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Mob: +92 300 3008585, Fax: +92 41 8815544

E-mail: editorpjn@gmail.com

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Effect of Coatings and Packaging Material on the Keeping Quality of Mangoes (*Mangifera indica* L.) Stored at Low Temperature

Kashif Sarfraz Abbasi[1], Nuzba Anjum[1], Shehla Sammi[1], Tariq Masud[1] and Sartaj Ali[2]
[1]Department of Food Technology, PMAS-Arid Agriculture University, Rawalpindi, Pakistan
[2]Department of Food Agriculture and Chemical Technology, Karakoram International University, Northern Areas, Gilgit, Pakistan

Abstract: In order to identify and compare the effects of different concentrations of coatings (Carboxy Methyl Cellulose, $CaCl_2$, Bee wax) and packaging (polyethylene sheet), on improving the keeping quality of mangoes its storage performance was evaluated. Mangoes after harvesting were given hot water treatment at 50±2°C for three minutes as quarantine measure against fungal attack. Then fruits were coated with three different concentrations of CMC and $CaCl_2$ along with bee wax coating and polyethylene sheet packaging. All the treatments were applied in combination with $KMnO_4$ soaked with sponge cubes used as ethylene absorbents. Fruits were kept at refrigerated temperature for 80 days and evaluated for physico-chemical and sensory changes at an interval of seven days. All coatings delayed fruit ripening and improved the keeping quality of the produce but best results were exhibited by Carboxy Methyl Cellulose (CMC) at 2% level. It extended storage life up to 77 days with appreciable retention of all the quality parameters.

Key words: Mango, coating materials, physico-chemical analysis

INTRODUCTION

Mango (*Mangifera indica* L) is a very delicious tropical fruit belongs to family *Anacardiaceae*. It is an abundant source of vitamins, minerals and is famous for its excellent flavor, attractive fragrance and nutritional value. It is as an emerging tropical export crop and is produced in about 90 countries in the world with a production of over 820,877MT. Pakistan is at 7th position among main mango producing countries with production of 77,468 MT and export accounts for 9.4% of total world production valued at $ 32.35 million (CSF, 2007). It is the second major fruit crop in Pakistan with more than 200 varieties, amongst important leading commercial ones are Chaunsa, Langra, Sindhri, Dusehri, Saroli, Fajri, Anwar Retol, Bagan Pali, Gulab Khas, Neelum, Maldah, Collector, etc. contributing major share in the economy of the country (Amin and Hanif, 2002).

The magnitude of post harvest losses in fresh fruits and vegetables is an estimated 5-25% in developed countries and 20-40% in developing countries, depending upon the commodity (FAO, 2001). Due to improper handling, packaging, storage and poor post harvest managements of fruits, producers and traders in Pakistan face 20-30% losses of this perishable commodity (Tahir *et al.*, 2002) that corresponds to 320.7 thousand tons with a value of Rs 3.0 billion (Haq, 2002), also contributing to low foreign exchange of $ 315 per tones as compare to international price of $ 861 per tones (PHDEB, 2007).

In recent years, coatings of some edible materials like Lipid based coatings, polysaccharide based coatings, protein based coatings, composite and bilayer coatings etc. have been applied on the skin of different fruits in order to reduce moisture loss, restrict oxygen entrance, lower respiration, retard ethylene production and seal in flavour volatiles (Baldwin *et al.*, 1995). In addition to these coatings applications the maintenance of cold chain during the post harvest management of fruits is very critical. These coatings are used to create modified atmosphere and to reduce weight loss during transport and storage by controlling the permeability and gaseous exchange (Cuq *et al.*, 1995). Previously such coatings have long been used on citrus, apples, tomatoes and cucumbers with excellent results but are less studied for the use on mango (Baldwin *et al.*, 1999). The use of polysaccharides and protein based coating materials on several types of fruits has been developed in past few years that Include sucrose fatty acid esters on apricot (Sumnu and Bayindirli, 1995) and bananas (Abbasi *et al.*, 2004), cellulose on mango (Baldwin *et al.*, 1999), edible coatings on strawberry (Del-Valle *et al.*, 2005) and corn protein in tomato (Park *et al.*, 1994). The application of reported coating material has also significantly increased the shelf life of different varieties of citrus and mangoes (Attia, 1995; Carrillo *et al.*, 1995; Farooqi *et al.*, 1995; Manzano *et al.*, 1997; Pal, 1998) respectively.

Pakistan is the leading mango exporting country in the world (Sauco, 2004) with premium product harvested

Corresponding Author: Tariq Masud, Department of Food Technology, PMAS-Arid Agriculture University, Rawalpindi, Pakistan

from the plains of southern Punjab and Sindh province. The demand for high quality produce is on an increase throughout the world. So, an increase in the quantity and improvement in the quality of fruit is highly desirable in order to fulfill the international standards for export. A significant extension in post harvest life of mango is important to permit transport, distribution and commercialization to distant export markets.

The objective of this research was to study the keeping quality of mango with the application of different coatings and packaging material under low temperature at farm level to reduce the wastage of this valuable fruit.

MATERIALS AND METHODS

Mango of cultivar 'Chaunsa' were harvested from Multan (Punjab) orchards at mature green stage. The fruits were carefully graded to ensure uniformity in maturity, size and color. The fruits were immediately given hot water treatment at 50±2°C for 3 min to avoid fungal attack and than air dried to drain off excess water. Mangoes were randomly divided into nine different categories for further studies.

Preparation of coating: Carboxy Methyl Cellulose (CMC) coatings (1, 2 and 3%) were prepared by dissolving 2.0 g, 4.0 g and 6.0 g of methyl cellulose powder (Hangzhou Hongbo Chemical Co. Ltd, China) in 200 ml of water-ethyl alcohol mixture (3:1L/L) at 80°C and stirred for 10 min by using magnetic stirrer. Ethyl alcohol was used to reduce drying time and obtain a transparent and shinny coating. 2% propylene glycol was also added in the formulation as plasticizer. Beewax coating (2%) was prepared by dissolving 4.0 g of wax (Wax Oils Pvt Ltd, India) in 200 ml of water-ethyl alcohol mixture (3:1L/L) at 70°C and stirred for 10 min by using magnetic stirrer. Low Density Polyethylene sheet (Mushtaq Sons Lahore, Pakistan) of 0.05 mm thickness (T_5) was used to wrap the fruit individually. Calcium chloride solutions (1, 2 and 3%) were prepared by dissolving 5 g, 10 g and 15 g of $CaCl_2$ (Sigma-Aldrich, U.S.A) in 500 ml of distilled water. The untreated fruits were left as control in T_0.

Coating and storage of fruits: Different treatments as various concentrations of coating materials and packaging material (T_0 = Control, T_1 = 1% CMC, T_2 = 2% CMC, T_3 = 3% CMC, T_4 = 2% bee wax, T_5 = Low Density Polyethylene Sheet, T_6 = 1% $CaCl_2$, T_7 = 2% $CaCl_2$, T_8 = 3% $CaCl_2$) were applied to the fruits. Fruits were dipped in different coating formulations (except in T_5) for 1 min, immediately taken out and dried under blowing air at 25±2°C. The dried coated fruits were placed in card board boxes (11 x 34 x 27 cm) provided with sponge cubes (4 cm^3) soaked in saturated potassium permanganate solution. Mangoes were stored at refrigerated temperature (8°C) for further studies.

Physical analyses: The physical analyses at regular interval of seven days were carried out to evaluate the quality change in the mangoes during their storage. The weight loss due to active metabolic rate was determined by weighing the samples with digital balance (OHAUS, Model TS4KD Florham Park, NJ, USA) and reported as percent loss in sample weight based on its initial weight. Total Soluble Solids (TSS) were recorded as °Brix by Digital Refractometer (PAL-III ATAGO, Japan) according to AOAC (1994) method no. 932.12.

Chemical analyses: Mangoes were analyzed for different chemical parameters after seven days interval. Titratable acidity was determined in terms of malic acid according to AOAC (1994) method no. 932.12. Ascorbic acid was determined by using 2,6 dichlorophenol indophenol dye as described by AOAC (1994) method no. 967.21.

Sensory evaluation: Sensory evaluation was carried out at an interval of seven days by the method described by Lawless and Heymann (1998). A trained panel of seven judges assessed fruits for their sensory parameters like color, taste, flavor and texture. The judges' average response was calculated for each parameter.

Statistical analysis: Different trials were conducted in Completely Randomized Design (CRD) with three replications. Data obtained were subjected to Analysis of variance using statistical software MSTATC as described by Steel *et al*. (1997).

RESULTS AND DISCUSSION

Physical analyses: The general trend was an increase in weight loss with time. This was true for all the treatments including control, however variable pattern of weight loss was observed in different set of treatments. The loss of water from treated fruits was lesser than the control. This was due to the fact that coatings (CMC, Bee wax, $CaCl_2$) served as semi permeable membrane around fruit surface and $KMnO_4$ sponges degraded ethylene produced by the fruits however weight loss in CMC coated fruits was significantly different from all other treatments. Statistical analysis ($p \leq 0.05$) revealed that during storage period T_2 (CMC 2%) showed minimum weight loss followed by $T_1 < T_3 < T_7 < T_6 < T_4 < T_8 < T_5$ and T_0 (Fig. 1) however non significant difference was recorded between T_4 and T_8. In T_4 (fruits sealed in polyethylene sheets) an initial increase and than a decrease in weight loss was recorded. The final decrease in weight loss might be due to the movement of water vapors from the saturated atmosphere into the fruits. These results are in agreement with those of Carrillo *et al*. (2000) who observed that coated or uncoated Haden mango in Mexico had an increasing trend of weight loss with the passage of storage time.

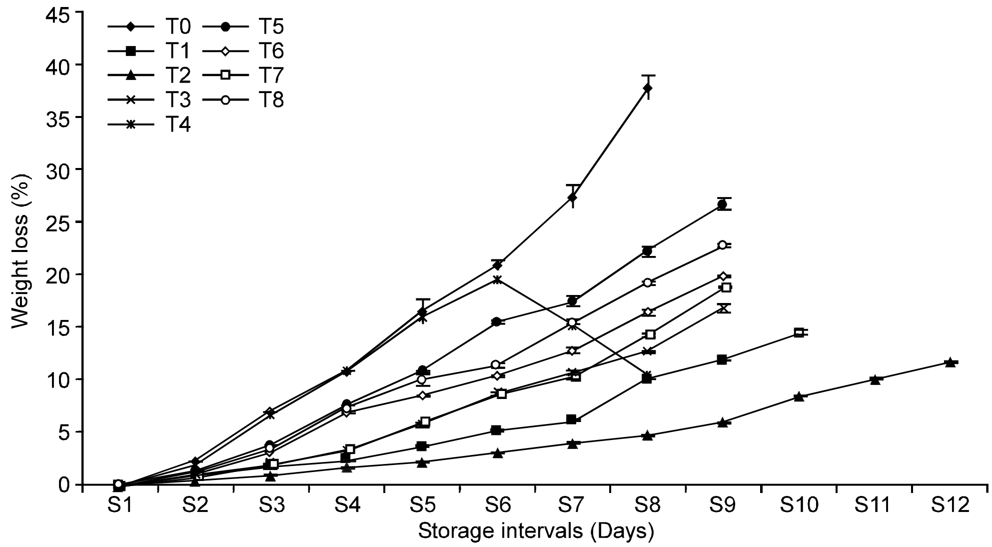

Fig. 1: Effect of storage and treatments on the weight loss (%) (mean±SE) of mangoes

However, weight loss was lowest in T_2 (11.65%) as compared to T_0 having highest percent weight loss (37.75%). Use of 2% CMC in conjunction with $KMnO_4$ sponges as an ethylene absorbents (in T_2) was highly effective in reducing weight loss in mango that may be due to less availability of ethylene in the storage atmosphere which in turn decrease the mitochondrial activity and respiration rate eventually reducing moisture loss from the fruit.

Weight loss is an important index of post harvest storage life in the fresh produce. It is mainly attributed to the loss of water during metabolic processes like respiration and transpiration. Moisture loss and gaseous exchange from the fruits is usually controlled by the epidermal layers provided with guard cells and stomata. The coating helps to reduce this further because it forms a film on the top of the skin acting as an additional barrier to moisture loss as been reported by Togrul and Arslan (2004). These barrier properties also reduce the oxygen uptake by the fruit which in turn slowed down rate of respiration and associated weight loss from the fruit surface. Application of CMC at 2% (T_2) level significantly reduced the weight loss from the fruit surface because of its water vapor barrier properties and extended the storage life of fruit up to 77 days with three times lesser weight loss than in the control. The effectiveness of CMC in avocados and Semperfresh™ on cherries in reducing the weight loss was previously reported by Maftoonazad and Ramaswamy (2005) and Yaman and Bayoindirli (2002) respectively.

The results of Total Soluble Solids (TSS) in general showed an initial increase and then a decrease. This trend was observed in all the fruits but the rate of increase in TSS in treated fruits was comparatively slower than in control. Samples treated with CMC (2%) showed significantly ($p \leq 0.05$) highest amount of TSS and this was followed in decreasing order as $T_7>T_5>T_6>T_1>T_8>T_3>T_0$ and T_4 (Fig. 2) however non significant difference was observed between T_2, T_7 and T_5. These results are also in agreement with those of Carrillo *et al.* (2000) who observed that Haden mango in Mexico coated or uncoated form had an increasing trend of total soluble solids with the passage of storage time and reached a peak after 16-24 days at 13°C and 85% RH and then decreased. After 35 days of storage total soluble solid contents were lowest in CMC coated fruit (15 °Brix) as compared to control having highest percent total soluble solid contents (24.5 °Brix). A similar effect of CMC on TSS has been reported in Haden mangoes (Carrillo *et al.*, 2000) in Mandarines (Bayindirli *et al.*, 1995) and in apple (Hayat *et al.*, 2005).

Change in TSS in the present study was might be due to the hydrolytic conversion of polysaccharides into soluble sugar as is the case in many climacteric fruits during the ripening process. In the initial stages of storage, rate of conversion of insoluble polysaccharide was faster than the rate of fermentation of mono and disaccharides into organic acids. Therefore, this resulted in an increase in TSS of the fruits. In the later stages of storage the rate of conversion of soluble mono and disaccharides into organic acids was faster than the conversion of in soluble polysaccharides into mono and disaccharides and thus resulted in decreased TSS in the fruits. This decreasing trend in TSS might be attributed to the microbial activity. The results are in line with the findings of Manzano *et al.* (1997) and Sarkar *et al.* (1997).

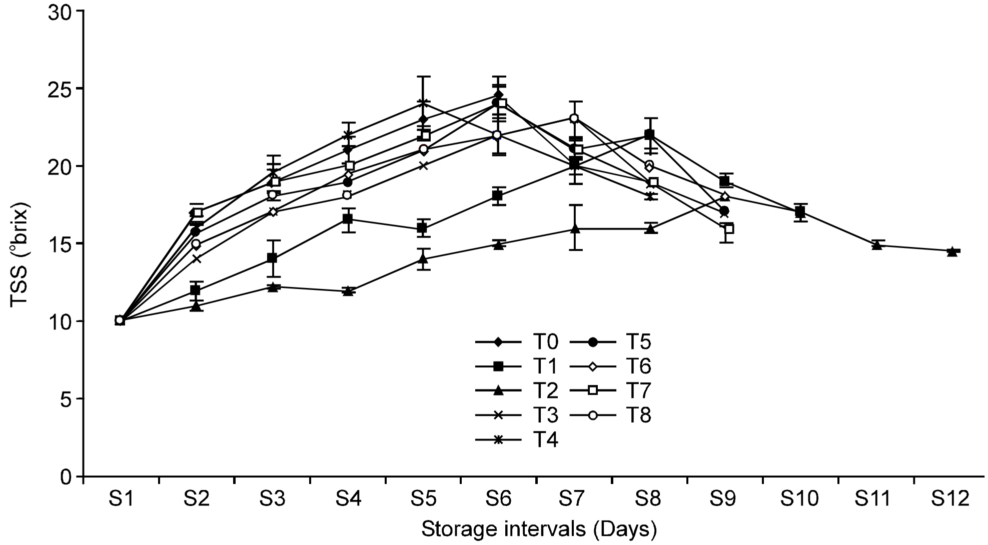

Fig. 2: Effect of storage and treatments on the TSS (mean±SE) of mangoes

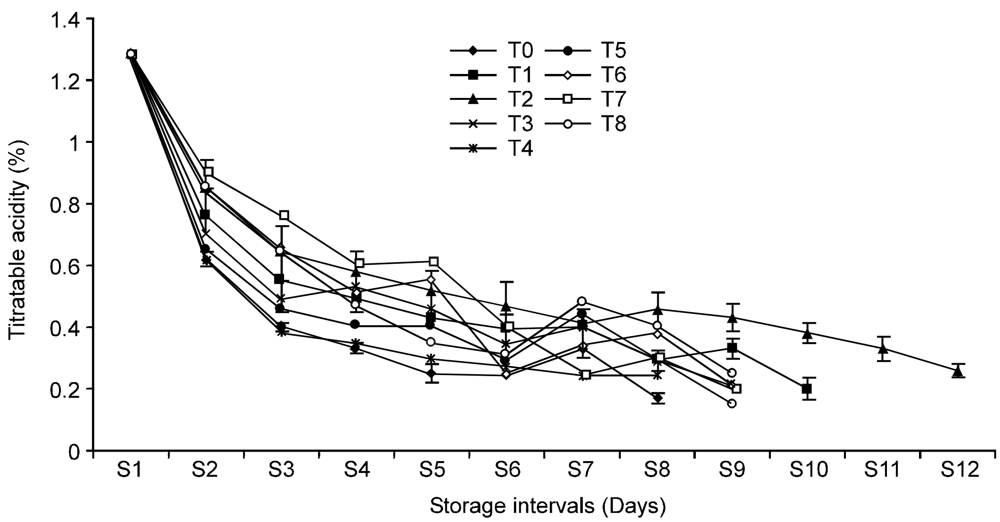

Fig. 3: Effect of storage and treatments on the titratable acidity (mean±SE) of mangoes

Chemical analyses: Titratable acidity showed decreasing trend in all the samples. The rate of decrease in titratable acidity in treated fruit was faster than in control. Statistical analysis ($p \leq 0.05$) showed that T_2 retained maximum acidity level followed by T_7>T_1>T_8>T_6>T_3>T_5>T_4 and T_0 (Fig. 3) and non significant difference was recorded between T_7 and T_1. The possible reason for the variation may be due the difference in the microenvironment created by coatings, packaging and ethylene absorbent used, coupled with less oxidative reactions and lesser decline in degradation of acids thus maintaining the integrity of ells. These results are in lines with findings of several researchers (Raje *et al.*, 1997; Li and Yu, 2001; Dong *et al.*, 2004; Hayat *et al.*, 2005), which were of the opinion that titratable acidity was higher in fruits like Alphonso mango, apples, peaches etc. either treated with coatings or ethylene absorbent as compared to control with similar decreasing trend of acidity stored at ambient temperature.

Organic acids are substrates for many enzyme mediated reactions during aerobic respiration in the plant cells and a reduction in the acidity may be expected as a result of such activity during the storage period. The decrease in acidity is thus correlated with the advancement of maturity and ripening in the fruits. The tendency of reduced acidity during storage might be due to that the fruit under going the ripening process diminished its malic acid and favored the formation of sugars. These results were also in confirmation with

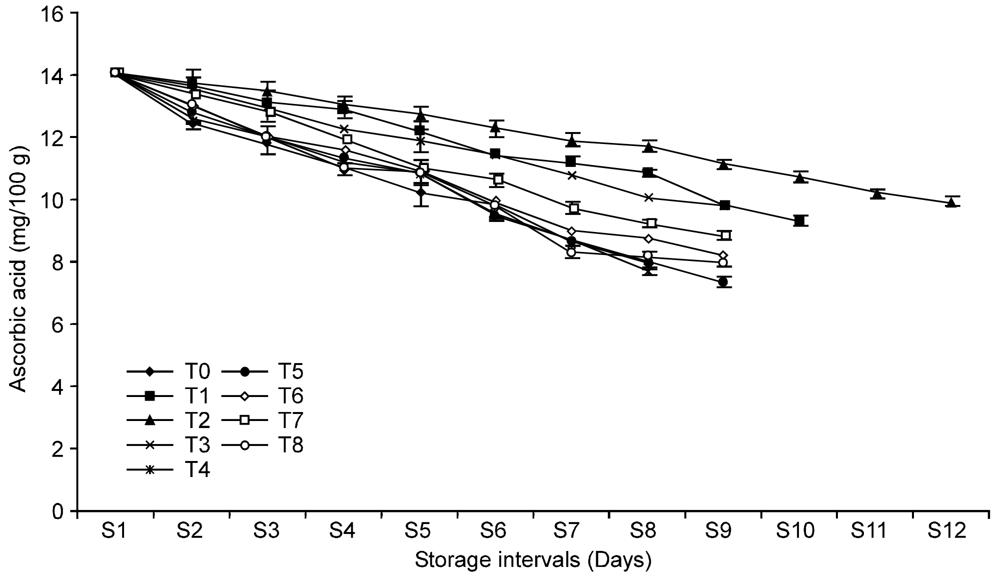

Fig. 4: Effect of storage and treatments on the ascorbic acid (mean±SE) of mangoes

those reported by Martinez *et al.* (1997). Another possibility for the decrease in acidity is consumption of acid by micro-organisms as a source of carbon. High amount of acidity in treated fruits might be due to the facts that carbon dioxide accumulated internally in the fruit tissues caused acidosis after dissolving and farming carbonic acids. These results were also in line with those of Carrillo *et al.* (1995).

Ascorbic acid decreased gradually with the storage time in all the fruits including control. Statistical analysis ($p \leq 0.05$) revealed that T_2 (CMC at 2%) retained maximum ascorbic acid values followed by $T_1>T_3>T_7>T_6>T_8>T_5>T_4$ and T_0 (Fig. 4). A non significant difference was recorded when samples were treated with 3% $CaCl_2$ (T_8) and 2% Bee wax (T_5). This decreasing trend of ascorbic acid during storage might be due to the presence of oxygen which resulted in the conversion of ascorbic acid into dehydroascorbic acid. The presence of oxygen and high rate of respiration accelerates oxidation process in fruits. These results were in line with the findings of Sumnu and Bayindirli (1995).

The rate of decrease of ascorbic acids content in coated fruits was slower as compare to control due to retarded oxidation process and hence the rate of conversion of ascorbic acid into dehydro-ascorbic acid was slowed down during storage. Sample treated with 2% CMC retained appreciable ascorbic acids (9.93 mg/100 g) in fruits even after 77 days of storage whereas nearly same loss in ascorbic acids (9.76 g/100 g) was recorded in T_0 only after 35 days of storage. These results are compareable with Carrillo *et al.* (2000) who examined a slower decreasing trend of ascorbic acid in Haden mangoes coated with different concentrations of Semperfresh as compared to non coated fruit at 13°C during 32 days of storage. These results are in line with those Dhaka *et al.* (2001) who observed that the retension of ascorbic acid content of Totapuri mango depends on the concentrations of coating and showed that Calcum chloride 1.0% and 8.0% wax emulsion retained the maximum ascorbic acid (9.85 and 9.89%) as compared to control (8.27%) at ambient temperature and cool chamber.

Sensory evaluation: Initial increase and decreasing trend near the end of storage was in consistent with all the sensory parameters like skin color, pulp color, taste, flavour and texture (Fig. 5, 6, 7, 8 and 9). Color is related to the presence of different pigments, Flavor is attributed to esters, alcohols, acids and carbonyl compounds. Taste is mainly due to sugar acid ratio; texture is related to the presence of peptic substances. During ripening, transition of chlorophyll into carotenoids (Kays, 1991), biochemical conversions of starch into sugar (Martinez *et al.*, 1997), insoluble protopectin into pectin (Gerardi *et al.*, 2001) and Loss of organic acid through oxidation (Campestre *et al.*, 2002) are responsible for the changes in these sensory parameters. Coatings at different levels cause these changes at varying level by retarding the concerned metabolic processes.

The general trend was an increase and than a decrease in skin color scores. In fruits with different post harvest treatments rate of change of skin color scores was comparatively slower than in control. Statistical analysis ($p \leq 0.05$) revealed that T_2 (CMC at 2%) showed maximum color scores followed by $T_1>T_3>T_6>T_7>T_8>T_4>T_5$ and T_0 after 77 days of storage at refrigerated temperature (Fig. 5) and non significant

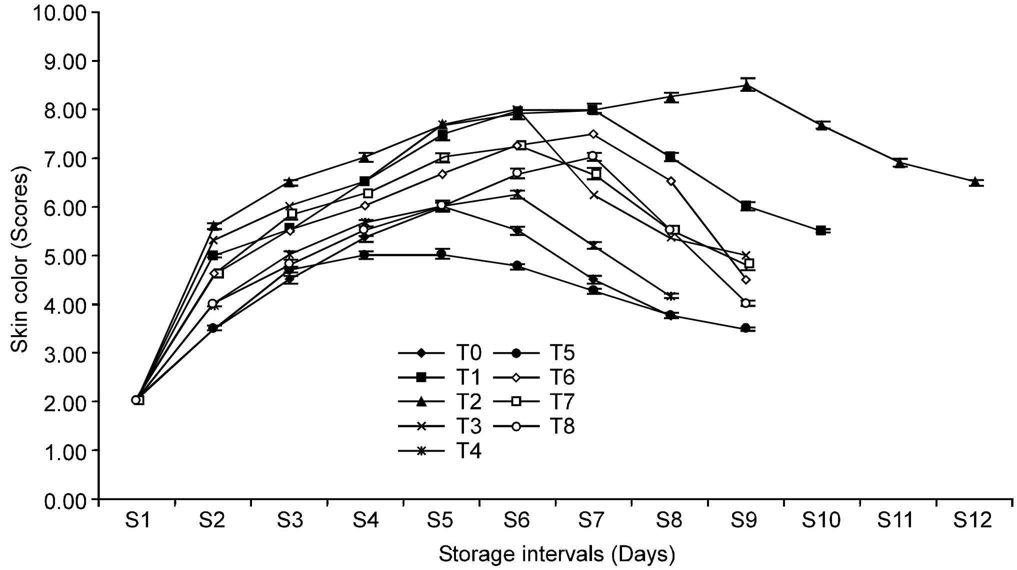

Fig. 5: Effect of storage and treatments on skin color (mean±SE) of mangoes

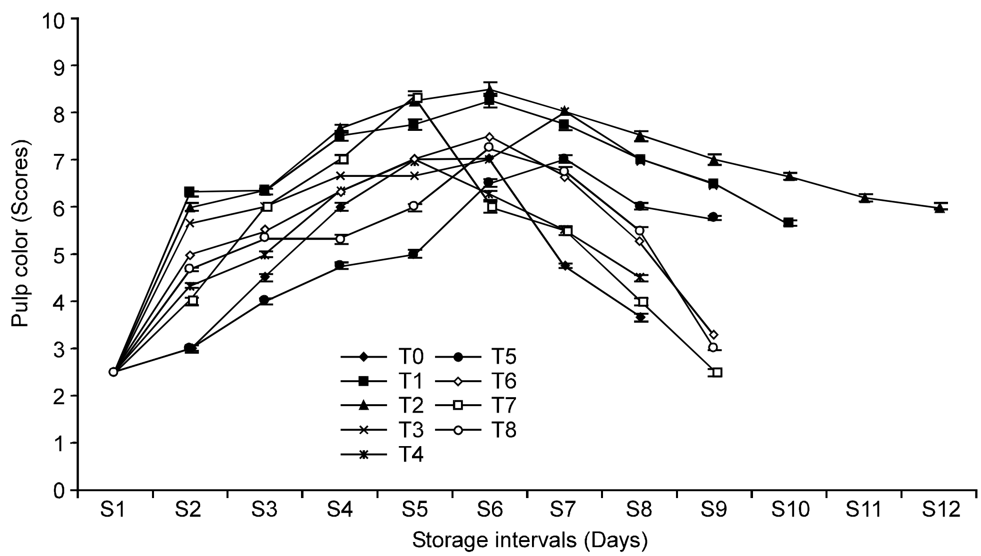

Fig. 6: Effect of storage and treatments on pulp color (mean±SE) of mangoes

difference was observed between T_5 and T_0. Color is the function of light striking the product, the deferential reflection of certain wavelengths and their visual perception. The color of plants is contributed by different pigments, which are classified into four main categories based on their chemistry; chlorophylls, carotenoids, flavonoids and betalains. However the plant kingdom is dominated by the presence of green pigment chlorophyll.

The transition from green to yellow color in mango was due to the chlorophyll degradation indicating an increased acceptability for consumption. The disappearance of green pigment chlorophyll is associated with the appearance of yellow pigment carotenoides (Montefiori *et al*., 2009). These carotenoids are stable compounds which are synthesized during developmental stages but masked by the presence of chlorophyll. These results coincide with those of Doreyappy-Goda and Huddar (2001) who reported that the concentration of carotenoids were increased due to a series of physico- chemical changes in green mature Alphanso and other varieties of mango stored at 18-34°C. During ripening peel color turned from light green or green or dark green to light yellow or yellow or orange yellow due to the breakdown of chlorophyll leading to disappearance of green colour, whereas pulp color which was white to pale yellow, changed from white or pale yellow to yellow or orange yellow due to the development of carotenoids.

In conclusion CMC at different levels showed best skin color scores during the storage period. T_2 (CMC at 2%) after 56 days storage showed maximum skin color scores and T_1 (CMC at 1%) T_3 (CMC at 3%) also retained appreciable color scores even after 60 days storage. Minimum skin color scores were observed in case of treatment T_0 (Control) and T_5 (Bee wax) due to the appearance of initial black spots on the fruits surface which extended on the whole with the progression in storage period.

The general trend was an increase and than a decrease in pulp color scores. Statistical analysis revealed ($p \leq 0.05$) that T_2 (CMC at 2%) showed maximum color scores followed by $T_1 > T_3 > T_6 > T_8 > T_7 > T_5 > T_4$ and T_0 after 77 days of storage at refrigerated temperature (Fig. 6) with non significant difference between T_8, T_7 and T_5. Initially pulp color was whitish yellow, with the onset of ripening fruit pulp turned to yellow, orange or reddish orange due to carotenoids formations. These investigations showed that although all of the treatments were effective to control the biochemical reactions, however, those treatments having the combinations of CMC with ethylene absorbent (T_1, T_2 and T_3) were more effective as compared to others. Those treatments having ethylene absorbent reached to higher sensory score at later stage, might be due to slower changes caused by modified storage conditions created by CMC or $KMnO_4$ which reduced respiration rate that caused slower metabolic activities due to removal of ethylene as compared to control having fast degradation due to free atmosphere during storage. Whereas the combination of CMC with ethylene absorbent ($KMnO_4$) act as a barrier to oxidative system and created modified atmospheric conditions that were more effective to control the ripening process might be due to delay in the enzymatic oxidation and photo degradation. These results are in agreement with those of Raje *et al.* (1997).

In different treatments, initially taste scores were low, hydrolytic changes associated with the ripening of fruits caused an increase in taste scores due to the conversion of starch into sugars in all the treatments. Statistical analysis ($p \leq 0.05$) revealed than T_2 (CMC at 2%) retained maximum taste scores followed by $T_1 > T_3 > T_7 > T_6 > T_8 > T_0 > T_4$ and T_5 after the storage period (Fig. 7) and non significant results were recorded between T_0 and T_4.

Taste is mainly due to sugar acid ratio. It is perceived by specialized taste buds on the tongue. Although there are many different tastes, most appear to primarily represent combinations of four dominant chemical sensations, sweet, sour, bitter and salty in which sweet and sour predominate, with bitterness being important in some fruit, saltiness on the other hand, is a seldom factor in fresh fruit. Thus, sweetness due to sugar and sourness from organic acids are dominant components in the taste of many fruits (Kays, 1991). In CMC treated fruits (T_1, T_2 and T_3) acceptable taste scores were recorded even after 56 days of storage while control is discarded with low taste scores after 49 days of storage. The results are in accordance with Kittur *et al.* (2001) who observed that fruits having polysaccharide based formulations coatings improved the sensory characteristics of banana and mango by maintaining dark green color, with glassy shining and moist-like appearance, maximum texture and taste also depends

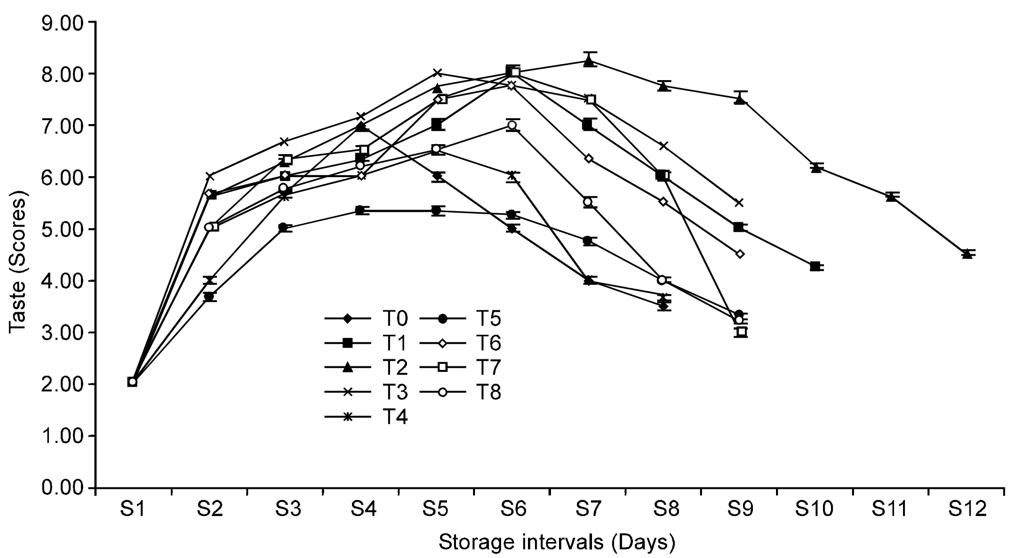

Fig. 7: Effect of storage and treatments on taste (mean±SE) of mangoes

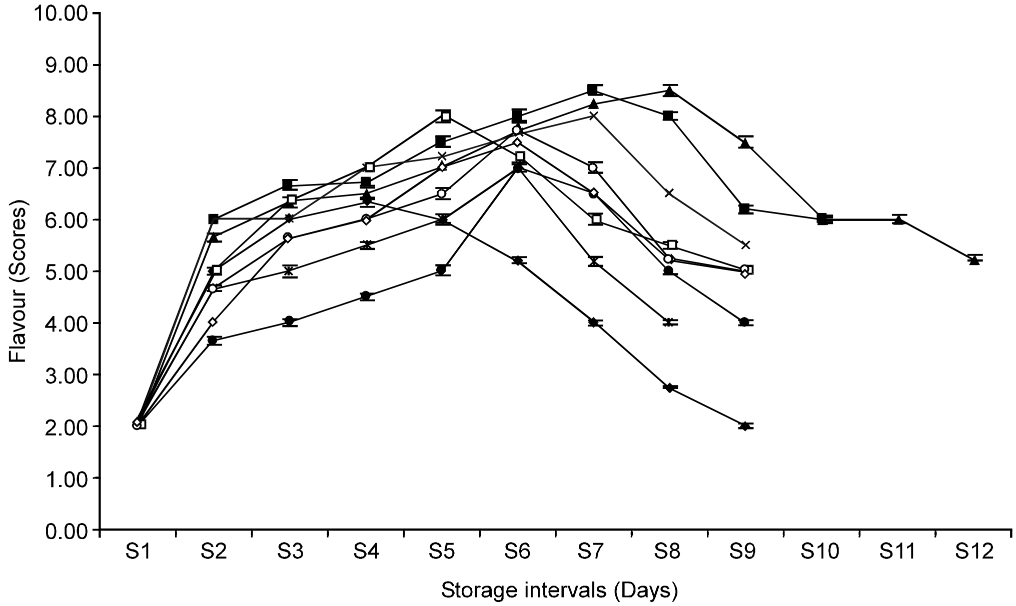

Fig. 8: Effect of storage and treatments on flavour (mean±SE) of mangoes

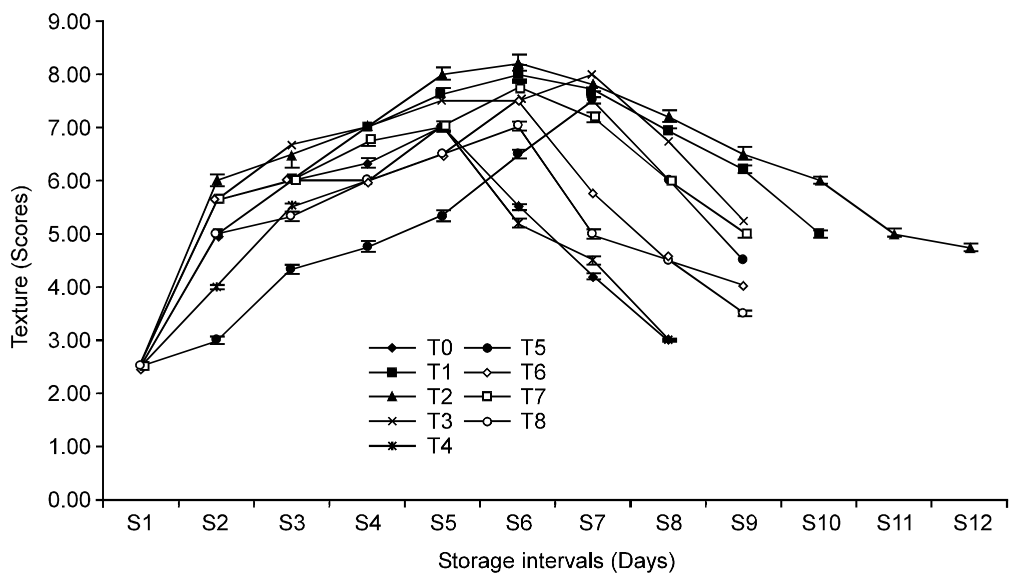

Fig. 9: Effect of storage and treatments on texture of mangoes

on type of coating at ambient temperature (27±2°C and 65% RH) and were best even after 21 days of storage. Uncoated fruit on the other hand, blackened due to over ripening and fungal infection and exhibited a very soft, collapsed texture.

The overall flavour impression is the result of the tastes perceived by the taste buds in the mouth and the aromatic compounds detected by the epithelium in the olfactory organ in the nose. Statistical analysis ($p \leq 0.05$) revealed than T_2 (CMC at 2%) retained maximum flavor scores followed by $T_1>T_3>T_7>T_8>T_6>T_5>T_4$ and T_0 after the storage period (Fig. 8) with non significant difference between T_5, T_4 and T_0. This difference in flavour retention might be due to different nature of treatment and modified atmospheric conditions created by different levels of coatings. It was observed earlier that coatings improve the flavour of fruit that depends upon the type and permeability (Baldwin *et al*., 1999), concentration of coating (Malik *et al*., 2003) or modified atmosphere packaging (Rodov *et al*., 1997) used etc.

Statistical analysis ($p \leq 0.05$) revealed than T_2 (CMC at 2%) retained maximum texture scores followed by $T_1>T_3>T_7>T_6>T_8>T_5>T_0$ and T_4 after the storage period (Fig. 9) and non significant difference was observed between T_0 and T_4. Texture is comprised of those properties of a product that can be appraised visually or by touch. In fruits, textural properties may also be assessed by skin and muscle senses in mouth. The internal textural properties of fruits are due to the composition and structure of the cells and their supporting tissues. These are mainly attributed primarily due to the cell wall and storage carbohydrates like pectin, starch etc. Fruit ripening is associated with depolymerization of storage carbohydrates consequently increased pectin-esterase and polygalacturonase activities. (Remon *et al*., 2003).

In addition turgor pressure is another important parameter affecting the textural properties of fruits. Pectic substances are structural polysaccharides responsible for the firmness of fruits and softening of fruit occurs when these pectin polymers become less tightly bound in the cell walls during ripening. Therefore, firmness, could also be used as index for fixing optimum stage of maturity for harvest (Kudachikar *et al*., 2001). Maintaining the textural composition in coated fruits can be described as slowed degradation of components contributing to the the structural rigidity in fruits (Maftoonazad and Ramaswamy, 2005). The reduction in texture scores during storage in all the treatments, might be due to the breakdown of insoluble pectic substances to soluble forms by a series of physico-chemical changes that caused by the action of pectic enzymes i.e. Esterase and polygalacturonidase. The faster reduction in texture scores in control sample might also be due to accelerated ripening process in free atmospheric conditions of storage temperature.

Conclusion: Mango treated with different levels of CMC (Carboxy Methyl Cellulose) along with $KMnO_4$ had maximum storage life than all other applications with remarkable conservation of physico-chemical and sensory parameters. T_2 (CMC 2%), T_1 (CMC 1%) and T_3 (CMC 3%) gave appreciable results, however T_2 had shown supremacy over the other two with the extension in the storage life up to 77 days at the refrigerated temperature. Different levels of $CaCl_2$ (T_7, T_6 and T_8) along with the ethylene absorbent extended the storage life of the produce up to 56 days and the same duration was observed in coating with Bee wax (T_5). In most of quality parameters, a non significant difference was recorded between control (T_0) and wrapping in Polyethylene sheet (T_4) with storage life of 49 days at refrigerated conditions. It is therefore concluded that CMC coating at 2% level significantly increased the storage life of mangoes and delayed the changes in physical, chemical and sensory parameters. The coating acted as physical barrier for the gaseous exchange between the fruits and its environment, consequently controlled rate of respiration and reduced substrate catabolism was achieved. However, for the comparative study it is recommended to carry out these post harvest treatments on other varieties of mangoes at variable temperatures.

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