic acid along with potassium metabisulphite are used in the preservation of mango pulp for a longer period of time and retain its quality characteristics (Strawn et al., 2010).

Talcott et al., (2005) found that there are various types of phytochemicals present in mango as vitamin C, carotenoids and polyphenols which enlighten the health boosting activities mostly because of its antioxidant factor. So the mango pulp can be preserved for longer time period with the help of different chemical preservatives for their effectiveness.

The finding of Kim et al., (2009) is that, when we applied the hot water treatment to mango which loses its nutritional value because of the oxidation reactions which occur in it during storage and transport. So it's better to export the mango in the processed form such as pulp to retain their maximum sensory and nutritional characteristics, prolonged the shelf life and withholding the antioxidants of mango. It was observed that acidity increases as the storage progressed. At the start acidity is 1.29%, which goes up to 1.49% after 90 days of study in the sample which contained 100 ppm potassium sorbate while the smallest raise in the acidity was 1.35% in the pulp sample contained 200 ppm potassium sorbate, 200 ppm sodium benzoate and 100 ppm potassium metabisulphite. And after 240 days maximum incline in acidity was 1.60% in the sample which contained none of preservative while least incline was in the sample having mixture of 100 ppm potassium sorbate, 100 ppm sodium benzoate and 200 ppm of potassium metabisulphite (Ahmad et al., 1986).

Malik et al., (1994) observed that, pH value of the pulp sample decreases with the passage of time. As the results showed that at the start of storage time pH was 2.90 while

at the end of storage study pH was 2.14. Thus as the storage time of preserved pulp increases, the pH values was decreases in the treated samples. The mango pulp was preserved with potassium metabisulphite, sodium benzoate and potassium sorbate, whereas minimal decrease of pH was noticed in treatment containing 100 ppm potassium bromate, 100 ppm potassium metabisulphite and 100 ppm sodium benzoate.

Islam, (1986) studied the effect of different chemical preservatives on stored mango pulp. He found that in all treatments of mango pulp brix₀ was equivalent. And after the storage of three month, there is an uplift of brix₀ upto 14.4% in the sample containing none of preservatives. Likewise, smallest change was noticed in the sample treatment containing 1000 ppm potassium metabisulphite. But at the end of storage time (six month), the treated samples showed different results of brix₀ values. Statistical analysis showed that, there is a non-significant effect for treatment while very significant effect for increasing the TSS contents during storage period. And this incline in TSS is due to the development of pectin (water soluble) from insoluble protopectin as observed by Khalil et al., (1979) and Riaz et al., (1988) in fruit bases and lime squash, respectively.

Larmond, (1977) and Khalil et al., (1979) observed that the fate of reducing and non-reducing sugars (Sucrose) are depends upon the chemical preservative treatments and storage conditions of mango pulp. According to study, on the reducing sugars there is a non-significant effect of sample preservative treatments while on sucrose constituents, there is a significant effect. The sucrose content at 0 day ranged from 5.77 to 6.39 % in a sample treatment contained 500 ppm potassium sorbate, 500 ppm sodium benzoate and 500 ppm potassium metabisulphite. While after 90 days of storage period, the reducing sugars inclined from 4.46 to 4.49 %. But after 270 days of storage a declining trend was noticed in all treatments that may be due to the resurgence of microbial spoilage which was gone toward the fermentation and development of off flavour. Results conclude that during the storage period, there was significant increase in the reducing sugars but a decline was observed in the non reducing sugars.

Amin et al., (2008) observed from their study that, chemical preservatives that were used for the preservation and storage of mango pulp have pronounced effect on the physico-chemical attributes of pulp. While there was an increase in reducing sugars, acidity, brix but decrease in non reducing sugars. Results showed that the concentration of chemical preservatives as potassium sorbate 400 ppm, sodium benzoate 500 ppm and potassium metabisulphite 1000 ppm showed the better effect on the control of microorganisms even after three months of storage period. However, the mango pulp samples which were tested to organoleptic assessment were acceptable even after nine month of storage.

Ogiehor et al., (2004) and Akhtar et al., (2009) noted the physico-chemical characteristics, microbiological parameters and sensory attributes of preserved pulp with potassium metabisulphite and sodium benzoate at different doses. During the study the action of chemical preservatives on the microorganisms was noted at ambient temperature in the absence of light for the 90 days of storage. Results showed that there were sufficient decrease in the fat and protein constituents while the value of brix⁰ and ash constituents were gone to be increased. A minute change (decrease) in the pH of pulp samples was noted with a relative increase in the acidity of the preserved pulp. At the ending of storage study microbial population will gone to be increased while the action of potassium metabisulphite was shown to be most effective against microbes. Addition of these chemical preservatives put negative influence on the sensory attributes of mango pulp. Where as even after 90 days of storage period, samples were accepted by the panel of judges.

Doreyappa-Gowda et al., (2001) and Bajwa et al., (2003) found that addition of 500 mg of sodium benzoate (SB) per kilogram of different fruit pulps separately did not illustrate any significant effect on protein constituents of mango pulp, while protein constituents would shown to be decreased by using the sodium benzoate in combination with other preservatives. But there was no sign of changes in the lipid constituents of mango pulp by using the benzoic acid as a preservative; however, there was decline in the fat content of pulp was noted in those samples which were preserved with the addition of SO₂. Sodium benzoate at the dose of 1000 mg/kg increased the ash constituents but total soluble solids not altered.

Germain et al., (2003) observed that the acidity of mango pulp increased with an analogous decline in pH by the application of benzoic acid. There is a significant influence of storage period on the physico-chemical characteristics. It was also observed that there was decline in the fat and protein constituents with the passage of time. While ash constituents were decreased during the study. There was no effect of benzoic acid on the brix⁰ value even after 60 days of storage. However, total soluble solids were increased during the last month of storage study. The reason for the increase in the non reducing sugars in the pulp was due to the conversion of starch into sucrose by the action of phosphorylase enzyme (Germain et al., 1981; Favier et al., 1993).

Warth, (1985) reported that the time at which fruit harvested determine the quality characteristics of pulp. Results showed that total soluble solids value (concentration) increased if the picking of fruit is done at the mid day then the other day timings. Acidity of the fruit samples increased with the addition of chemical preservatives. Correspondently, the pH value of the stored pulp samples decreased continuously as the time progress during storage but the differences between acidity and pH remained non significant (Germain et al., 2003).

Abbassi et al., (2009) correlate the fluctuation in lipid profile of the pulp samples with the ripened condition of the mango. Results showed that there was inclined in the pH of the pulp samples while titratable acidity decreased as the storage progressed.

According to Fulya et al., (1999) and Doreyappa et al., (2001) during the storage, changes occur in the physico-chemical characteristics of mango pulp. Results showed that there was decrease in the pH while acidity of samples increases. Basically the route cause which is the basis for the incline in the acidity of the sample was climb in the concentration of weakly ionized acid and their salts during storage of mango pulp. Their is an other reason for the incline in the acidity was the oxidation of reducing sugars (sucrose), formation of acids by break down of polysaccharides and by degradation of pectic compounds and uronic acid (Hummel et al., 1950; Iqbal et al., 2001; Hussain et al., 2008).

Bajwa et al., (2003) and Hussain et al., (2008) found that pH plays twice function in the fruit juices or beverages by acting as a preservative and as well as flavour enhancer. Finding showed that there was increase in the acidity of the sample corresponding to decrease in pH of the pulp. These changes in the physico-chemical characteristics were due to the addition of sodium benzoate in the sample.

Medlicott et al., (1985) and Selvaraj et al., (1989) observed that during the maturation of the mango fruit there was decline in the acidity. The main organic acids in mangoes are malic acid and citric acid. During the ripening period there was decline in the quantity of these acids. So for the storage of mango pulp addition of citric acid is essential to maintain its keeping quality and sensory characteristics. Lizada, (1993) study findings showed that the cycle of citrate synthase was decreased while the action of succinate dehydrogenase and isocitrate dehydrogenase was increased during the maturation of mango.

Tovar et al., (2000) noted that in the slightly processed mango chunks and pasteurized pulp there was slightly increased in the acidity which was stored at ambient temperature. Results showed that chunks that were dipped in CaCl₂ having decline in the acidity as the storage progressed. In several other studies, chunks of persimmon, strawberry (Palmer et al., 1997b) and peach (Palmer et al., 1997a) which were kept at 50C for about one week showed decline in acidity.

Gonza et al., (2000) concluded from their results that the application of potassium sorbate, d-isoascorbic acid and 4-hexylresorcinol increase the shelf life of mangoes (chunks and slices) and their processing form (pulp and puree) for about 14 days at 100C. During the ripening of mango at 250C there was decline in the acidity was noticed but acidity increased in chemically preserved mango pulp samples at same temperature.

Tucker, (1993) studied the effect of different chemical preservatives as citric and malic acid on mango pulp. He observed that gluconeogenesis is basically due to the malate

metabolism because the contribution of acidity to the quantity of total soluble solids is very minute.

Oyaizu, (1986) noted the reducing power of mango pulp. He find it by the donation of electron for the reduction of $[\text{Fe}(\text{CN})_6]^{3-}$ to $[\text{Fe}(\text{CN})_6]^{4-}$. Findings showed that every sample had a capability to reduce iron (ferric), and the reducing power values for the mango pulp sample that were 0.44 to 1.34.

Milos et al., (2000) observed the association between phenolic constituents, antioxidant capacity and ascorbic acid contents in the pulp sample. Stronger association of reducing power with vitamin C has been showed in the sample than with the phenolic constituents.

Vergara-Valencia et al., (2007) observed that the antioxidant activity of unripe mango pulp was directly correlated with the dietary fiber contents. Results showed that dietary fiber have high starch and minute lipid contents and balanced soluble dietary fibre / insoluble dietary fibre, which have immense significance for their application in the human diet. The pulp showed average water holding capacity while oil holding capacity was less. The mango pulp could be a substitute for the formation of products that have balanced dietary fiber and glycemic response is least, intended to those persons having exceptional energy requirements.

Ramesh et al., (2004) and Renuka et al., (2009) studied on the fortification of various fruit juices and beverages. During the study mango, orange and pineapple juice were fortified with fructooligosaccharides because this is prebiotic and low caloric. Results showed that in place of sucrose (sweetener) that was used in the preparation of juices can somewhat replaced with fructooligosaccharides without markedly influencing the quality and overall acceptability of juices. Study showed that TSS, acidity, colour and pH did not alter during the storage. Fructooligosaccharides constituents mango, orange and pineapple juice were 3.33, 3.64, and 3.76 g/100 mL of juice. The sensory analysis of the chemically preserved juices indicated that juices remained acceptable up to 5 months storage at room temperature. They conclude from their study that, maximum quantity of fructooligosaccharides was present at the end of storage period.

Sangeetha et al., (2002) noted that the pH value of the fruit juices, fortified with fructooligosaccharides decreased which is important parameter to preserve the fruit juices as his is important for to control the microbial load in stored samples. Results showed that pH of the treated pulp were 3.34 to 3.60 as compared to the pH of the pulp at the start of the study which was 3.28. Same kinds of results as to the change in pH as a function of storage temperature and time duration have been made by the following scientists (Souci et al., 1987; Kaanane et al., 1988; Martin et al., 1995).

Verbeke, (2005) noted the effect of different physico-chemical factors especially TSS (Brix) of fruits pulp and juices stored with the help of different chemical preservatives. Results showed that the brix⁰ of fruit juices

was 15.70 and was unwavering all the way through storage period. The constancy of the total soluble solids might be because of the thermal applications former to storage. Results showed that acidity was approximately constant throughout the storage period. And the juice retained its sensorial properties, as compared to the sample in which no treatment was applied.

Maceiras et al., (2007) studied the consistency and rheological behaviour of various fruit purees and pulp. And the consistency was noted with the help of rotational viscosimeter at variable temperatures ranged from 18-380C. Studied showed that rheological parameters depends upon time and temperature of cooking and storage. The experiment results demonstrate that by the application of heating treatments viscosity of pulp was significantly affected. Observations showed that viscosity or consistency was higher in the jams than in purees. Results demonstrate that the fruits that were used for the making of puree having 10% sugar contents while in the jam above 40%, so the alteration in the consistency might be because of the sugar presents in it (Cancela et al., 2003; 2005). So this study is very important for proper demonstration of fruit composition for the making of final product.

Yusof et al., (2003) determine the effects of different maturity stages of guava fruit and puree on its physico-chemical factors. Results showed that acidity, pH, and sugars contents declined as the maturity progressed. But the Brix _ acid ratio was increased. Ascorbic acid showed a increasing trend. The susceptibility to browning reaction of the puree colour was less and by the addition of sugar it was improved. At the end of storage study the sensory characteristics were also improved.

Maciel et al., (2001) noted the influence of storage temperature on the quality of mango pulp. Results showed that titratable acidity remained constant during storage but pH increased significantly and total soluble solids decreased. Chemically preserved pulp pulp had less microbial count then control sample. The sensory characteristics of chemically preserved pulp also improved.

GoÈksungur et al., (1995) studied the effect of different chemical preservatives especially sodium benzoate, potassium metabisulphite and potassium sorbate on cucumber pickle fermentation. They observed that acidity increases at the end of storage period. Results showed that in the start of study acidity of cucumber is very low, which goes up to 30% increase after 90 days of storage in the cucumber sample containing 100 ppm potassium sorbate while the minimum incline was noted up to 13% in the sample containing 200 ppm sodium benzoate, 200 ppm potassium sorbate and 100 ppm potassium metabisulphite. After 270 days of storage the acidity increased up to 34% in those samples in which no preservatives were added while minimum incline was observed in those samples which were preserved with the combination of 100 ppm of potassium sorbate, 100 ppm of sodium benzoate and 200 ppm of potassium metabisulphite.

Microbiological characteristics

Brenndor et al., (1985) found that the total bacterial count of mango pulp increases during storage while the mango pulp sample having 0.2% potassium metabisulphite treatment give the best result for the control of microbial growth.

Hussain et al., (2003) found that the growth of microorganism in mango pulp is significantly reduced by the application of potassium metabisulphite.

Islam, (1986) observed that microbial growth reduce by potassium metabisulphite in mango pulp up to 87.5% but this microbial load goes to be increased at the last of storage period.

Ploetz et al., (1994) found that mango is consumed fresh and in numerous other forms as puree, pulp, nectar and juices. The mango preservation in the form of pulp can retain their keeping quality for a longer period of time and the preservatives which are added in it decrease the microbial activity and improving the sensory characteristics. In numerous countries of the world heat treatments especially hot water treatment are the excellent way to control the occurrence of pests and spoilage, in mango (Aveno et al., 2004). These treatments are commercially applicable in many countries because of their effectiveness (Jacobi et al., 1995; Anwar et al., 2007). And after heat treatment mango can be processed into pulp, puree, nectar, jam, jellies, etc. Phase of maturity (Jacobi et al., 2001), mango variety and fruit size determines the duration of time and temperature of application (Kim et al., 2009). It is suggested that mango is applied the hot water treatment within 24 h of post harvest and then their processing is done. Because of the lessen damage to mango fruit and superior market price, hot water application are more widely applied to get batter profit (Laidlaw et al., 1996). While it is adopted by the small farmers with companionable applications, easily applicable by the supply chain, diet conscious peoples and environmentally gracious technique (Mitcham et al., 2009). And after this treatment processing is done and stores the processed mango with the help of different chemical preservatives.

Chiply, (1983) and Lambert et al., (1991) noted from his study that, increase in the microbial population of the chemically preserved mango pulp is directly correlate with the duration of storage. There was no indication of the growth of microbes up to two months of storage time in the samples of chemically preserved pulp. But the study showed that after three months of storage there was minute incline in the growth of microbes in the preserved samples. It was concluded from the above mentioned study that, for the long time storage of mango pulp the efficient doses of preservatives are 500 ppm of sodium benzoate, 400 ppm of potassium sorbate and 1000 ppm of potassium metabisulphite.

Larmond, (1977) and Picouet et al., (2009) found that the overall acceptability of pasteurized, chemically preserved

ready-to-serve drinks or different beverages depends upon the application of chemical treatments that were applied to them. The drink sample that was prepared with the addition of 1000 ppm of potassium metabisulphite showed the score of 25.69 was excellent in the overall acceptability while the least score of 22.54 was shown by the sample containing potassium sorbate 100 ppm and potassium metabisulphite was 200 ppm. Ahmed et al., (1986) also observed the similar kind of results on sulphited citrus squash.

Citric acid, potassium sorbate, sodium benzoate and potassium metabisulphite were used to preserve mango in the form of pulp for a longer period of time separately or in different combinations. Pasteurization was done at 82 °C during the study for about 28-29 min and then treated samples were placed in polyethylene bags by the addition of different chemicals and placed or store at room temperature for about 120 days. The effective treatment for the destruction of microbes was 600 ppm of sodium benzoate, 500 ppm of potassium sorbate and 1000 ppm of potassium metabisulphite. Normality was observed physically and organoleptically after 270 days. The storage life of pasteurized mango pulp was extended and there were no changes in chemical and sensory attributes (Hussain et al., 2003).

Ogunrinola et al., (1996) and Hashmi et al., (2007) studied the behavior of microorganism growth on the mango pulp that is stored with the help of sodium benzoate and potassium metabisulphite. 1000 mg/kg of the potassium metabisulphite showed batter inhibitory effect on the microbial growth as compared to other combination followed by combination of 500 mg/kg of sodium benzoate and 500 mg/kg of potassium metabisulphite each. Results showed that at the end of storage duration microbial growth will be higher which might be because of the variation in the temperature of storage and modification in pH of the pulp that might be took place because of the application of chemical preservatives in the mango pulp samples. The highest level of contamination in mango pulp samples was observed in control sample in which none of the preservatives was added (Akhtar et al., 2009). Study finding showed that none of the either preservatives which was used in this study for the preservation of mango pulp completely inhibit the microbial growth at a specified dose for time duration of three months; however, the chemical preservative had synergistically effective to the inhibition of microorganisms.

Iqbal et al., (2001); Amin et al., (2008); and Hussain et al., (2008) demonstrate the effect of potassium metabisulphite and sodium benzoate on the growth of microorganisms in the pulp samples of mango which were stored at room temperature for about 120 days. They observed from their study that there was a synergistic effect of the above mentioned chemical preservatives at the quantity of 500 ppm. Physico-chemically parameter of mango pulp was significantly affected by the application of chemical preservatives and as a result of it there was a decline in the

pH where as the acidity was increased with the passage of storage. However, there was a negative influence by the use of preservatives on the sensory characteristics of mango pulp but product remained acceptable at the end of storage period.

Sakano, (1998) studied the effect of different chemical preservatives on mango pulp. From their study he concluded that the acidic conditions of mango pulp were effective to inhibit the growth of microorganisms but such kind of situations put negative influence on the sensory and physico-chemical characteristics of mango pulp.

Sivakumar et al., (2010) studied the microbiological parameters of mango pulp. According to their research the infection of Salmonella and Escherichia coli have been linked to the eating of fresh vegetables, fruits and their juices. During study they noted the chance of Salmonella and E. coli occurrence on fresh and frozen sliced papayas, and mangoes and, their processed form as pulp and puree. They observed that Salmonella and E. coli have the capacity to grow on fluctuated temperature papaya and mango slices, and their stored pulp held at 23 °C. They also check the growth of microbes at different temperature. Results demonstrate that there was a fever growth of E. coli on papaya pulp where as salmonella can grow both on mango and papaya pulp at 12 °C. However, on refrigerated papaya and mango pulp, salmonella and E. coli will survived for about one month held at 4 °C. In the previous 20 years the occurrence of food born illness is due to the E. coli and salmonella had been increased from fresh fruits and the juices which were prepared form it (Brandl, 2006). So for the control of these type of problems, we can store the pulp of these fruits with the help of different preservatives for the retention of their keeping quality, avoid microbial outbreak and improving sensory characteristics (Gibbs et al., 2009).

According to Hsin-Yi et al., (2001) and Leite et al., (2002), the survival of E. coli in mango pulp was about 13 days at 6°C and in mango juice for about 6 days at 80C. Results showed that the growth of E. coli was also observed in papaya juice which was held at 40C and 200C (Yigeremu et al., 2001 and Mutaku et al., 2005). Inoculation of Salmonella typhimurium and choleraesuis was done in papaya juice and noted that these micribes grow gradually at 4 °C but quickly at 37 °C. Penteadó et al. 2004 found that Salmonella enteritidis grow in the pulp of papaya stored at 25 and 300C.

Bassett et al., (2008) found that inherent factors of papaya and mango may influence its microbial contamination. Due to the combination of temperature and acidic pH E. coli growth in mango pulp is restricted. They found that the temperature which was suitable for the survival and reproduction of E. coli was 5-44°C and the pH was 3.9-4.4 (Meng et al., 2007). The findings documented here were like to earlier studies for survival of E. coli in pulps and juices (Hsin-Yi et al., 2001 and Leite et al., 2002).

Beuchat et al., (2008) found that Salmonella can grow on mango slices at different temperature during the storage apart from the initial population of microorganisms. They also found that Salmonella can grow on tomato chutney which is preserved at pH 4 but the growth of microbes was less as compared to mango. Salmonella can also grow in mango pulp at 24°C while survived up to at 5°C. They suggest in their studies that mango pulp stored with the help of different chemical preservatives give best storage results then fresh or other type of storage.

Foster et al., (1995) observed that both E. coli and Salmonella grew on fresh cut mangoes and their stored pulp; however, Salmonella grew more rapidly than E. coli at 23°C. At 13°C Salmonella populations grew, while E. coli only survived. However, results showed that E. coli populations were higher than Salmonella populations at 13°C after 28 days of storage period. The quicker rate at which Salmonella initially grow may have more quickly diminished nutrients and produced byproducts resulting in the lesser populations of Salmonella (Cox, 2000). The fate of E. coli and Salmonella on mango pulp and puree were compared to the findings about tomatoes.

Beuchat et al., (2008) observed that Salmonella growth in tomato pulp at both 12 and 21 °C within 72 hours. They treated the sample with different preservatives and stored it for three months and observed from their results that Salmonella growth occur in the sample in which no preservatives are added but the treatments which were preserved with the help of different chemical preservatives showed no or less signs of microbial count.

Yigeremu et al., (2001) and Mutaku et al., (2005) concluded from their results that microbes rapidly grow in papaya juice at room temperatures within 48 h without the addition of any preservatives. But the attack of microbial growth on papaya juice is less which is prepared from the pulp preserved with chemical preservatives. Minute increases in cell populations were noted for E. coli and Salmonella in papaya juice held at room temperature for treated pulp or refrigerated temperatures.

Golden et al. (1993) and Penteadó et al., (2004) observed that rapid microbial growth in cantaloupe and honeydew melon pulps when stored at 25 °C for a period of three months. They observed that huge growth of microbes and TBC (total bacterial count) after 48 hours of storage but no significant signs of microbial load in chemically preserved pulp even after end of storage period. They also observed the microbial and sensory studies of melon and watermelon pulp stored at 30°C within 24 h up to three months.

Oyarzabal et al., (2003) observed the effects of potassium metabisulphite and sodium benzoate on the growth of microorganisms in banana puree stored at room temperature. Results showed that the preservatives that were applied in combination put synergistic action for the control of microorganisms. In addition to this, chemical preservatives markedly affect the physico-chemical parameters of banana

puree and because of this a sufficient increase in the acidity while a decline in the pH was observed at the end of storage period. However, sensory characteristics were negatively affected by the application of the above mentioned preservatives. Application of these preservatives had poor effect on the sensory characteristics of the stored puree.

Iola F. et al., (2006) noted the effect of *Penicillium expansum* on the stored mango juice. They noted that due to *Penicillium expansum* changes were observed in the composition of mango juice and as a result of this spoilage occurred. Numerous changes also occur in the sensory characteristics of stored juice. In addition to the development of various fermented products as acetic acid, lactic acid, etc and the formation of sugars as fructose, sucrose, there were changes observed in the inorganic acids as in the spoiled juice the quantity of mallic, shikimic, citric and quinic acid was decreased which leads toward the spoilage of mango juice. They concluded from their studies that use of the chemical preservatives for the storage of mango pulp to utilization in mango juice or nectar are better option than the pulp or juice preserved without the help of any chemical preservatives.

Frazier et al., (1988) and Splittstoesser, (1996) found that fungi were most widely grown on the fruit products because of its low pH values while at that pH bacterial growth was minimum and least affected the sensory and physical profile. The glycerol constituents of the must caused the moldiness in the grapes. They also suggest that the diacetyl and acetylmethyl carbinol were the indicators of bacteria and fungi, which developed off flavour in the different processed fruit (Singhal et al., 1997).

Toma's-Barbera'n et al., (2001) preserve the mango pulp with the help of different chemical preservatives and found from their results that the enzyme activity was still high when 1% ascorbic acid was used for their preservation. They concluded that specific amount of preservative quantity applied for different variety of pulp depend upon their physico-chemical characteristics especially pH and acidity. Therefore it can be sure that 1% of this acid is insufficient to prevent the polyphenoloxidase catalysis of the reaction between polyphenols and oxygen.

Smit Yvette et al., (2011) studied on the microbiological profile of mango pulp. They observed that since today, the low pH foods and the juices, and the several other products as puree, pulp and nectar which were prepared from it were susceptible to spoilage and deterioration by the action of different microorganisms. They noted that *Alicyclobacillus* was cause maximum deterioration to these products because it survived at the acidic environment of juices even when these were exposed to thermal treatments during processing. They concluded that pulp stored with chemical preservatives showed better results than the control one. By adding these chemical pH of the pulp and juices decreased and pulp can be stored for longer period of time by maintaining its sensory characteristics and decreased microbial load.

Cerny et al., (1984) studied the effect of *Alicyclobacillus* and their significance as spoilage microbes on aseptically packed apple juice. Later on, spoilage incidents attributed to *Alicyclobacillus* species were noted in numerous juice concentrates (Splittstoesser et al., 1994; Goto et al., 2003 and Jensen et al., 2003), fruit pulp and juices (Jensen, 2000 and Matsubara et al., 2002), carbonated juices of different fruits (Pettipher et al., 2000), isotonic and lemonade water (Yamazaki et al., 1996), fruit pulps (Gouws et al., 2005), iced tea (Duong et al., 2000) and in canned tomatoes (Walls et al., 1998) worldwide. All of these concluded from their research that fruit products stored with the help of different chemical preservatives will control the microbial load for longer period of time than the sample stored without any additives.

Ndiaye et al., (2009) noted the influence of different type of heating treatments especially microwave heating on fresh and chemically preserved apple puree. Findings showed that by the above mentioned applications, we were able to control the populations of microbes but this heating application can not destroy the enzymes which were present in the puree and also by this activity degradation of vitamin C can occur. While the acidity and viscosity of the puree was not affected by this application during the storage. Short microwave heating control the microbial load and improve the nutritional and sensory characteristics. 30% decline of vitamin C was noticed in the treated puree after seven days storage at 50°C. But for the untreated (control) samples Vitamin C content decreased up to 63%. After 15 days of storage at 5 °C, Vitamin C constituents decreased up to 50% for both treated and untreated puree samples (Vadivambal et al., 2007).

Ramesh et al., (2002) studied on the microbiological attributes of apple puree. They observed that Initial population of *E. coli*, *L. innocua* and aerobic mesophilic microorganisms in the puree was 7.44, 6.89 and 2.76 log cfu g⁻¹, respectively. By the application of microwave heating, aerobic mesophilic microorganisms and *E. coli* were significantly affected, with the decline of 1.19 and 1.05 log cfu g⁻¹, respectively. Where as the above heating application markedly influence the growth of *L. innocua* having count below that of 10 cfu g⁻¹. Population of aerobic mesophilic microorganisms in the samples remained constant during the storage period at 4-5 °C, but there was minute increase in its populations after two week of storage (Cañumir et al., 2002).

Pitchaon et al., (2009) noted the potential of mango seed kernel towards the tyrosinase inhibition and antioxidant capacity. And these activities were loosed when the mango was processed. Results showed that peel extracts having high antioxidant capacity because of the phenolic constituents which were present in it. Results showed that the extracts also possessed tyrosinase inhibitory effect.

EL-Mansy et al., (1982) studied the effect pasteurization temperature on the flowing characteristics of treated pulp of mango with macerating and pectolytic enzymes. Findings

showed that there was no effect on the pseudoplastic time dependent behavior of the mango pulp by applying the pasteurization treatment singly or in combination with enzymes.

Rodrigo et al., (2007) observed the quality of fresh cut mango fruit and pulp preserved with different preservatives such as antioxidants, calcium salts and plant natural antimicrobials compounds. The basic aim of the use of these natural preservatives in the storage of puree and pulp was due to their low toxicity and resistant against allergenicity. These preservatives also maintain the keeping quality of pulp and control the microbial growth on it.

Gould, (1989) studied the method of food preservation by using different chemicals. During his research he used potassium metabisulphite as a basic chemical preservative. He used different kind of fruits for preservation with this chemical along with citric acid. Preservation of fruits had been done up to 120 days. Results showed that product that is preserved with the help of different preservatives had better shelf life having good keeping qualities. Product also had less microbial load and better sensory characteristics.

Manganelli et al., (1983) noted the effects of sorbic acid, benzoic acids and their salts on the microbial activity (yeasts) of stored mango pulp. They used different concentration of these preservatives for the storage of pulp. Results showed that chemical preservatives produced better effect for the control of microbial activity and the pulp can be stored for longer period of time having better keeping quality and low microbial load.

Sensory characteristics

Saini et al., (2000) observed that the browning in mango pulp upto 83.33% can be reduced by the application of potassium metabisulphite. Potassium metabisulphite reduced the color degradation by cease the millard reaction. Heikal and El-Sidawi, (1972) observed that browning in mango pulp is due to the reducing sugars and amino acids. By the action of potassium metabisulphite and sodium benzoate the amount of reducing sugar decreases while non-reducing sugar increases. So color degradation can be avoided.

Oms-Oliu et al., (2010) observed that the action of potassium sorbate, potassium metabisulphite and sodium benzoate, retains overall acceptability, nutrients stability and reduces microbial load.

Hashmi et al., (2007) observed that potassium sorbate, potassium metabisulphite, sodium benzoate separately or in combination with other chemical preservatives used for the improvement of sensory characteristics, control microbes and retain overall acceptability.

According to Kader, (2002) quality characteristics of mangoes are important for consumer acceptance of it. The quality parameters of mango including sufficient acidity, consistent and intense pulp colour and amount of total

soluble solids, depending upon variety of mango and category of end consumer preference. The flavour attribute depend upon the mango variety, maturity of it at harvesting; methods of post harvest preservation or storage of mango; including the kind of treatment, and occurrence of mechanical damage, which can also affect flavour characteristics of the mango (Kader, 2008a; 2008b).

Tharanathan et al., (2006) found that as the stage of maturity increases, their will be decreased in the chlorophyll constituents while the carotenoids contents tends to be increased. The yellowness of the pulp is due to the occurrence of carotenoids which give an attractive sensory appearance to consumer. And the preservation of it with the help of different chemical preservatives was used to increase its shelf life, improve sensory characters, and decrease microbial load (Ornelas-Paz et al., 2008; Saeed et al., 2010).

Jacxsens et al., (2010) were reported that Haden and Ataulfo mango varieties have higher β -carotene constituents as compared to Kent and Tommy Atkins, which are responsible to retain original colour for longer period of storage time after heat treatment. Chemicals which are used for the preservation of mango pulp improves their sensory characteristics physically appearance.

According to Baldwin, (2010) studied that flavour is a vital quality factor that determines the consumer attraction to the mango. The genetic characteristics determine the flavour constituents of mango fruit. These flavour contents are affected by various conditions of pre and post harvest, type of packaging, storage time and conditions. So the mango fruit can be processed and stored in the form of pulp with the help of different chemical preservatives for a longer period of time with maximum retention of original flavour. Basically the changes that occur in the flavour constituents is endorsed to mutation in the profile of fatty acid sequence this is palmitic acid changed to palmitoleic acid during maturation of mango. And if the harvesting of it is done at the beginning of ripening, then it gives the excellent flavour profile to the mango (Lalel et al., 2003b).

Sofos et al., (1981) and Sonia et al., (2003) studied that physico-chemical and sensory characteristics of stored mango pulp. They proposed from their study that pulp can be stored with the application of sodium benzoate at the concentration of 600 mg and 1200 mg of potassium metabisulphite for 360 days at room temperature without sufficient effect on the sensory characteristics of mango pulp. They also found that the effect of these preservatives on the taste of pulp is variable. They also observed that there is periodical decrease in the colour of the pulp sample. Results showed that chemically preserved pulp had poorer flavour as comparison to pulp at the start of study. With the passage of time pulp flavour is decreased. Various studied proved that the pulp samples were showed significant influence on the physico-chemical and organoleptic attributes of mango pulp by the addition of these chemical preservatives (Kapse et al., 1985; Mercadante et al., 1998).

Tovar et al., (2000); (2001) noted the post harvest physiology and keeping quality of fruits (mango) along with their storage. They noted that pulp can be preserved for longer time period by using the different chemical preservatives. Results showed that stored mango pulp have better sensory characters and having less microbial load as compared to the pulp that is stored without any type of preservative.

Adedeji et al., (1992) and Herianus et al., (2003) studied the volatile and aroma changes in stored and fresh mango (*Mangifera indica* L.) skin and pulp which were picked at different stages of maturity and ripening. They concluded from their research that, glycosidical aroma compounds in different mango varieties were significantly affected by the fruit part and the stage of ripening. They found that glycosideal compounds were most widely present in the skin while terpenes were present in the pulp part of fruit. These aroma compounds were formed by the metabolism of carbohydrates. While as the storage progressed, the Glycosidical constituents were also gone to increase in pulp portion of mango (Stahl-Biskup et al., 1993).

Cocci et al., (2006) and Rosario et al., (2009) noted the influence of calcium chloride and ascorbic acid on mango pulp and fresh cut mangoes and also note the effect of storage on antioxidant activity, bioactive constituents and colour characteristics. The better colour retention properties were showed by the pulp that was preserved by the chemicals than the fresh one.

According to Gil et al., (2006), the treatments which were preserved with chemical preservatives showed the incline in the vitamin C contents as comparison to control mango pulp. Their have no effect on carotene constituents by application of chemical but there was definite decline of vitamin E was noted in the preserved pulp during the storage period. Treatments which are preserved with chemicals have higher antioxidant activity. Results showed that by the addition of vitamin C, antioxidant activity was improved and as well as hinder the anti browning agent, so quality improved (Chantanawarangoon, 2000).

Va'squez-Caicedo et al., (2007) observed the effects of thermal mango processing in pulp or puree. They observed that colour can be retained in mango pulp by the inactivation of polyphenol oxidase and peroxidase enzymes, and also by b-carotene contents stability. During the study the mango pulp was pasteurized at 84°C to 93°C for about 15 minutes. This thermal treatment was applied to the destruction of enzymes and also for getting pulp having uniform viscosity. Results showed that during the heat treatment carotenoids contents preserved while there was significant loss of vitamin A constituents. Observations also showed that polyphenol oxidase was rapidly deactivated after one minute of pasteurization while about 4.5-7.0 % of peroxidase activity was observed even after 15 minutes at different pasteurization temperatures.

According to Yanishlieva et al., (1998) studied that different thermal applications affect the nutritional

properties of pulp, concentrate, nectar and puree, by the destruction of carotenoid constituents. Results showed that oxidation of carotene was occur in the presence of free radicals and formation of its epoxy, carbonyl and many other compounds (Wache et al., 2003). So to avoid these changes in final product pulp can be stored without pasteurization, with certain chemical preservatives. In this way keeping quality of mango pulp is maintained.

Dube et al., (2004) noted the influence of pasteurization on mango puree. According to their observations puree preserved with chemical preservatives along with heat treatments showed better results for sensory attributes and having longer shelf life, and better physico-chemical characteristics. While control treatments showed more microbial load and having high pH, low acidity and fermentation occur.

According to van den Berg et al., (2000) b-carotene contents were responsible for the development and retention of colour in the mango pulp. They observed that as we apply the pasteurization application to the pulp, there was degradation of the colour pigments as well as nutrients was also negatively affected. The colour fluctuation that was developed by the pasteurization treatment was noticed by the absorption spectra of the pigments. Instead of the previous studies that was on the carrot juice which was subjected to heat treatments (Marx et al., 2003), the documented study showed that the time and temperature of application was significant influence the carotenoids contents (Sitte et al., 1980).

Ribeiro et al., (2008) work on the antioxidant activities and flavouring constituents of different mango pulp varieties. They observed that different pulp contain different type and concentration of flavouring compounds. They contain different pigments as xanthone-C-glycosides and flavanol-O-glycosides. They took the methanolic and ethanolic extracts of peel, flesh and seed kernels of different mango varieties and analyzed for their physico-chemical and colour profile.

Stahl et al., (1993) noted the effect of steam blanching on polyphenoloxidase, peroxidase and colour of mango slices, chunks and purees. There was complete inactivation of polyphenoloxidase after 5 min and peroxidase after 7 min of heat treatment. They observed that steam blanching of 3 min give residual activity of polyphenoloxidase, peroxidase 2.85% and 8.33% respectively and when compared with samples heat treated for 5 min had no effect on colour even 20 days of storage. Due to insufficient blanching time colour changes were occur because non-enzymic browning had occurred.

Battacharya et al., (1998) studied the rheological parameters of enzyme treated stored mango pulp. Pulp was treated with pectinase enzyme at various temperatures ranged from 25-40°C and times (35-145 min). Study findings showed that fresh as well as treated pulp behaved as pseudoplastic fluid having yield stress. Rheological parameters such as apparent viscosity, flow behaviour index, yield stress and

consistency index, were dependent upon the enzyme concentration and thermal processing time. And their consistency increase as the enzyme dose and time of thermal application increases. However, there was markedly decline in the apparent viscosity with a rise in the dose of enzymes used.

El-Shiaty, (1986) work on the strawberry juice and tomato puree colour deprivation at various pH values ranged from 2.8-4.6 during thermal at 100–1300C for 0–110 min and high pressure thermal having 300–710 MPa pressure for about 58 min and the temperature of application was 650C. Study findings showed that as the pH increases there was incline in the colour deterioration.

Gliemmo et al., (2009) studied the color stability of chemically preserved pumpkin puree at room temperature. And also noted the effects of pH, potassium sorbate, ascorbic acid and packaging material on it. The color stability of pumpkin puree of pH 4.00 and 5.00 containing potassium sorbate, ascorbic acid or their mixture, packed in polyethylene and in polyvinyl chloride–polyvinylidene chloride copolymer (PCPC) bags, was analyzed throughout the storage at ambient temperature. The presence of potassium sorbate decreased color loss of purees packed in PCPC bags and increased the discoloration of purees contained in polyethylene suggesting, in the first case, that potassium sorbate oxidation removed the available oxygen avoiding carotenoids oxidation, while in the second case, oxidation will occur between potassium sorbate and carotenoids due to the presence of oxygen. Application of ascorbic acid to a puree of pH 4.00 containing potassium sorbate and packed in polyethylene minimized the losses of colour degradation; probably due to the antioxidant action of ascorbic acid. The increase in pH from 4.00 to 5.00 in the presence of potassium sorbate significantly minimized color degradation of puree packed in PCPC.

Liao et al., (1988) and Zerdin et al., (2003) studied the effects of chemically stored puree on colour degradation. They found that it is may be due to presence of oxygen in the packaging material and this oxygen present in purees packed in polyvinyl chloride–polyvinylidene chloride copolymer (PCPC) came from the elaboration process since packaging oxygen permeability is negligible. Both potassium sorbate and ascorbic acid can help to avoid carotenoid degradation. The potassium sorbate content decreased as a result of its oxidative degradation by 10–20% after 20 days of storage as it was observed in previous studies (Gliemmo et al., 2006). Due to this, available oxygen promote carotenoids degradation by oxidation, ascorbic acid is usually added to fruit pulps and purees to prevent development of oxidative off-flavors and off-color, by reduction of the oxygen in the headspace. Choi et al., 2002 also reported that ascorbic acid exerts a stabilizing effect on carotenoids and maintain keeping quality of pulp and puree.

Nindoa et al., (2007) studied the rheological properties of purees which were prepared from the tiny textured fruits as

blueberries, were significant in handling and thermal processing applications. They also note the effect TSS contents and temperature on the rheological parameters of stored puree which was used for further processing. They observe that as the temperature increases the flow of puree also increases but it affects the nutritional properties of puree. The 10_20 % solid contents also improve the rheological parameters of respected puree.

Choi et al., (2002) noted the effect of depolymerized mango pulp as a stabilizer in oil-in-water emulsion in which contained the sodium caseinate. Study showed that the emulsion have minute droplet size that was prepared from the enzyme treated pulp which led to wards the high creaming constancy as compared to the emulsion that was prepared without the application of enzymes. Results showed that as the break down of pectin in the mango pulp increases, the creaming stability of pulp also improved but having no effect on the emulsion droplet size. They concluded from the results that good stability emulsion have reducing sugar constituents of 60mg glucose/g fresh weight and 2% (w/w) sodium caseinate. Studied showed that depolimerization overall improves the physico-chemical characteristics of pulp.

Benjar et al., (2006) worked on pineapple puree and note the colour degradation in it due to enzymatic activity. Browning in pineapple puree can be prevented by thermal inactivation of enzyme (Polyphenoloxidase), was examined at different temperatures between 40-900C and in relation to exposure time. The rate of inactivation of enzyme varied with temperatures and application time.

Filipa et al., (1997) noted the quality characteristics of hot filled pasteurized fruit purees and also noted the effect of packaged material on it at filling temperatures. Pectinesterase and ascorbic acid were used as pasteurization and quality criteria for purees, respectively. Definite filling temperatures as well as packaging material (container) dimensions were important to get intent pasteurization value. Results showed that at low pasteurization and hot filling temperatures we get good quality puree.

Guerrero et al., (1996) studied on colour degradation of banana puree during storage preserved with sodium bisulphate. And also note the effect of thermal applications during processing and storage temperature influence on the banana puree. Results showed that colour changes in puree were directly correlated with the storage temperature. More deterioration in the colour was observed. As the temperature increases during storage colour degradation will be more. Colour degradation control by the application of sodium bisulphate on it. So it can improve the shelf life, keeping quality and sensory characteristics of puree.

Ajila et al., (2007) studied on the bioactive components of different fruits and vegetables as anthocyanins, polyphenols and carotenoids. These compounds have high potential to antioxidant activity. Basically the conducted study demonstrates the antioxidant potential of mango peel. High quantity of carotenoids and anthocyanins were present in

the ripened mango peel while unripened mango peel contains more polyphenol constituents. During the study the antioxidant capacity was measured by radical scavenging activity (DPPH free), reducing power action and iron induced lipid peroxidation by liver microsomes. Findings showed that mango peel have good potential to antioxidant activity, that's why it is essential for its functioning in functional and nutraceutical foods.

El-Nemr et al., (2003) analyzed the mango juice after bottling and during storage, for checking the fluctuation in the aroma contents which have an unpleasant influence on the quality attributes of juice. The reason for the losses in the aroma volatile components in the juices were applying the heat application for about 10 min at 85°C and also due to the development of the its byproducts as 5-methyl furfural, butyl-3-hydroxy butanoate, acetyl furan and β -terpineol. Deterioration reactions have been contributed by these byproducts and more deterioration have been occurring in the vitamin C contents of the juice. The reasons for the spoilage or developing of off flavour in the juice which was stored at room temperature were the development of ethyl fatty acids, along with this there was a decrease in the oxygenated and hydrocarbons constituents. These were the significant factors which influenced the flavour of stored mango juice.

Mysore et al., (2008) evaluate the influence of processing conditions on volatile compounds of chemically preserved fruit pulp of *Annona squamosa*. The pulp of fully ripened fruit was subjected to treatment applications as frozen and stored for about 12 months, and heated to 550C and 850C for about 20 min each. The flavour of the one year preserved frozen pulp was not alter from the fresh pulp at the start of study. However, there was inclining in the flavour contents of heated pulp at 550C and 850C.

Bhatia et al., (1961) observed that temperature higher than 550C seems to act considerably in emerging the quality of pulp, in terms the development of discoloration if pulp, bitter taste and poor flavor, the changes developed in the flavor attributes was compared to that of fresh pulp.

Donadon et al., (2001) studied the effect of different type of packaging material on the quality of preserved mango chunks. They used three type of packaging material; polypropylene cups, low-density polyethylene bags or polyethylene terephthalate clamshell trays, and stored at 30C for 2 weeks. The mango chunks were tested for flavor, appearance, colour, total soluble solids (TSS), titratable acidity, ascorbic acid contents, O₂ and CO₂ concentration in the packages. Results showed that chunks had better shelf life having good keeping quality. The titratable acidity in chunks was reduced during storage. The microbiological count was lower in preserved chunks than control in which no preservatives were added.

LuEck, (1990) studied the effect of sorbic acid and its salts (sodium sorbate and potassium sorbate) on the preservation of mango pulp. During his research he used different concentration of these preservatives. Results showed that

potassium sorbate showed better results then the sodium sorbate. At the end of his study he noted that pulp which is stored with the help of preservatives showed better results then the sample which is stored without any preservative.

Ogiehor et al., (2004) studied the preservatives effect on the mango puree. The observed that preservatives had significant effect on the sensory, physico-chemical and microbiological characteristics of mango puree.

References

- Abbasi, N.A., I. Zafar, M. Maqbool and I.A. Hafiz. 2009. Post harvest quality of mango (*Mangifera indica* L.) fruit as affected by chitosan coating. *Pak. J. of Bot.* 41(1): 343-357.
- Adedeji, J., T.G. Hartman, J. Lech, H. Chi-Tang. 1992. Characterization of glycosidically bound aroma compounds in the African mango (*Mangifera indica* L.). *J. of Agri. Food Chem.* 40: 659-661.
- Ahmad, M., M.A. Chaudhry and I. Khan. 1986. Technological studies on citrus and other fruit base drinks. *Nucleus.* 23(3-4): 41-45.
- Ajila, C.M., K.A. Naidu, S.G. Bhat, U.J.S. Prasada Rao. 2007. Bioactive compounds and antioxidant potential of mango peel extract. *Food Chem.* 105: 982-988.
- Akhtar, S., S. Mahmood, S. Naz, M. Nasir and M.T. Sultan. 2009. Sensory evaluation of mangoes (*Mangifera indica*.L) grown in different regions of Pakistan. *Pak. J. of Bot.* 41(6): 2821-2829.
- Amin, M., U.M. Aman, M.S. Mazhar, U.D. Islam, M.S. Khalid and A. Saeed. 2008. Mango fruit desapping in relation to time of harvesting. *Pak. J. of Bot.* 40(4): 1587-1593.
- Anwar, R. and A. U. Malik. 2007. Hot water treatment affects ripening quality and storage life of mango (*Mangifera indica* L.). *Pak. J. of Agric. Sci.* 44: 304-311.
- Aveno, J.L. and M.E.M.Orden. 2004. Hot water treatment of mango: A study of four pasteurization temperatures on mango. *J. of Food Sci.* 67: 56-59.
- Bajwa, E.E., Z. Naeem, J. Anjum and A. Nazir. 2003. Development, standardization and storage studies on watermelon-lemon. *Pak. J. Food Sci.* 12: 21-24.
- Baldwin, E. A. 2010. Fruit and vegetable flavour. <http://www.ne-postharvest.com/hb66/022flavor.pdf> accessed on 5th, November, 2010.
- Bassett, J., P. McClure. 2008. A risk assessment approach for fresh fruits. *J. Appl. Microbiol.* 104: 925-943.

- Benjar, C. and N. Athapol. 2006. Thermal inactivation of polyphenoloxidase in pineapple puree. 39: 492–495.
- Beuchat, L.R., D.A. Mann. 2008. Survival and growth of acid-adapted and unadapted *Salmonella* in and on raw tomatoes as affected by variety, stage of ripeness, and storage temperature. *J. Food Prot.* 71: 1572–1579.
- Bhatia, B. S., L. V. L. Sastry, G. V. Krishnamurthy, K. G. Nair and G. Lal. 1961. Preservation of custard apple (*Annona squamosa* L.). *J. of Sci. of Food and Agri.* 12: 529–532.
- Bhattacharya, S. and N. K. Rastogi. 1998. Rheological Properties of Enzyme-treated Mango Pulp. *J. of Food Engin.* 36: 249-262.
- Brandl, M.T. 2006. Fitness of human enteric pathogens on plants and implications for food safety. *Annu. Rev. Phytopathol.* 44: 367–392.
- Brenndor, B., L. Kennedy, C.O. Oswin, D.S. Trim, G.C. Mrema and C. Werek. 1985. Bobby solar dryers. Their role in post harvest processing. *Common Wealth Sci. Council.*
- Cancela, M. A., E. A. Lvarez and R. Maceiras. 2003. Polymers in Alimentary Industry: Properties of the Sodium Alginate. *Electric J. of Envir. Agri. and Food Chem.* 2(3): 1–8.
- Cañumir, J. A., J. E. Celis, J. de Bruijn and L. V. Vidal. 2002. Pasteurization of apple juice by using microwaves. *LWT–Food Sci. and Tech.* 35: 389–392.
- Cerny, G., W. Hennlich, K. Poralla. 1984. Spoilage of fruit juice by bacilli: isolation and characterisation of the spoiling microorganism. *Z. Lebensm. Unters. For.* 179: 224-227.
- Chantanawarangoon, S. 2000. Quality maintenance of fresh-cut mango slices. *Pak. J. of Nutri.* 6 (2): 143-148.
- Chiply, J.R. 1983. Sodium benzoate and benzoic acid. In: A.C. Branen, and P.M. Davidson (Eds.) *Antimicrobials in Foods*, Marcel Dekker Inc., New York, USA. 16.
- Choi, M. H., G. H. Kim and H. S. Lee. 2002. Effects of ascorbic acid retention on juice color and pigment stability in blood orange (*Citrus sinensis*) juice during refrigerated storage. *Food Research International.* 35: 753–759.
- Cocci, E., P. Rocculi, S. Romani, M. Dalla Rosa. 2006. Changes in nutritional properties of minimally processed apples during storage. *Postharvest Bio. Technol.* 39: 265–271.
- Cox, J. 2000. *Salmonella*. In: Robinson, R.K., Batt, C.A., Patel, P.D. (Eds.), *Encyclopedia of Food Microbio.*, vol. III. Academic Press, California. 1928–1937.
- Donadon, J. R., J. F. Durigan, G. H. A. Teixeira, M. A. Lima and B. Sarzi. 2001. Production and preservation of fresh-cut tomy atkins mango chunks. *J. of Food Sci.* 34: 561-565.
- Doreyappy-Gowda, L.N.D. and A.G. Huddar. 2001. Studies on ripening changes in mango (*Mangifera indica* L.) fruits. *J. Food Sci. Tech. Mysore.* 38: 135-137.
- Dube, M., K. Zunker, S. Neidhart, R. Carle, H. Steinhart and A. Paschke. 2004. Effect of technological processing on the allergenicity of mangoes (*Mangifera indica* L.). *J. of Agri. and Food Chem.* 52: 3938–3945.
- Duong, H.A., N. Jensen. 2000. Spoilage of iced tea by *Alicyclobacillus*. *Food Aust.* 52: 292.
- El Ansari, M. A., K. K. Reddy, K. N. S. Sastry and Y. Nayudamma. 1971. Polyphenols in mango. *J. of Food Sci.* 34-39.
- EL-Mansyl, H. A., S. K. EL-Samahy, A. A. Askar, H. T. Omran and N. A. AbdEl-Salam. 1982. Effect of Enzyme Treatments and Concentration of Mango Pulp on its Flow Behavior. *J. of Fruit processing.* 8: 330-334.
- El-Nemr, S. E., I. A. Ismail and A. Askar. 2003. Aroma changes in mango juice during ripening. *J. of Food Sci.* 45: 55-67.
- El-Shiaty, M.A., S.S. Rizk and G.A. El-Sherbiny. 1986. Stability of concentrated juice blends of some citrus species during storage. *Egyptian J. Food Sci.* 14 (2): 461-469.
- Favier, J.C., R.J. Ireland, C. Laussuc and M. Feinberg. 1993. *Répertoire général des aliments. Tome 3: Table de composition des fruits exotiques, fruits de cueillette d’Afrique.* 55-59.
- Filipa V. M. Silva and S. Cristina L. M. 1997. Quality Optimization of Hot Filled Pasteurized Fruit Purees: Container Characteristics and Filling Temperatures. *J. of Food Engi.* 32: 35 I-364.
- Foster, J.W., M.P. Spector. 1995. How *Salmonella* survives the odds. *Annu. Rev. Microbiol.* 49: 145–174.
- Frazier, W. C., D. C. Westhoff. 1988. Contamination, preservation and spoilage of vegetables and fruits. In W. C. Frazier and D. C. Westhoff (Eds.), *Food Microbio.* 196–217.
- Fulya, T., Y. Go'ksungur, A. D. Handan, U. nlu'tu'rk, G. Ulgar and Z. Nes,e. 1999. Mango processing. *J. Sci. Food Agri.* 79: 1197-1202.
- Germain, K., B.K. Benoi and M.L. Israel. 2003. Effect of ripening on the composition and the suitability for jam processing of different varieties of mango (*Mangifera indica*) *Afr. J. Biotech.* 2: 301-306.

- Germain, P. and G. Linden. 1981. Activités enzymatiques. In: Analyse des constituants alimentaires. (Eds.): B. Deymier, J.L. Multon and D. Simon. Techniques d'Analyse et de contrôle dans les industries agroalimentaires, Tec. Doc Lavoisier, Paris. 4: 211-244.
- Gibbs, R., N. Pingault, T. Mazzucchelli, L. O'Reilly, B. MacKenzie, J. Green, R. Mogyorosi, R. Stafford, R. Bell, L. Hiley, K. Fullerton, P. Van Buynder. 2009. An outbreak of *Salmonella enterica* Serotype Litchfield infection in Australia linked to consumption of contaminated papaya. *J. Food Prot.* 72: 1094–1098.
- Gil, M.I., E. Aguayo, A.A. Kader. 2006. Quality changes and nutrient retention in fresh-cut versus whole fruits during storage. *J. Agric. Food Chem.* 54: 4284–4296.
- Gliemmo, M. F., M. E. Latorre and C. A. Campos. 2006. Preservación de pure de calabaza mediante la aplicación conjunta de varios factores de estrés microbiano. In III Congreso Argentino de Microbiología de Alimentos (III CAMA), Buenos Aires, Argentina.
- Gliemmo, M.F., M.E. Latorre, L.N. Gerschenson and C.A. Campos. 2009. Color stability of pumpkin (*Cucurbita moschata*, Duchesne ex Poiret) puree during storage at room temperature: Effect of pH, potassium sorbate, ascorbic acid and packaging material. *Food Sci. and Tech.* 42: 196–201.
- GoÈksungur, Y., U. GuÈvencÈ and N. Zorlu. 1995. Effect of Sodium benzoate and potassium sorbate on cucumber pickle fermentation. *DogÈ a Turkish J. Bio.* 19: 143–149.
- Golden, D.A., E.J. Rhodehamel, D.A. Kautter. 1993. Growth of *Salmonella* spp. In cantaloupe, watermelon, and honeydew melons. *J. Food Prot.* 56: 194–196.
- Gonza´lez-Aguilar, G. A., C. Y. Wang and J. G. Buta. 2000. Maintaining quality of fresh-cut mangoes using antibrowning agents and modified atmosphere packaging. *J. of Agric. and Food Chem.* 48: 4204–4208.
- Goto, K., K. Mochida, M. Asahara, M. Suzuki, H. Kasai, A. Yokota. 2003. *Alicyclobacillus pomorum* sp. nov., a novel thermo-acidophilic, endospore-forming bacterium that does not possess u-alicyclic fatty acids, and emended description of the genus *Alicyclobacillus*. *Int. J. Syst. Evol. Microbiol.* 53: 1537-1544.
- Gould, G. W. 1989. Mechanisms of Action of Food Preservation procedures. Elsevier Applied Science London UK.
- Gouws, P.A., L. Gie, A. Pretorius, N. Dhansay. 2005. Isolation and identification of *Alicyclobacillus acidocaldarius* by 16S rDNA from mango juice and concentrate. *Int. J. Food Sci. Tech.* 40: 789-792.
- Guerrero, S., S. M. Alzamora and L. N. Gerschenson. 1996. Optimization of a Combined Factors Technology for Preserving Banana Puke to Minimize Colour Changes Using the Response Surface Methodology. *J. of Food Engin.* 28: 307-322.
- Hashmi, M. S., S. Alam, A. Riaz and A. S. Shah. 2007. Studies on Microbial and Sensory Quality of Mango Pulp Storage with Chemical Preservatives. *Pak. J. of Nutri.* 6 (1): 85-88.
- Heikal, H.A. and M.H. El-Sidawi. 1972. Some factors responsible for the browning of lime and orange juices. *Agri. Res. Rev.* 50: 199-214.
- Herianus J.D. Lalel, S. Zora and T. Soon Chye. 2003. Glycosidically-bound aroma volatile compounds in the skin and pulp of 'Kensington Pride' mango fruit at different stages of maturity. *Postharvest Bio. and Tech.* 29: 205-218.
- Hsin-Yi, C., C. Chou. 2001. Acid adaption and temperature effect on the survival of *E. coli* O157:H7 in acidic fruit juice and lactic fermented milk product. *Int. J. Food Microbiol.* 70: 189–195.
- Hummel, M. and R. Okey. 1950. Relation of canned tomato products to storage losses of ascorbic acid. *Food Res.* 15: 405-414.
- Hussain, I., A. Zeb, I. Shakir and A.S. Shah. 2008. Combined effect of potassium sorbate and sodium benzoate on individual and blended juices of apricot and apple fruits grown in Azad Jammu and Kashmir. *Pak. J. Nutr.* 7(1): 181-185.
- Hussain, S., R. Saleem, R. Atif and I. Muhammad. 2003. Studies on physico-chemical, microbiological and sensory evaluation of mango pulp storage with chemical preservatives. *J of Res. (Sci.)*, Bahauddin Zakariya Univ., Multan, Pak. 14(1): 01-09.
- Iola F. D., D. Ivonne and G. Ana M. 2006. Study of natural mango juice spoilage and microbial contamination with *Penicillium expansum* by high resolution 1H NMR spectroscopy. *Food Chem.* 96: 313–324.
- Iqbal, S.A., S.Yasmin, Wadud and W.H. Shah. 2001. Production storage packing and quality evaluation of Gouva Nectar. *Pak. J. Food Sci.* 11: 33-36.
- Islam, N.U. 1986. Some physico-chemical studies on the mango pulp stored in glass Bottles, M.Sc. Thesis, Deptt of Food Tech., Uni. of Agri. Faisalabad. 49.
- Jacobi, K. K., E. A. Macare and E. H. Hertherington. 2001. Postharvest heat disinfestations treatments of mango fruit. *Scientia Horticulturæ.* 89: 171–193.

- Jacobi, K. K., E. A. Macrae and E. H. Hetherington. 2000. Effects of hot air conditioning of 'Kensington' mango fruit on the response to hot water treatment. *Postharvest Bio. and Tech.* 21: 39–49.
- Jacobi, K. K., L. S. Wong and J. E. Giles. 1995. Effect of fruit maturity on quality and physiology of high humidity hot air treated 'Kensington' mango (*Mangifera indica* Linn.). *Postharvest Bio. and Tech.* 5: 149–159.
- Jacxsens, L., P. A. Luning, J. G. A. J. van der Vorst, F. Devlieghere, R. Leemans and M. Uyttendaele, 2010. Simulation modelling and risk assessment as tools to identify the impact of climate change on microbiological food safety — The case study of fresh produce supply chain. *Food Research International.* 43: 1925–1935.
- Jensen, N. 2000. *Alicyclobacillus* in Australia. *Food Aust.* 52: 282–285.
- Jensen, N., F.B. Whitfield. 2003. Role of *Alicyclobacillus acidoterrestris* in the development of a disinfectant taint in shelf-stable fruit juice. *Lett. Appl. Microbiol.* 36: 9–14.
- Kaanane, A., D. Kane and T. P. Labuza. 1988. Time and temperature effect on stability of Moroccan processed orange juice during storage. *J. of Food Sci.* 53: 1470–1473, & 1489.
- Kader, A. A. 2002. Quality and safety factors: Definition and evaluation for fresh horticultural crops. *Postharvest technology of horticultural crops.* Univ. of California. 279–285.
- Kader, A. A. 2008a. Mango quality attributes and grade standards: a review of available information and identification of future research needs (report to the National Mango Board). Davis, CA, USA: Kader Consulting Services.
- Kader, A. A. 2008b. Fresh-cut mangoes as value added product (literature review and interviews). http://mango.org/media/31003/fresh_cut_mangos_literature_review.pdf.
- Kapse, B.M., D.A. Rana, D.K. Salunkhe and D.M. Khedkar. 1985. Sensory evaluation of different varieties of mango during storage. *Ind. Food Pack.* 39: 43–48.
- Khalil, M., M. Ramzan, A. Ali and R.A. Riaz. 1979. Studies on the preparation and storage stability of comminuted lime squash. *Pak. J. Sci. Ind. Res.* 22 (5): 267–272.
- Kim, Y., A. J. Lounds-Singleton and S. T. Talcott. 2009. Antioxidant phytochemical and quality changes associated with hot water immersion treatment of mangoes (*Mangifera indica* L.). *Food Chem.* 115: 989–993.
- Laidlaw, W. G., J. W. Armstrong, H. T. Chan and E. B. Jang. 1996. The effect of temperature profile in heat-treatment disinfestations on mortality of pests and fruit quality. *Proceedings of the International Conference on Tropical Fruits: Global Commercialization of Tropical Fruits: Global Commercialization of Tropical Fruits, Kuala Lumpur, Malaysia.* 343–352.
- Lakshminarayana, S., N. V. Subhadra and H. Subramanyam. 1970. Some aspects of mango processing and preservation. *J. of Food Sci. and Tech.* 34: 45–49.
- Lalel, H. J. D., Z. Singh and S. C. Tan. 2003b. Elevated levels of CO₂ in controlled atmosphere storage affects shelf life, fruit quality and aroma volatiles of mango. *Acta Horti.* 628: 407–413.
- Lambert, A.D., J.P. Smith and K.L. Dodds. 1991. "Food Microbiology", Black Academic and Professional, London.
- Larmond, E. 1977. "Laboratory methods for sensory evaluation of foods". Research Branch Canada, Department of Agric. Publication. 1637.
- Lee, S. K. and A. A. Kader. 2000. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biology and Technology.* 20: 207–220.
- Leite, C.C., A.G. Guimaraes, M.D. da Silva, P.N. de Assis, R.L. Cardoso. 2002. Evaluation of the behavior of *Escherichia coli* O157:H7 in fruit pulp. *Hig. Aliment.* 16: 67–73.
- Liao, M., P. A. Seib. 1988. Chemistry of L-ascorbic acid related to foods. *Food Chem.* 30: 289–312.
- Lizada, C. 1993. Mango. In *Biochemistry of Fruit Ripening.* Ed. G. B. Seymour, J. E. Taylor and G. A. Tucker, Chapman and Hall, London. 255–271.
- LuÈck, F. 1990. Food applications of sorbic acid and its salts. *Food Addit. Contam.* 7:711–715.
- Maceiras, R., E. A. ´lvarez, M.A. Cancela. 2007. Rheological properties of fruit purees: Effect of cooking. *J. of Food Engin.* 80: 763–769.
- Maciel, M. I. S., V. L. A. G. Lima, E. A. Mélo, F. G. Prazeres, D. E. S. Lima, A. M. Souza and M. S. Lima. 2001. Quality evaluation of minimally processed mango cv. 'espada'.
- Malik, M.A., M.A. Haq and N. Muhammad. 1994. "Prospectus of mango processing in Pakistan", In: A. Saeed (Ed.), *Mango, A Brochure of the Horticulture Foundation of Pak., Islamabad.*

- Manganelli, E. and A. Casolari. 1983. Sensitivity of yeasts to sorbic and benzoic acids and their salts. *Ind Conserve*. 58: 23-25.
- Martin, J. J., E. Solanes, E. Bota and J. Sancho, 1995. Chemical and organoleptic changes in pasteurized orange juice. *Alimentaria*. 261: 59-63.
- Marx, M., M. Stuparic, A. Schieber and R. Carle. 2003. Effects of thermal processing on trans-cis-isomerisation of b-carotene in carrot juices and carotene-containing preparations. *Food Chem*. 83(4): 609-617.
- Matsubara, H., K. Goto, T. Matsumura, K. Mochida, M. Iwaki, M. Niwa, K. Yamasato. 2002. *Alicyclobacillus acidiphilus* sp. nov., a novel thermo-acidophilic, u-allycyclic fatty acid-containing bacterium isolated from acidic beverages. *Int. J. Syst. Evol. Microbiol*. 52: 1681-1685.
- Medlicott, A. P. and A. K. Thompson. 1985. Analysis of sugars and organic acids in ripening mango fruits (*Mangifera indica* L. var. Keitt) by high performance liquid chromatography. *J. of the Sci. of Food and Agri*. 36: 561-566.
- Meng, J., M.P. Doyle, T. Zhao, S. Zhao. 2007. Enterohemorrhagic *Escherichia coli*. In: Doyle, M.P., L.R. Beuchat. (Eds.), *Food Microbiology Fundamentals and Frontiers*. ASM Press, Washington, DC. 187-236.
- Mercadante, A.Z. and D.B. Rodriguez-Amaya. 1998. Effects of ripening, cultivar differences and processing on the carotenoid composition of Mango. *J. Agric. Food Chem*. 46: 128-130.
- Milos, M., J. Matelic and I. Jercovik. 2000. Chemical composition and antioxidant effect of glycosidically bound volatile compounds from oregano (*Origanum vulgare* L. ssp. *hirtum*). *Food Chem*. 71: 79-83.
- Mitcham, E. and E. Yahia. 2009. Alternative treatments to hot water immersion for mango fruit report to the national mango board. <http://www.mango.org/media/73313/alternatives%20to%20hot%20water%20treatment-final%20report.pdf> accessed 10.8.2010.
- Mitra, S.K. and E.A. Baldwin. 1997. Mango. In S. Mitra (Ed.), *Postharvest physiology storage of tropical and subtropical fruit*. New York, NY: CAB International. 85-122.
- Musingo, M. N., C. A. Sims, R. P. Bates, S. F. O'Keefe and O. Lamikanra. 2001. Changes in ellagic acid and other phenols in muscadine grape (*Vitis rotundifolia*) juices and wines during storage. *American J. of Enology and Viticulture*. 52: 109-114.
- Mutaku, I., W. Erku, M. Ashenafi. 2005. Growth and survival of *Escherichia coli* O157: H7 in fresh tropical fruit juices at ambient and cold temperatures. *Int. J. Food Sci. Nutr*. 56: 133-139.
- Mysore, N. S., B. Revathy, R. Lingamallu Jaganmohan, V. Munusamy R. and R. Somasundaram. 2008. Influence of processing conditions on flavour compounds of custard apple (*Annona squamosa* L.). 41: 236-243.
- Ndiaye, C., X. Shi-Ying, W. Zhang. 2009. Steam blanching effect on polyphenoloxidase, peroxidase and colour of mango (*Mangifera indica* L.) slices. *Food Chem*. 113: 92-95.
- Nindoa, C.I., J. Tanga, J.R. Powersb, P.S. Takharc. 2007. Rheological properties of blueberry puree for processing applications *LWT*. 40: 292-299.
- Ogiehor, S. I. and M. J. Ikenebomehclearly. 2004. Antimicrobial effects of sodium benzoate on the growth, survival and aflatoxin production potential of some species of *Aspergillus* in Garri during storage. *Pak. J. Nutr*. 3: 300-30.
- Ogunrinola, O. A., D. Y. C. Fung and I.J. Jeon. 1996. *E. Coli* O157: 117 growth in laboratory media as affected by phenolic antioxidants. *J. Food Sci*. 61: 1017-1020.
- Oms-Oliu, G., M. A. Rojas-Graü, L. A. González, P. Varela, R. Soliva-Fortuny and I. H. M. Hernando. 2010. Recent approaches using chemical treatments to preserve quality of fresh-cut fruit: A review. *Postharvest Bio. and Tech*. 57: 139-148.
- Ornelas-Paz, J. D., E. M. Yahia and A. A. Gardea. 2008. Changes in external and internal color during postharvest ripening of Manila and Ataulfomango fruit and relationship with carotenoid content determined by liquid chromatography-APCI+-time-of-flight mass spectrometry. *Postharvest Bio. and Tech*. 50: 145-152.
- Oyaizu, M. 1986. Studies on products of the browning reaction. Antioxidative activities of browning reaction products prepared from glucosamine. *Eiyogaku Zasshi*. 44: 307-315.
- Oyarzabal, O.A., M.C.L. Nogueira, D.E. Gombas. 2003. Survival of *Escherichia coli* O157:H7, *Listeria monocytogenes*, and *Salmonella* in juice concentrates. *J. Food Prot*. 66: 1595-1598.
- Palmer, W. K. and A. A. Kader. 1997b. Effect of slicing and controlled-atmosphere storage on the ascorbate content and quality of strawberries and persimmons. *Postharvest Bio. and Tech*. 10: 39-48.
- Palmer, W. K. and A. A. Kader. 1997a. Effect of controlled-atmosphere storage on the quality and carotenoid content of sliced persimmons and peaches. *Postharvest Bio. and Tech*. 10: 89-97.

- Penteado, A.L., B.S. Eblen, A.J. Miller. 2004. Evidence of *Salmonella* internalization into fresh mangos during simulated post harvest insect disinfestations procedures. *J. Food Prot.* 67: 181–184.
- Pettipher, G.L. 2000. *Alicyclobacillus* spp. e their detection and control in fruit juice. *Soft Drinks Int.* 31-32.
- Picouet, P. A., L. Andreas, A. Maribel, C. Massimo, V. Inmaculada. 2009. Minimal processing of a Granny Smith apple purée by microwave heating. *Innovative Food Sci. and Emerging Tech.* 10: 545–550.
- Pitchaon M., G. Michael. 2009. Antioxidant and tyrosinase inhibitory activity of mango seed kernel by product. *Food Chem.* 117: 332–341.
- Ploetz, R. C., G. A. Zentmyer, W. T. Nishijima, K. G. Rohrbach and H. D. Ohr. 1994. *Compendium of tropical fruit diseases.* APS Press. 88.
- Ramesh, M. N., K. Ramalakshmi, P. T. Sangeetha and S. G. Prapulla. 2004. Beverage concentrate based on fructooligosaccharides. Indian Patent Office, Gov. of India, 457/DEL. Preparation of nutraceutical beverage concentrate based on FOS: The novelty of the process is the preparation of nutraceutical beverage concentrate based on FOS is prepared by fermentation. This work is very much in line with the present research work.
- Ramesh, M. N., W. Wolf, D. Tevini and A. Bogner. 2002. Microwave blanching of vegetables. *J. of Food Sci.* 67(1): 390–398.
- Renuka, B., S.G. Kulkarni, P. Vijayanand and S.G. Prapulla. 2009. Fructooligosaccharide fortification of selected fruit juice beverages: Effect on the quality characteristics. *Food Sci. and Tech.* 42: 1031–1033.
- Riaz, R.A., A. Ali and M. Saleem. 1988. Studies on the preparation and storage stability of communitated Kinnow fruit beverage bases. *Pak. J. Sci. Ind. Res.* 32 (8): 574-578.
- Ribeiro, L.C.A. Barbosa, J.H. Queiroz, M. Kno` dler and A. Schieber. 2008. Phenolic compounds and antioxidant capacity of Brazilian mango (*Mangifera indica* L.) varieties. *Food Chem.* 110: 620–626.
- Rodrigo, D., L. Ann van and H. Marc. 2007. Combined thermal and high pressure colour degradation of tomato puree and strawberry juice. *J. of Food Engin.* 79: 553–560.
- Rosario, M., R. S`ancheza, A. Maria, R. Graub, A. Gustavo, G. Aguilera and M. Bellosob. 2009. Effect of minimal processing on bioactive compounds and antioxidant activity of fresh-cut `Kent` mango (*Mangifera indica* L.). *J. Postharvest Biol. Technol.* 51: 384-390.
- Saeed, A., R. Muhammad, A. Anwaar and N. Atif. 2010. Physico-chemical, microbiological and sensory stability of chemically preserved mango pulp. *Pak. J. Bot.*, 42(2): 853-862.
- Saini, S., D.S. Sogi and A.S. Bawa. 2000. Shelf-life studies on chemically preserved sand pear (*Pyrus pyrifolia* cv patharnakh) pulp. *J. Food Sci. Tech. Mysore.* 40: 230-232.
- Sakano, K. 1998. Revision of biochemical pH-stat: involvement of alternative pathway metabolism. *Plant and Cell Physiology.* 39(5):467–473.
- Saleh, N. A. M. and M. A. I. El-Ansari. 1975. Polyphenolics of twenty local varieties of mango. *J. of Food Tech. Pak.* 34-41.
- Sangeetha, P. T., M. N. Ramesh and S. G. Prapulla. 2002. Influence of media components and reaction parameters on the production of fructosyl transferase and fructooligosaccharides. *Sciences des aliments.* 22: 277–287.
- Selvaraj, Y., R. Kumar and D. K. Pal. 1989. Changes in sugars, organic acids, amino acids, lipid constituents and aroma characteristics of ripening mango (*Mangifera indica* L.) fruit. *J. of Food Sci. and Tech.* 26(6): 308–313.
- Singhal, S., P. R. Kulkarni and D. V. Rege. 1997. Fruit and vegetable products. In S. Singhal, P. R. Kulkarni and D. V. Rege (Eds.), *Handbook of indices of food quality and authenticity.* Cambridge: Woodhead Publishing Limited. 79–130.
- Sitte, P., H. Falk and B. Liedvogel. 1980. Chromoplasts. In F. C. Czygan (Ed.), *Pigments in plants.* 117–130.
- Sivakumar, D., Y. Jiang, E. M. Yahia. 2010. Maintaining mango (*Mangifera indica* L.) fruit quality during the export chain. *Food Research International.*
- Smit, Y., C. Michelle, V. Pierre and R. Corli Witthuhn. 2011. *Alicyclobacillus* spoilage and isolation e: A review. *Food Microbio.* 28: 331-349.
- Sofos, J.N. and F.F. Busta. 1981. Antimicrobial activity of sorbate. *J. Food Protect.* 44: 614-622.
- Sofos, J.N., M.D. Pierson, J.C. Blocher and F.F. Busta. 1986. Mode of action of sorbic acid on bacterial cells and spores. *Int. J. Food Microbiol.* 3: 1-17.
- Sonia, S., D.S. Sogi, A.S. Bawa. 2003. Shelf-life studies on chemically preserved sand pear (*Pyrus pyrifolia* cv Patharnakh) pulp; *J. Food Sci. Tech.* 40: 230-232.
- Soong, Y. Y. and P. J. Barlow. 2006. Quantification of gallic acid and ellagic acid from longan (*Dimocarpus longan* Lour) seed and mango (*Mangifera indica* L.)

- ernel and their effects on antioxidant activity. *Food Chem.* 97: 524–530.
- Souci, S. W., W. Fachmann and H. Kraut 1987. *Food composition and nutrition tables 1986/87*. Stuttgart: Wissenschaftliche verlagsgesellschaft.
- Splittstoesser, D. F. 1996. Microbiology of fruit products. In L. P. Somogyi, H. S. Ramaswamy and Y. H. Hui (Eds.), *Processing fruits: Sci. and Tech.* 261–292.
- Splittstoesser, D.F., J.J. Churey, C.Y. Lee. 1994. Growth characteristics of aciduric sporeforming bacilli isolated from fruit juices. *J. Food Protect.* 57: 1080-1083.
- Stahl-Biskup, E., F. Intert, J. Holthuijzen, M. Stengele, G. Schulz. 1993. Glycosidically bound volatiles*/a review 1986_/1991. *Flav. Fragr. J.* 8: 61-80.
- Strawn, L. K., M. D. Danyluk. 2010. Fate of *Escherichia coli* O157:H7 and *Salmonella* spp. on fresh and frozen cut mangoes and papayas. *International J. of Food Microbio.* 138: 78–84.
- Talcott, S. T., J. P. Moore, A. J. Lounds-Singleton and S. S. Percival. 2005. Ripening associated phytochemical changes in Mangoes (*Mangifera indica*) following thermal quarantine and low-temperature storage. *J. of Food Sci.* 70:337–341.
- Tharanathan, R. N., H. M. Yashoda and T. N. Prabha, 2006. Mango (*Mangifera indica* L.), “The King of Fruits” — An overview. *Food Reviews International.* 22: 95–123.
- Toma´s-Barbera´n, F. A. and J. C. Espi´n. 2001. Phenolic compounds and related aromatic compounds of mango. *J. of Food Sci.* 34: 67-69.
- Tovar, B., H. S. Garcí’a and M. Mata. 2001. Physiology of pre-cut mango. I. ACC and ACC oxidase activity of slices subjected to osmotic dehydration. *Food Research International.* 34: 207–215.
- Tovar, B., L.I. Ibarra, H.S. Garcí’a, M. Mata. 2000. Some compositional changes of Kent mango (*Mangifera indica*) slices during storage. *J. of Applied Horti.*
- Tucker, G. A. 1993. Introduction. In *Biochemistry of Fruit Ripening*. Ed. G. B. Seymour, J. E. Taylor and G. A. Tucker. Chapman and Hall, London. 1–51.
- Va´squez-Caicedo, A., S. Susanne, C. Reinhold and N. Sybille. 2007. Effects of thermal processing and fruit matrix on b-carotene stability and enzyme inactivation during transformation of mangoes into pure´e and nectar. *Food Chem.* 102: 1172–1186.
- Vadivambal, R., and D. S. Jayas. 2007. Changes in quality of microwave-treated agricultural products — a review. *Biosystems Engin.* 98: 1–16.
- Van den Berg, H., R. Faulks, H. Fernando Granado, J. Hirschberg, B. Olmedilla and G. Sandmann. 2000. Review: The potential for the improvement of carotenoid levels in foods and the likely systemic effects. *J. of the Sci. of Food and Agri.* 80: 880–912.
- Verbeke, W. 2005. Consumer acceptance of functional foods: sociodemographic cognitive and attitudinal determinants. *Food Quality and Preference.* 16(1): 45–57.
- Vergara-Valencia, N., G. Eliana, A. Edith, T. Juscelino, R. Jenny and B. Luis. 2007. Fibre concentrate from mango fruit: Characterization, associated antioxidant capacity and application as a bakery product ingredient. 40: 722–729.
- Wache´, Y., A. Bosser-DeRatuld, J. C. Lhuguenot and J. M. Belin. 2003. Effect of cis/trans isomerism of b-carotene on the ratios of volatile compounds produced during oxidative degradation. *J. of Agri. and Food Chem.* 51: 1984–1987.
- Walls, I., R. Chuyate. 1998. *Alicyclobacillus* e historical perspective and preliminary characterization study. *Dairy Food Environ. Sanit.* 18: 499-503.
- Warth, A.D. 1985. Resistance of yeast species to benzoic and sorbic acids and to sulfur dioxide. *J. Food Protect.* 48: 564-569.
- Wu, X., G. R. Beecher, J. C. Holden, D. B. Haytowitz, S. E. Gebhardt and R. L. Prior. 2004. Lipophilic and hydrophilic antioxidant capacities of common foods in the United States. *J. of Agri. and Food Chem.* 52: 4026–4037.
- Yamazaki, K., H. Teduka, H. Shinano. 1996. Isolation and identification of *Alicyclobacillus acidoterrestris* from acidic beverages. *Biosci. Biotechnol. Biochem.* 60: 543-545.
- Yanishlieva, N. V., K. Aitzetmu¨ller and V. G. Raneva. 1998. b-Carotene and lipid oxidation. *Fett/Lipid.* 100(10): 444–462.
- Yigeremu, B., M. Bogale, M. Ashenafi. 2001. Fate of *Salmonella* species and *E. coli* in fresh-prepared orange, avocado, papaya, and pineapple juices. *Ethiop. J. Health Sci.* 11: 89–95.
- Youngmok, K., K. Jeffrey, B. T. Stephen and T. 2007. Antioxidant phytochemical and fruit quality changes in mango (*Mangifera indica* L.) following hot water immersion and controlled atmosphere storage. *Food Chem.* 105: 1327–1334.
- Yusof, S., M. Suhaila and A. Abdullah. 2003. Effect of fruit maturity on the quality and phenolic compounds of mango. *J. of Biotech. And Research.* 34-41.
- Zerdin, K., M. L. Rooney and J. Vermu¨e. 2003. The vitamin C content of orange juice packed in an oxygen scavenger material. *Food Chem.* 82: 387–395.